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Sasol Sigma Defunct Colliery Surface Mitigation Project: Proposed River Diversion and Flood Protection Berms

Aquatic and Wetland Assessment

Project Number:

SAS5250

Prepared for:

Sasol Mining (Pty) Ltd

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Report Type:	**Aquatic and Wetland Assessment**
Project Name:	**Sasol Sigma Defunct Colliery Surface Mitigation Project: Proposed River Diversion and Flood Protection Berms**
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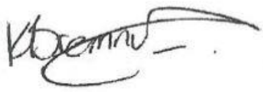
Kieren Bremner Pr.Sci.Nat.	Aquatic Reporting		07-09-2018
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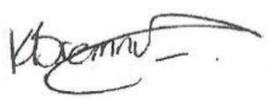
I, Kieren Bremner, as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of the operations at Sigma Defunct Colliery, other than fair remuneration for work performed, specifically in connection with the relevant specialist studies required for compliance to the recently approved Basic Assessment, issued by the Department of Water and Sanitation.



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EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Sasol Mining to undertake the required environmental regulatory process required to implement the proposed surface mitigation measures at the Sigma Defunct Colliery. Two rivers flow through the Sigma mining area, namely the Rietspruit and the Leeuspruit. Beneath these river courses/floodplains there is a potential for pillar failure, which can result in subsidence and therefore various mitigation measures have been proposed to reduce the significant risk areas to an acceptable low risk. The surface mitigation measures that were considered include full stream diversions, partial stream diversion and ash backfilling of mined panels or various combinations thereof. This Wetland and Aquatic Impact Assessment is required as part of this process.

Wetlands

There are 413.9 hectares (ha) of wetlands within the project area. These wetlands have been categorised Present Ecological State (PES) values ranging from D to E and Ecological Importance and Sensitivity (EIS) values ranging from C to D.

Approximately 51.5 ha will be lost through the implementation of the surface mitigation measures at Sigma Defunct Colliery. Of this, 9.8 ha is lost directly and 41.7 ha will be lost indirectly, where direct loss constitutes the loss due to the infrastructure footprint and indirectly constitutes the drying out of the floodplain portions due to separation from the main channel because of the proposed construction of the flood protection berms and canals. These surface mitigation measures will result in a decline in the PES and EIS of the wetland hydro-geomorphic (HGM) units.

In addition to various mitigation measures, it is suggested that a Wetland Offset Strategy be implemented to account for the loss of wetlands due to the implementation of the project.

It is suggested that monitoring take place monthly during the construction phase, quarterly for the first two years after construction and annually for three years thereafter.

Geomorphology

The general area and region is devoid of any major fourth order (4th order) landforms. The area is specifically lacking relief and areas of high gradient.

This is due to the surface geology dominated by Ecca sedimentary rock with some dolerite intrusions and specifically sills exposed to surface.

The ridge at Boschenvaal on the edge of the Vaal River is arguably one of the few fourth order landforms in the area. The Fine Ash Dam (FAD) and associated infrastructure is large enough to form an anthropogenic fourth order landform.

There are some small andesite outcrops that form a ridge near Section 3 and the school. Dolerite formations are not as prominent. Previous mining and subsidence in wall mining areas probably form a larger geomorphological driver in the area than dolerite.

The proposed activities are not of the order of magnitude of the FAD or Boschenvaal ridge.

The proposed berms and diversions will be designed to keep the landscape stable, prevent erosion and be as natural as possible.

Within the proposed structures, high and low energy zones will be included and designed for. Pools in series and meanders and islands or dissipaters will assist in aquatic habitat formation and refuse for migration.

Aquatics

The upper reaches of both the Leeuspruit and the Rietspruit are comprised largely of wetland habitats. In many instances, a defined instream channel was absent. Therefore, of the eleven potential biomonitoring points assessed for the determination of the PES of the aquatic resources present within the study area, only six sites were considered suitable for water quality analysis and the application of the Fish Response Assessment Index (FRAI) in the assessment of the fish community integrity; and only five sites were considered suitable for the application of the South African Scoring System (Version 5) (SASS5) and Macro-Invertebrate Response Assessment Index (MIRAI) methodologies used in the assessment of the macro-invertebrate community integrity within the study area. Nevertheless, data collected was deemed sufficient to determine the ecological status of the instream aquatic components present within the study area. It should be noted that while an assessment of the Rietspruit system was investigated at the time of the assessment, these systems were found to be dry and as such, all results in terms of instream ecology based on the MIRAI and FRAI indices are applicable to the Leeuspruit system only.

Water Quality

Based on the *in situ* water quality variables recorded at the time of the survey, the elevated electrical conductivity values were expected to deter the colonisation and/or inhabitation of these watercourses by sensitive aquatic biota to some extent. However, it should be noted that extensive portions of this system were dominated by wetland habitat, the nature of which was expected to be a major driver for the elevated salt loads observed. As such, the aquatic assemblage inhabiting these systems were expected to be relatively tolerant of the inherent water quality conditions observed.

pH values observed along the length of the portion of the Leeuspruit assessed may be regarded as somewhat alkaline. Electrical conductivity values recorded at the time of the survey were observed to exhibit moderate to high levels, which to an extent, was to be expected within a system inherently dominated by wetland habitat. However, an increase in electrical conductivity observed between sites SRD9 and SRD10 serves as an indication that potential sources of pollution (point- and/or diffuse sources) could be emanating from the residential area adjacent to the Leeuspruit between sites SRD9 and SRD10. However, confirmation of this suspicion would require further infield investigation. Temperatures observed at each site may be regarded as largely natural on consideration of the natural seasonal and diurnal cycles at the time of the assessment and based on the inherent nature of the system at each point.

Aquatic Macro-Invertebrate Integrity

Based on the derived reference list and distribution, a total of approximately 50 different aquatic macroinvertebrate families were to be expected within the study area. Of these aquatic macroinvertebrate families, a total of only 25 taxa were collected at the time of the survey, ranging from 6 families at the Site SRD10 to 17 families at Site SRD4. Accordingly, the corresponding SASS5 scores ranged from a low 21 to moderate 84 at the same respective sampling sites. The highest Average Score Per Taxon (ASPT) values were observed at Sites SRD4 and SRD9 along the Leeuspruit, decreasing notably downstream of Site SRD9.

The lowest macroinvertebrate diversity obtained at the time of the survey was observed at Site SRD10. Both the SASS5 and ASPT scores thus reflect a direct impact to the Leeuspruit system, most likely because of impacts to the water quality observed at Sites SRD10 and SRD11. The potential for point and diffuse sources of pollution emanating downstream of Site SRD9 was deemed likely. The results of both the water quality assessment as well as the observed ASPT values, which are an indication of the general sensitivity of the colonised macroinvertebrate assemblage, serve as an indication, that water quality is a major driver within the Leeuspruit system.

On application of the MIRAI, the index suggested that the primary driver at each of the assessed sites was related to the limited available habitat present, which was to be expected as these systems are predominantly comprised of wetland habitat for sites SRD1, SRD4 and SRD9 (Ecological Category E). However, the results suggest some impact related to water quality at sites SRD10 and SRD11 (Ecological Category F and E/F, respectively).

Fish Community Integrity

On application of the FRAI, the results indicated both poor diversity and abundance within the Leeuspruit system at the time of the assessment. An ecological category of E was thus assigned to this section of the Leeuspruit occurring within the area assessed based on the results of the July 2018 survey.

Conclusion

The results of the July 2018 survey correspond with the historical data available for the portion of the Leeuspruit system assessed. While many potential impacts related to the proposed activities (i.e. construction of the canal and berms) are likely to have a negative impact on the biodiversity of this portion of the Leeuspruit.

Special care will be required to minimise the loss of stream connectivity and fragmentation of the Leeuspruit system. In addition, strict monitoring will be required both in the study area as well as downstream of the proposed activities to ensure impacts are not expressed further downstream and to ensure no further loss to the ecological integrity of the system over the long term.

It is, however, important to note that should the proposed project not be permitted to proceed, the impacts relating to potential for pillar failure which can result in subsidence to the Leeuspruit and Rietspruit systems have the potential to outweigh the impacts relating to the system should the proposed rehabilitation and mitigation measures be granted.

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GLOSSARY OF TERMS

Alien invasive vegetation	Plants that do not occur naturally within the area but have been introduced either intentionally or unintentionally. Vegetation species that originate from outside of the borders of the biome - usually international in origin.
Basal cover	The cross-sectional area of the plant that extends into the soil.
Base flow	Long-term flow in a river that continues after storm flow has passed.
Biodiversity	The number and variety of living organisms on earth, the millions of plants, animals and micro-organisms, the genes they contain, the evolutionary history and potential they encompass and the ecosystems, ecological processes and landscape of which they are integral parts.
Catchment	The area contributing to runoff at a particular point in a river feature.
Ecoregion	An ecoregion is a "recurring pattern of Ecosystems associated with characteristic combinations of soil and landform that characterise that region”.
Groundwater	Subsurface water in the saturated zone below the water table.
Intermittent flow	Flows only for short periods.
Indigenous vegetation	Vegetation occurring naturally within a defined area.
Perennial	Flows all year round.
Wetland	Defined according to the National Water Act, 1998 (Act No. 36 of 1998) (NWA) as: *“Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.”*

LIST OF ACRONYMS

AIP	Alien Invasive Plants
BRP	Bioregional Plan
CBA	Critical Biodiversity Areas
CMA	Catchment Management Agencies
DMR	Department of Mineral Resources
DWA	Department of Water Affairs
DWAF	Department of Water and Forestry
DWE	Digby Wells Environmental
DWS	Department of Water and Sanitation
EC	Ecological Class
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMF	Environmental Management Framework
F	Facultative species
FD	Facultative dry-land species
FW	Facultative Wetland species
GIS	Geographical Information System
Ha	Hectares
HGM	Hydrogeomorphic
IHAS	Invertebrate Habitat Assessment System
IUCN	International Union for Conservation of Nature
MIRAI	Macro-Invertebrate Response Assessment Index
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
MRA	Mining Right Area
NEM:BA	National Environmental Management Biodiversity Act, 2004 (Act No. 10 of 2004)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NFEPA	National Freshwater Ecosystems Priority Areas
NWA	National Water Act, 1998 (Act No. 36 of 1998)
OW	Obligate Wetland Species
PES	Present Ecological State

REC	Recommended Ecological Category
RQIS	Resource Quality Information Services
SANBI	South African National Biodiversity Institute
SASS5	South African Scoring System Version 5
SFI	Soil Form Indicator
SWI	Soil Wetness Indictor
TUI	Terrain Unit Indicator
WMA	Water Management Areas
WRC	Water Research Commission
WUL	Water Use Licence

1 Introduction

Biodiversity within inland water ecosystems in southern Africa is both highly diverse and of great regional importance to local livelihoods and economies, as these valuable natural resources (including any associated biota) provide a broad array of goods and services e.g. a source of water for domestic, industrial and agricultural purposes, as well as integral roles in the power generation and waste disposal industries (Dudgeon *et al.*, 2006; Darwall *et al.*, 2009). However, the fact that these freshwater systems may well be the most endangered ecosystem in the world threatens any of the 126,000 described species that depend upon freshwater habitats for any critical part of their life cycle, as well as any associated provisioning and/or regulatory ecosystem services (Dudgeon *et al.*, 2006).

Major global threats identified within these species-rich systems include ecosystem destruction, habitat alteration, changes in water chemistry, and direct additions and/or losses of aquatic biota (Malmqvist and Rundle, 2002). The magnitude of the threat to and loss of, biodiversity in these vulnerable ecosystems is an indicator of the extent to which current practices are unsustainable. Hence, the importance of implementing conservation and management strategies that protect all elements of freshwater biodiversity, which in turn, would also help to guarantee water availability in the future (Dudgeon *et al.*, 2006).

The fact that South Africa is a water-scarce country makes these aquatic ecosystems even more susceptible to anthropogenic activities and their associated impacts. Consequently, the state (quality and quantity) of the county's water resources is fully dependant on good land management practices within catchments. Therefore, to achieve ecological and socio-economic sustainability, our natural water resources rely upon an integrated ecosystem-based approach to natural resource management (i.e. Integrated Water Resource Management).

1.1 Project Description

Sasol Mining's Sigma Defunct Colliery (now referred to as the Sigma Defunct Colliery) occupies a mining area of approximately 11 643 ha (see Figure 1-1 and Figure 1-2 for the regional and local setting respectively). Mining activities at the Sigma Defunct Colliery was conducted under Mining Licences No. 1/2001 and 3/2001, granted by the Department of Mineral Resources (DMR).

Sigma Defunct Colliery commenced operations in 1952 with underground mining, holding mineral rights to several coal deposits in the Sasolburg district. Underground mining methods were the primary method of extracting these reserves and included mechanised board-and-pillar, rib-pillar extraction and bottom-coaling methods. Access to the underground operations was via several shafts, and the coal was then conveyed to a 'dry' coal handling plant at 3 Shaft where the coal was screened and fed to silos.

In 1992 the Wonderwater opencast mine was developed to extract coal from the north-eastern side of the reserves which occupied a mining area of approximately 385 ha. The Wonderwater opencast mine was mined utilising truck and shovel methods. The mining ceased in 2005 after which the opencast mine was backfilled and rehabilitated. The final voids were left as part of the water management of the underground workings.

The Mohlolo Operations, situated adjacent to the Wonderwater opencast mine commenced with its activities in 1999 and occupied a mining area of approximately 264 ha. The underground operations were accessed from the Wonderwater opencast mines highwalls in the north and the south and divided the operations into Moholo North and Mohlolo South. The underground mining was scaled down and ceased by 2005, the underground mine workings were left to be flooded.

Sigma Defunct Colliery applied for mine closure where a closure application and closure report was submitted to the DMR in 2009. Sigma Defunct Colliery began to implement the proposed mitigation measures as per the requirements of the closure plan to address all the significant risks and rehabilitation measures which were required to obtain the needed closure certificate. Jones and Wagener (J&W) were appointed to assist Sasol Mining in the compilation of a risk assessment report which aimed to identify all the latent risks which Sigma Defunct Colliery have and rate them in accordance with the Sasol Risk Assessment Methodology. The report proposed mitigation measures to be implemented to reduce the significant rated risks to an acceptable level. The report was compiled in 2015 and has now been updated in 2018.

As part of the risk report, mitigation measures have been proposed and grouped together as underground mitigation measures (ash backfilling) and surface mitigation measures (river diversions and flood protection berm constructions).

The Underground Mitigation Measures which includes ash backfilling of certain areas with ash slurry is being dealt with as a separate project and under a separate environmental authorisation process.

The Surface Mitigation Measures proposed in the Risk Assessment Report requires environmental authorisation. Two rivers flow through the Sigma mining area namely the Rietspruit and the Leeuspruit. Beneath these water courses or floodplains a hazard of pillar failure exists which can result in subsidence. Subsidence is expected to have a significant impact on surface aspects should it occur and no mitigation measures are implemented. The risk of this occurring is considered to be significant. Therefore various mitigation measures have been proposed to reduce the significant risk areas to an acceptable residual risk (insignificant risk).

According to the J&W Design Report (2018), a total of 37 areas (associated with underground mined panels with a significnat potential of pillar failure) were identified, of which 36 are located within the Leeuspruit and only one within the Rietspruit. J&W's Design Report (2018) sub-divided the Leeuspruit into four sections numbered in the direction of stream flow (from south to north).

It should be noted that J&W have indicated that no upgrades to any existing culverts or bridge crossings are proposed as part of this project.

The surface mitigation measures that were considered include full stream diversions, a partial stream diversion and ash backfilling of mined panels or various combinations thereof.

A description of the various diversions types is provided below:

- Full stream diversion:
  - Typically consists of a diversion canal which follows along a completely new alignment from the original stream alignment. The stream flow is diverted along the new route and discharges back into the existing stream downstream of the affected area. A diversion canal mitigates the risk by moving the stream away from the significant risk area.
- Partial stream diversion:
  - A partial stream diversion entails confining the stream flow by means of either channelling the stream or flood protection berms or both for it not to cross areas where a significant chance of pillar failure which can result in subsidence could occur. The purpose of flood protection berms is to prevent the existing stream flow from entering significant risk areas. Where possible, flood protection berms are used in isolation, however if the position of a berm obstructs the natural stream flow (i.e. crossing existing watercourse centreline), flood protection berms are used in combination with channelling the stream. This prevents unnecessary secondary issues, for example backwater or ponding upstream of the berm, and allows unimpeded flow of the stream past the problem areas.
- Backfilling:
  - Ash backfilling is predominantly used where a full stream diversion or partial stream diversion alone does not mitigate the risk or where a diversion canal cannot avoid crossing over a significant risk area. In the case where a full diversion or partial diversion is not possible, only backfilling is proposed.
  - It must be noted that although mentioned, ash backfilling is being dealt with as a separate project and is not considered to be incorporated as part of this environmental authorisation process.

1.2 Surface Mitigation Measures

As mentioned above the surface mitigation measures have been divided into 5 sections along the Leeuspruit with only one section in the Rietspruit. A description of each section is provided below:

Significant Risk Area	Mitigation Measure Implemented	Description
Leeuspruit: Section 2	■ Flood protection berm to be constructed to avoid one area of significant risk.	■ The flood protection berm will comprise of suitable material, typically clayey sand or sandy clay material obtained from other necessary excavations.
Leeuspruit: Section 3	■ Combination of diversion canals, flood protection berms and ash backfilling.	■ The proposed design comprises of two flood protection berms to direct the flow of water away from significant areas; ■ A formalised canal to divert the stream flow away from the natural stream flow path (Armorflex or a similar approved lining); and ■ Ash backfilling will be utilised were diversions are not possible. Ash Backfilling is considered to be a separate project and under a separate environmental authorisation process.
Leeuspruit: Section 4	■ Two Full stream diversion canals are proposed, namely the Southern diversion canal and Northern diversion canal; ■ Flood protection berms will also be utilised; and ■ Ash Backfilling will also be utilised.	■ This section is located immediately west of the Sasolburg residential area and comprises approximately 2.3km of the Leeuspruit, from the Afrikaans High Sasolburg up to the R59 provincial road; and ■ Ash backfilling will be utilised were diversions are not possible. Ash Backfilling is considered to be a separate project and under a separate environmental authorisation process.
Leeuspruit: Section 5	■ This section's design comprises mainly of backfilling polygons due to surface restrictions on either side of the stream.	■ Located on the south-western side of the area is private infrastructure and northeast is an operational sand mine; and ■ Some of these areas have

Significant Risk Area	Mitigation Measure Implemented	Description
		already been backfilled. Ash Backfilling is considered to be a separate project and under a separate environmental authorisation process.
Rietspruit: Section 1	■ Only one significant risk area has been identified; and ■ A flood protection berm is proposed.	■ Small diameter pipes will also be installed at low points along the berm to allow the slow release of water accumulated behind the berms.

1.3 Environmental Authorisation process

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Sasol Mining to undertake the required environmental regulatory process required to implement the proposed surface mitigation measures at the Sigma Defunct Colliery. This proposed project will require the following authorisations:

Authorisation Process	Relevant Legislation	Competent Authority
Environmental Authorisation – Basic Assessment (BA) Process	National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA)	Department of Mineral Resources (DMR)
Water Use Licence (WUL)	National Water Act, 1998 (Act No. 36 of 1998) (NWA)	Department of Water and Sanitation (DWS)
Notification of Intent to Develop (NID)	National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA)	South African Heritage Resources Agency (SAHRA) and Free State Provincial Heritage Resources Authority (FS-PRHA)

The following listed activities in terms of NEMA that will be triggered by the proposed project have been listed below:

- Listing Notice 1 Activity 9 - It is proposed that the canals to divert the water will exceed 1000 metres in length and will have a width of 12.5 - 30 metres (Northern and southern diversion);
- Listing Notice 1 Activity 12 - The canals to be constructed to divert the water will exceed 100 square metres which are proposed to be located within a water course;
- Listing Notice 1 Activity 19 - Movement of soil of more than 10 cubic metres within a watercourse;

- Listing Notice 1 Activity 27 – The clearing of vegetation of more than 1 ha but less than 20 ha
- Listing Notice 1 Activity 24 - Construction of access roads to the river during construction phase and maintenance to be undertaken during operational phase.

Activities identified as water uses in terms of Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (NWA) may not be undertaken without a Water Use Licence (WUL) or General Authorisation. The following Section 21 Water Uses will be triggered from the project:

- Section 21(c): impeding or diverting the flow of water in a watercourse;
- Section 21(i): altering the bed, banks, course or characteristics of a watercourse.

Construction of the diversion canals in proximity to wetlands and water resources will require a WUL to be undertaken.

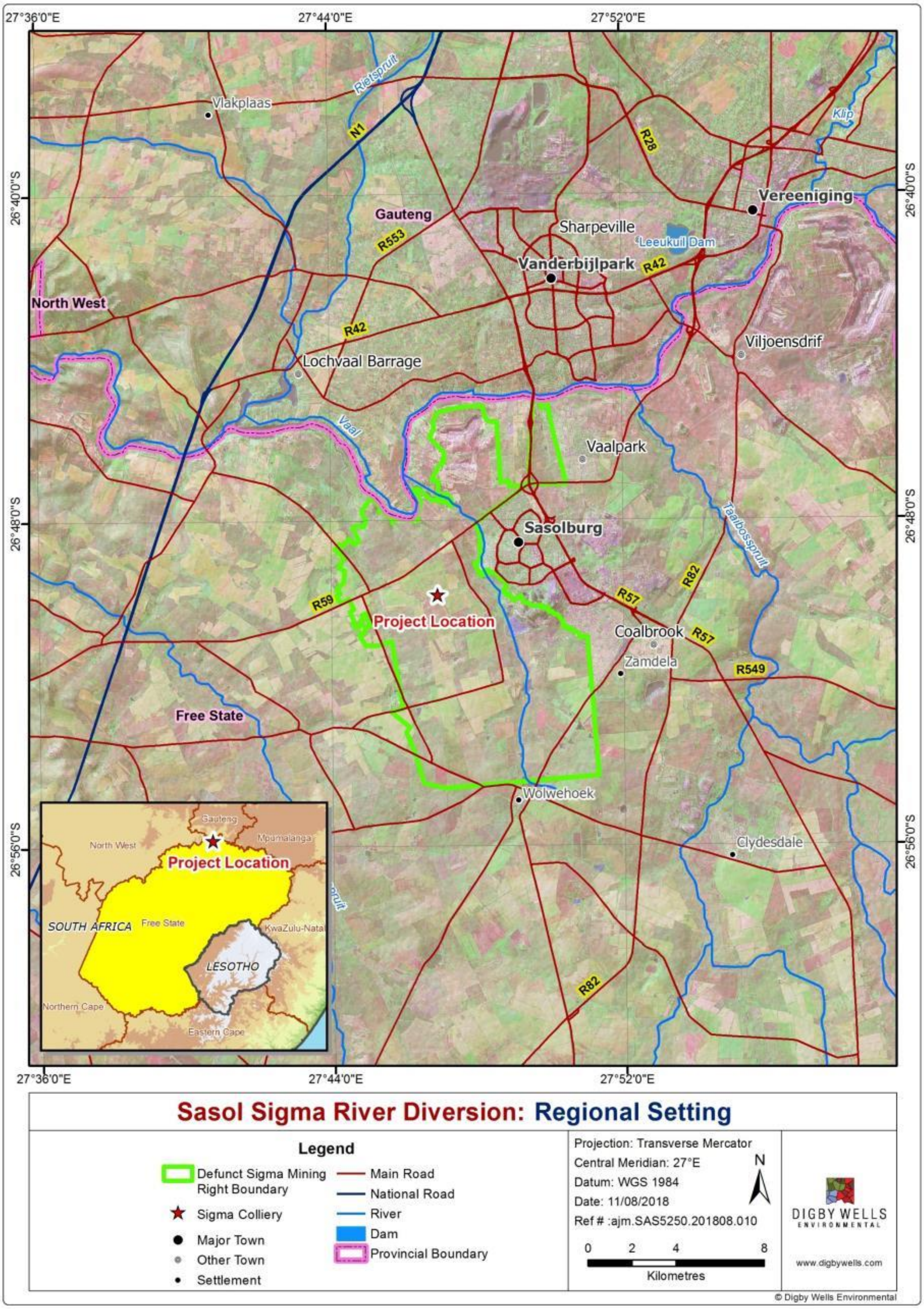

Figure 1-1: Regional Setting

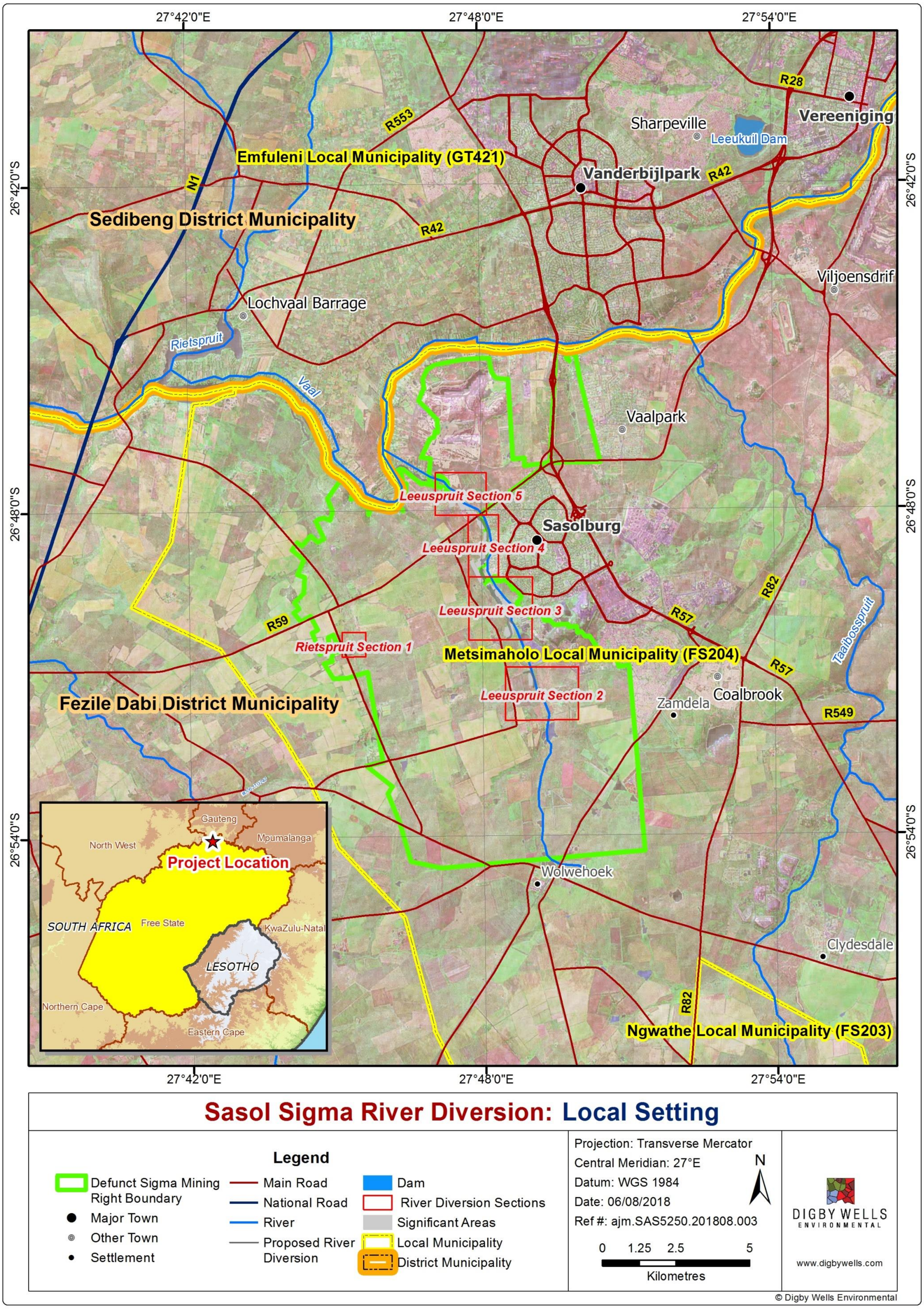

Figure 1-2: Local Setting

1.4 Aims and Objectives

The aim of the project is to determine the impacts associated within the implementation of the surface mitigation measures on wetland and aquatic resources.

To achieve the above aim the following objectives are proposed:

- Conduct a baseline aquatic assessment and impact assessment of the associated watercourses;
- Conduct a wetland impact assessment of the associated watercourses based on a previous wetland report compiled by Digby Wells in 2016 with the assistance of J&W and Wetland Consulting Services; and
- Provide recommendations for aquatic and wetland mitigation measures.

1.5 Policy and Legal Framework

The assessments aim to support the following regulations, regulatory procedures and guidelines:

- Section 24 of the Constitution of the Republic of South Africa ,1996 (Act No. 108 of 1996);
- The National Water Act, 1998 (Act No. 36 of 1998) (NWA);
- National Environmental Management Biodiversity Act, 2004 (Act No. 10 of 2004) (NEM:BA);
- Section 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA); and
- Regulations on use of water for mining and related activities aimed at the protection of water resources (GN 704 in GG 20119 of 4 June 1999).

1.6 Assumptions and Limitations

The following limitations were encountered during this study:

- The wetland impact assessment is based on a baseline wetland assessment completed by Digby Wells in 2016 with the participation of J&W and Wetland Consulting Services therefore a repeat of this work was not deemed necessary;
- The previous wetland assessment assigned EIS values for artificial wetlands. The tool is not designed for use in wetland systems; however, they are useful in terms of quantifying some of the services that these systems do supply.
- The composition of freshwater resources in the study area prior to major disturbance is unknown. For this reason, reference conditions are hypothetical, and are based on professional judgement and/or inferred from limited data available;

- With ecology being dynamic and complex, certain aspects, some of which may be important, may have been overlooked. It is, however, expected that the study area has been accurately assessed and considered, based on the field observations undertaken and the consideration of existing studies and monitoring data in terms of freshwater ecology;
- To obtain a comprehensive understanding of the dynamics of the aquatic biota present within a watercourse (e.g. migratory pathways, seasonal prevalence, breeding cycles, etc.), studies should include investigations conducted during different seasons, over many years and through extensive sampling efforts. Given the time constraints of the baseline assessment, such long-term research was not feasible and could not be conducted. Consequently, the findings presented are based on professional experience, supported by a literature review, historical knowledge of the site and extrapolated from the data collected at the time of the field survey; and
- Although selected assessment indices (i.e. SASS5) are not specifically designed and/or recommended for use in wetland systems (Chutter, 1998; Dickens and Graham, 2002), it was considered a valuable source of data in terms of species sensitivity and composition within the study area. For the purposes of this study, application was limited to the channelled systems that exhibited some evidence of riverine elements (e.g. flowing systems).

2 Details of the Specialists

Kathryn Roy: Wetlands consultant; Kathryn received a Bachelor of Science in Ecology and Environmental Science and an Honours degree in Environmental Management from the University of Cape Town. She has also received her MSc in Restoration Ecology through the University of KwaZulu-Natal and has over 5 years of experience in the environmental field. Kathryn focuses on wetland assessments throughout South Africa as well as wetland and rehabilitation monitoring programmes within the mining and energy production sectors. She has also completed flora surveys and site-specific rehabilitation plans. Kathryn previously worked extensively with alien invasive species removal programmes, ecological restoration projects and sustainable development programmes within the Government Sector.

Kieren Jayne Bremner: Wetlands Manager. Kieren completed an M.Sc. (Aquatic Health) from the University of Johannesburg and has 10 years of consulting experience. In her early career she was exposed to various sectors of the Environmental Management field such as water use licensing, BAs, EIAs and public participation. During this time, she was given the opportunity to initiate and manage various aquatic biomonitoring programmes within the mining and energy production sectors within South Africa. In 2009, Kieren began to focus largely on wetland and aquatic specialist assessments, gaining invaluable and extensive experience in the biomonitoring and water monitoring field in rivers and wetlands throughout South Africa. International countries of project experience include: Botswana, the

Democratic Republic of Congo and Ghana. Kieren is registered by the SA RHP as an accredited aquatic biomonitoring specialist. Pr. Sci. Nat: 119341.

Danie Otto manages the South African Operations and Technical Services at Digby Wells. He holds an M.Sc in Environmental Management with B.Sc Hons (Limnology & Geomorphology, and GIS & Environmental Management) and B.Sc (Botany and Geography & Environmental Management). He is a biogeomorphologist that specialises in ecology of wetlands and rehabilitation. He has been a registered Professional Natural Scientist since 2002.

Danie has 21 years of experience in the mining industry in environmental and specialist assessments, management plans, audits, rehabilitation, and research.

He has experience in 8 countries and his experience is in the environmental sector of coal, gold, platinum (PGMs), diamonds, asbestos, rock, clay & sand quarries, copper, phosphate, andalusite, base metals, heavy minerals (titanium), uranium, pyrophyllite, chrome, nickel etc.

He has wetland and geomorphology working experience across Africa including specialist environmental input into various water resource related studies. These vary from studies of the wetlands of the Kruger National Park to swamp forests in central Africa to alpine systems in Lesotho.

3 Description of Environment

3.1 Climate

The study area occurs within a summer rainfall region with warm summers and moderate dry winters. Climate data used herein originates from the Vereeniging International Weather Station (Station Number 043 87843) from the South African Weather Bureau. Rainfall records reported are for the periods 1951 – 1984 and 1991-2012 to give long term climatic averages and variability (Digby Wells Environmental, 2014).

Relative to the country's average mean annual precipitation (MAP) of 490 mm (Worldwide Fund for Nature - South Africa, 2016), this area experiences moderately high mean rainfall of approximately 635 mm per annum (i.e. long term average between 1951 – 2012). Furthermore, the study area is located within the Highveld ecoregion (Level II ecoregion 11.03), which has been noted to attain an average temperature range of 12-20°C, a maximum temperature range between 20-32°C during January and a minimum temperature range between -2-4°C during July (Kleynhans *et al.*, 2007).

3.2 Associated Watercourses

The water resources of South Africa are divided into quaternary catchments, which are regarded as the principal water management units in the country (Department of Water Affairs, 2011). These catchments represent the fourth order of the hierarchical classification system, in which the primary catchments are the major units. The primary drainages are further grouped into or fall under Water Management Areas (WMA) and Catchment

Management Agencies (CMA). The Department of Water and Sanitation (DWS) has established nine WMAs and nine CMAs as contained in the National Water Resource Strategy 2 (2013) in terms of Section 5 subsection 5(1) of the National Water Act, 1998 (Act No. 36 of 1998). The establishment of these WMAs and CMAs is to improve water governance in different regions of the country, to ensure a fair and equal distribution of the Nations freshwater resources, while making sure that the resource quality is sustained.

The study area is located predominantly within the C22K quaternary catchment of the Vaal water management area (WMA 5), which lies in the eastern interior of South Africa (Department of Water Affairs and Forestry, 2004). The catchment area is characterised by expansive urban, mining and industrial areas. The primary drainage features associated with the Mineral Lease Area are perennial wetlands, namely the Leeuspruit and the Rietspruit, which fall within the Sub-Quaternary-Reaches (SQRs) C22K-01812 (Leeuspruit) and the upper reaches of the Rietspruit, which feeds into the Vaal River (C22K-01793). The systems are fed by several non-perennial adjoining tributary wetland systems.

Figure 3-1 indicates the freshwater resource management classification associated with the Sigma Defunct Colliery, as well as the associated perennial and non-perennial drainage features within the Mineral Lease Area.

3.3 Regional Vegetation

The Sigma Defunct Colliery falls within the Grassland Biome (Mucina and Rutherford, 2012), one of the nine South African plant biomes and the second most bio-diverse biome in South Africa. The Grassland Biome is situated primarily on the central plateau of South Africa, and the inland areas of Kwa-Zulu-Natal and the Eastern Cape provinces. This biome is rich in flora and fauna diversity but is under threat due to rapid urbanisation and expansion of mining and industrial activities.

The study area also occurs in the Central Free State Grassland regional vegetation type, which is characterised by short grassland covering undulating plains (Mucina and Rutherford, 2012). It is considered a 'Vulnerable' vegetation type with a conservation target of 24%. In natural condition *Themeda triandra* is dominant, whereas *Eragrostis curvula* and *E. chloromelas* become dominant in degraded habitats. Table 3-1 lists species characteristic of the vegetation type.

Table 3-1: Plant species characteristic of the Central Free State Grassland

Plant form	Species
Graminoids	*Aristida adscensionis (d), A. congesta (d), Cynodon dactylon (d), Eragrostis chloromelas (d), E. curvula (d), E. plana (d), Panicum coloratum (d), Setaria sphacelata (d), Themeda triandra (d), Tragus koelerioides (d), Agrostis lachnantha, Andropogon appendiculatus, Aristida bipartita, A. canescens, Cymbopogon pospischilii, Cynodon transvaalensis, Digitaria argyrograpta, Elionurus muticus, Eragrostis lehmanniana, E. micrantha, E. obtusa, E. racemosa, E. trichophora, Heteropogon contortus, Microchloa caffra, Setaria incrassata, Sporobolus discosporus.*
Herbs	*Berkheya onopordifolia var. onopordifolia, Chamaesyce inaequilatera, Conyza pinnata, Crabbea acaulis, Geigeria aspera var. aspera, Hermannia depressa, Hibiscus pusillus, Pseudognaphalium luteo-album, Salvia stenophylla, Selago densiflora, Sonchus dregeanus.*
Geophytic Herbs	*Oxalis depressa, Raphionacme dyeri.*
Succulent herbs	*Tripteris aghillana var. integrifolia.*
Low shrubs	*Felicia muricata (d), Anthospermum rigidum subsp. pumilum, Helichrysum dregeanum, Melolobium candicans, Pentzia globosa.*

3.4 Regional Geomorphology

The general area and region is devoid of any major fourth order (4^{th} order) landforms. The area is specifically lacking relief and areas of high gradient.

This is due to the surface geology dominated by Ecca sedimentary rock with some dolerite intrusions and specifically sills exposed to surface.

Continental scale landforms are first order, regional landforms like the Drakensberg range from second order with structures such as the Vaal River or Vredefort Dome forming third order landforms. Fourth order landforms are limited in this area. The ridge at Boschenvaal on the edge of the Vaal River is arguably one of the few fourth order landforms in the area. The Fine Ash Dam (FAD) and associated infrastructure is large enough to form an anthropogenic fourth order landform.

There are some small andesite outcrops that form a ridge near Section 3 and the school. Dolerite formations are not as prominent. Previous mining and subsidence in long wall mining areas probably form a larger geomorphological driver in the area than dolerite.

The proposed activities are not of the order of magnitude of the FAD or Boschenvaal ridge.

The proposed berms and diversions will be designed to keep the landscape stable, prevent erosion and be as natural as possible.

Within the proposed structures, high and low energy zones will be included and designed. Pools in series, meanders and islands or dissipaters will assist in habitat formation and refuges for migration.

3.5 Regional Biodiversity Importance

3.5.1 Bioregional Context

The Southern Temperate Highveld global freshwater ecoregion is delimited by the South African interior plateaux sub-region of the Highveld aquatic ecoregion, of which the main habitat type (in terms of watercourse) is Savannah-Dry Forest Rivers (Darwall *et al.*, 2009). Aquatic biota within this bio-region have mixed tropical and temperate affinities, sharing many species between the Limpopo and Zambezi systems (Skelton, 1990; Skelton *et al.*, 1995; Darwall *et al.*, 2009).

It should be noted that the level of biological and ecological investigation within this ecoregion was noted to be high, while the threats to this ecosystem integrity are also relatively well known, which have broadly been attributed to surface water abstraction and impacts associated with the human development and/or ‘footprint’ (Scott, 2015). Consequently, this global freshwater ecoregion has been defined largely by the temperate upland rivers and seasonal pans present throughout the area, and is considered to be bio-regionally outstanding with a conservation status of Endangered (Nel et al., 2004; Darwall et al., 2009).

3.5.2 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as ‘FEPAs’) to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa’s freshwater biodiversity within the context of equitable social and economic development. The second aim is comprised of two separate components: the (i) national component aimed to align DWA (or currently the DWS) and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems, while the (ii) sub-national component is aimed to use three case studies to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes. The project further aimed to maximise synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation (Driver *et al.*, 2011).

The spatial layers (FEPA's) include the nationally delineated wetland areas that are classified into hydrogeomorphic (HGM) units, which have been ranked in terms of their biodiversity importance. Whilst being an invaluable tool, it is important to note that the NFEPA's were delineated and studied at a desktop and low-resolution level. The NFEPA assessment does, however, hold significance from a national perspective. These layers were assessed to evaluate the importance of the wetland areas located within the study area (Table 3-2).

Table 3-2: NFEPA Wetland Classification Ranking Criteria

Criteria	Rank
Wetlands that intersect with a RAMSAR site.	1
▪ Wetlands within 500 m of an IUCN threatened frog point locality; ▪ Wetlands within 500 m of a threatened water-bird point locality; ▪ Wetlands (excluding dams) with the majority of their area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes; ▪ Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of exceptional Biodiversity importance, with valid reasons documented; and ▪ Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands that are good, intact examples from which to choose.	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of biodiversity importance, but with no valid reasons documented.	3
Wetlands (excluding dams) in A or B condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion); and Wetlands in C condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion).	4
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing Impacted Working for Wetland sites.	5
Any other wetland (excluding dams).	6

The assessor considered the strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable use of water resources contained therein to evaluate the importance of the wetland areas (Nel *et al.* 2011, Figure 3-3). The wetland types that dominate the landscape are floodplains, channelled valley bottoms and unchannelled valley bottoms associated with the Leeuspruit and Rietspruit. Wetlands within the area are ranked 5 or 6.

3.6 Mining and Biodiversity Guideline

The Mining and Biodiversity Guideline (2013) can be seen as a cumulative finding of all available biodiversity and ecological related information with a final mapped area. The assessment looks at NFEPA and regional biodiversity plans such as the Free State Biodiversity Plan. This is shown in Figure 3-4 below.

Most of the area impacted by the surface mitigation measures are unclassified by the Mining and Biodiversity Guidelines. However, there are small pockets within Leeuspruit Section 3 that are classified as 'Moderate Risk for Mining'.

3.7 Free State Biodiversity Plan

The Free State Biodiversity Plan (2015) is a spatial tool that forms part of the national biodiversity planning tools and initiatives that are provided for in national legislation and policy. The Free State Biodiversity Plan was published in 2015, and like those of the other provinces, identifies and maps the protected areas, Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) to aid management guidelines for the Free State. Currently there is only a terrestrial component for the plan; however, the aquatic component is expected in 2018.

Most of the area impacted by mitigation measures are classified by the Free State Biodiversity Plan as degraded. However, there are small pockets within Leeuspruit Section 4 which are classified as 'ESA 2'. Leeuspruit Section 5 has large areas classified as 'ESA 2' as well as 'ESA 1. Rietspruit Section 1 is closely bordered by 'CBA 2'. This will need to be updated, once the aquatic component is published.

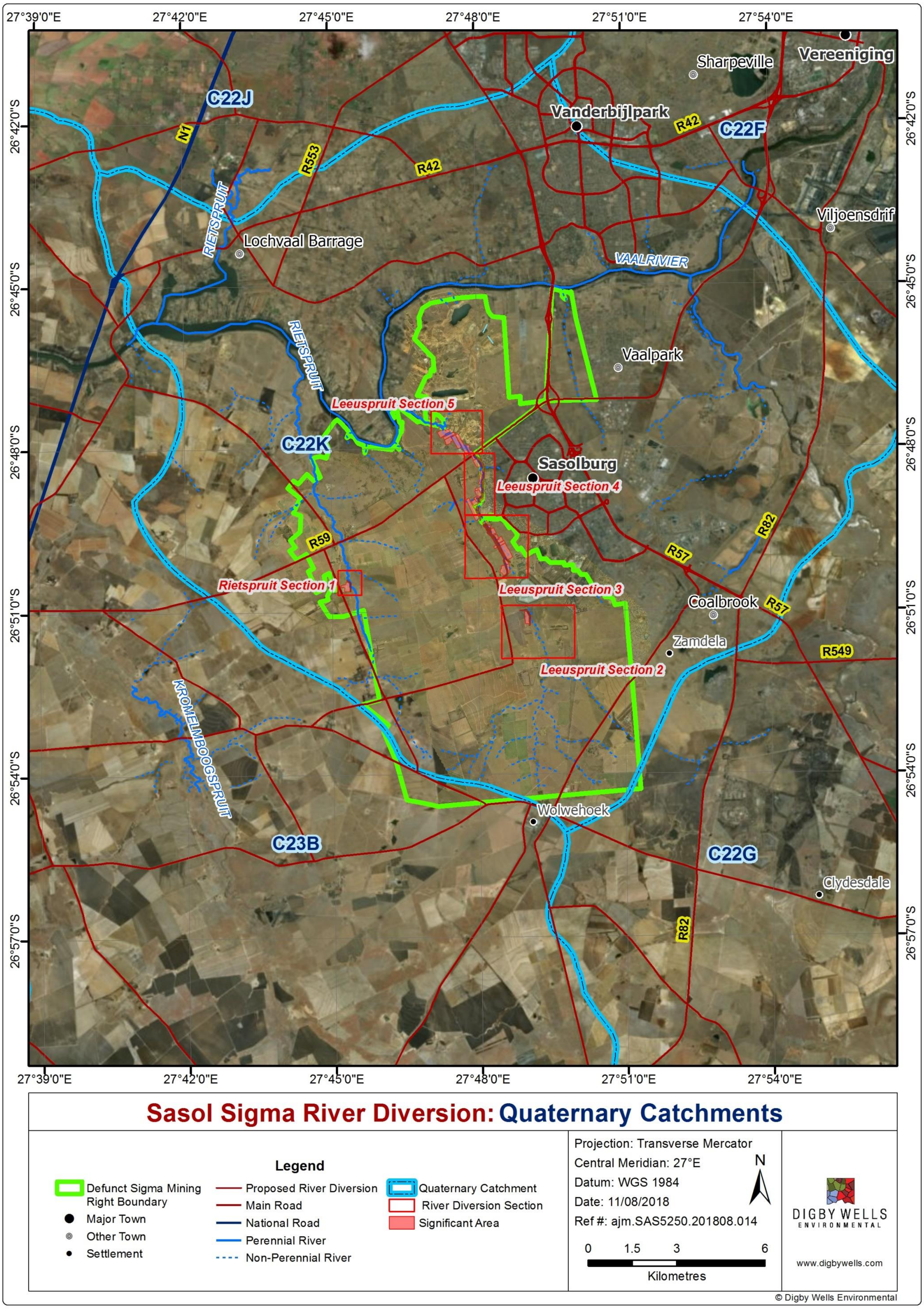

Figure 3-1: Quaternary Catchments

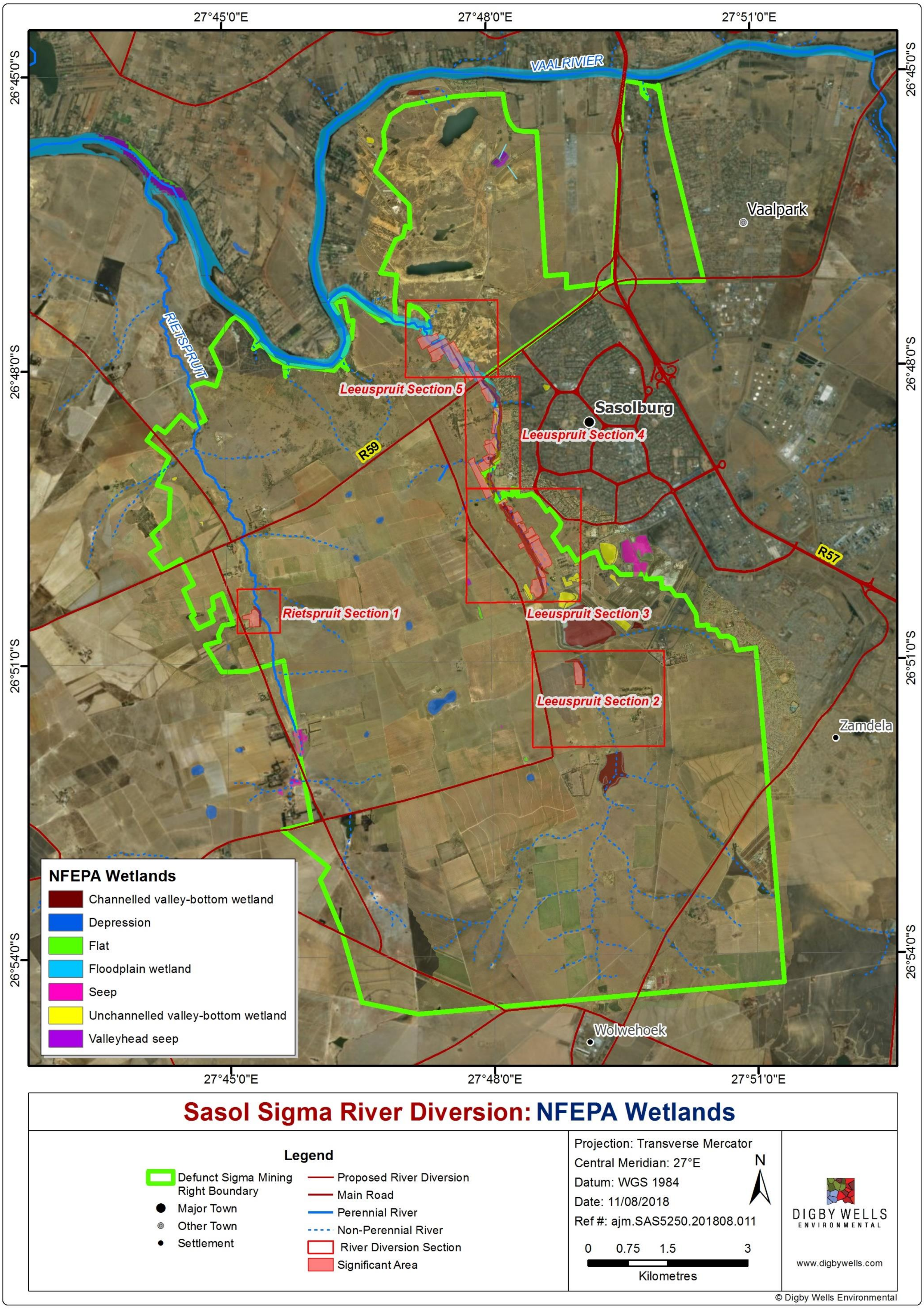

Figure 3-2: NFEPA catchments, FEPA-identified wetland systems and associated wetland clusters

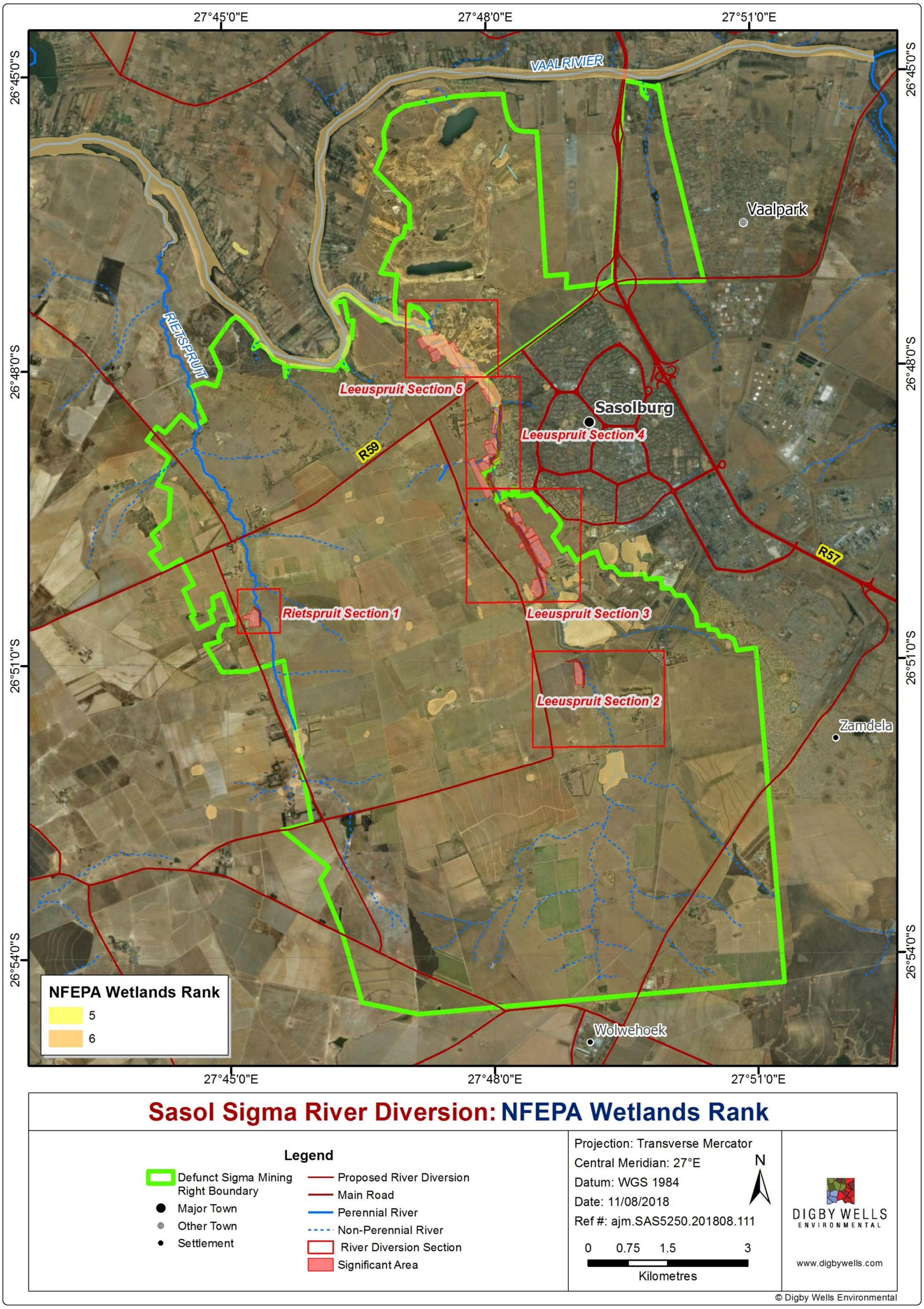

Figure 3-3: NFEPA wetlands, as classified according to biodiversity importance

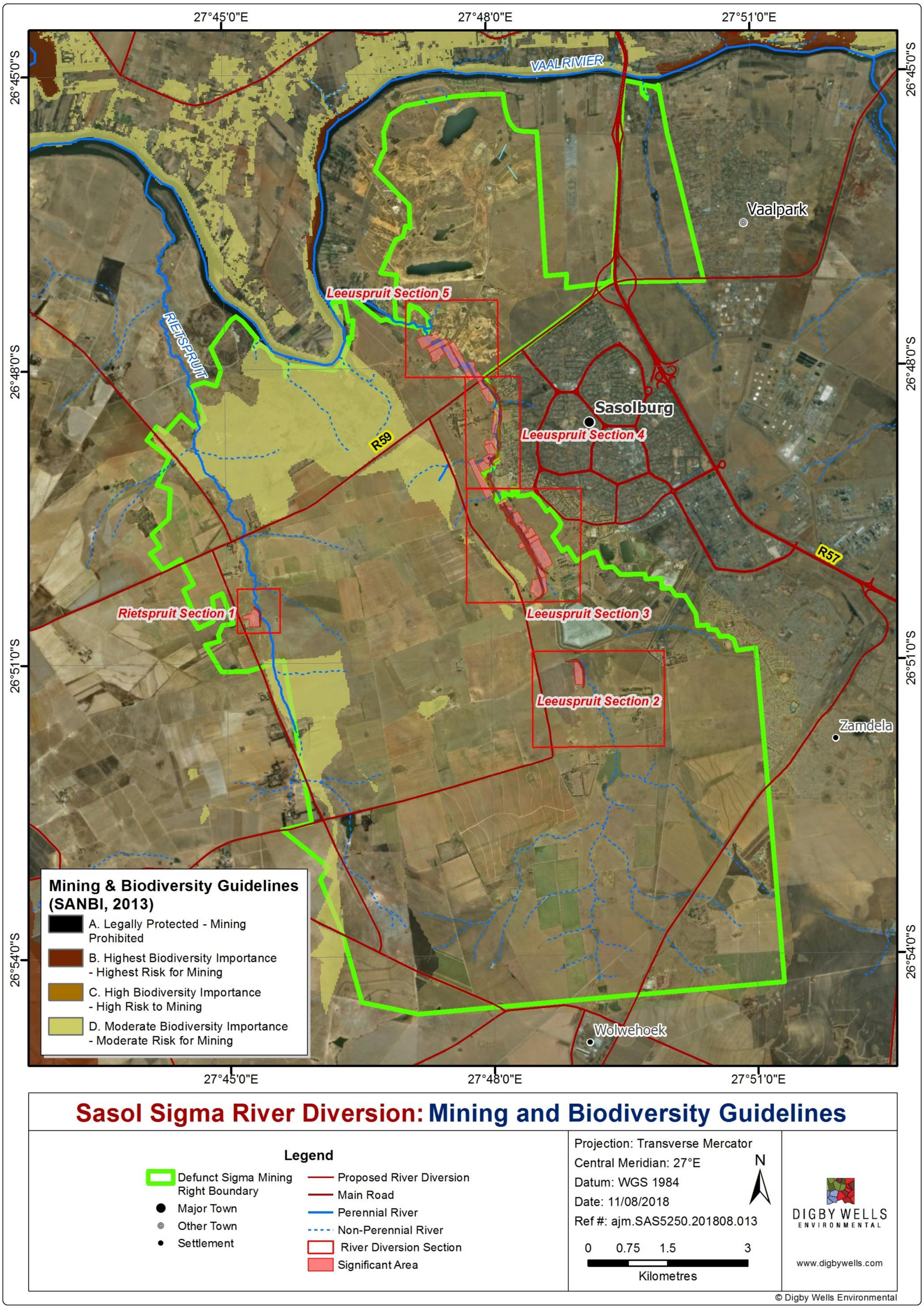

Figure 3-4: Mining and Biodiversity Guideline

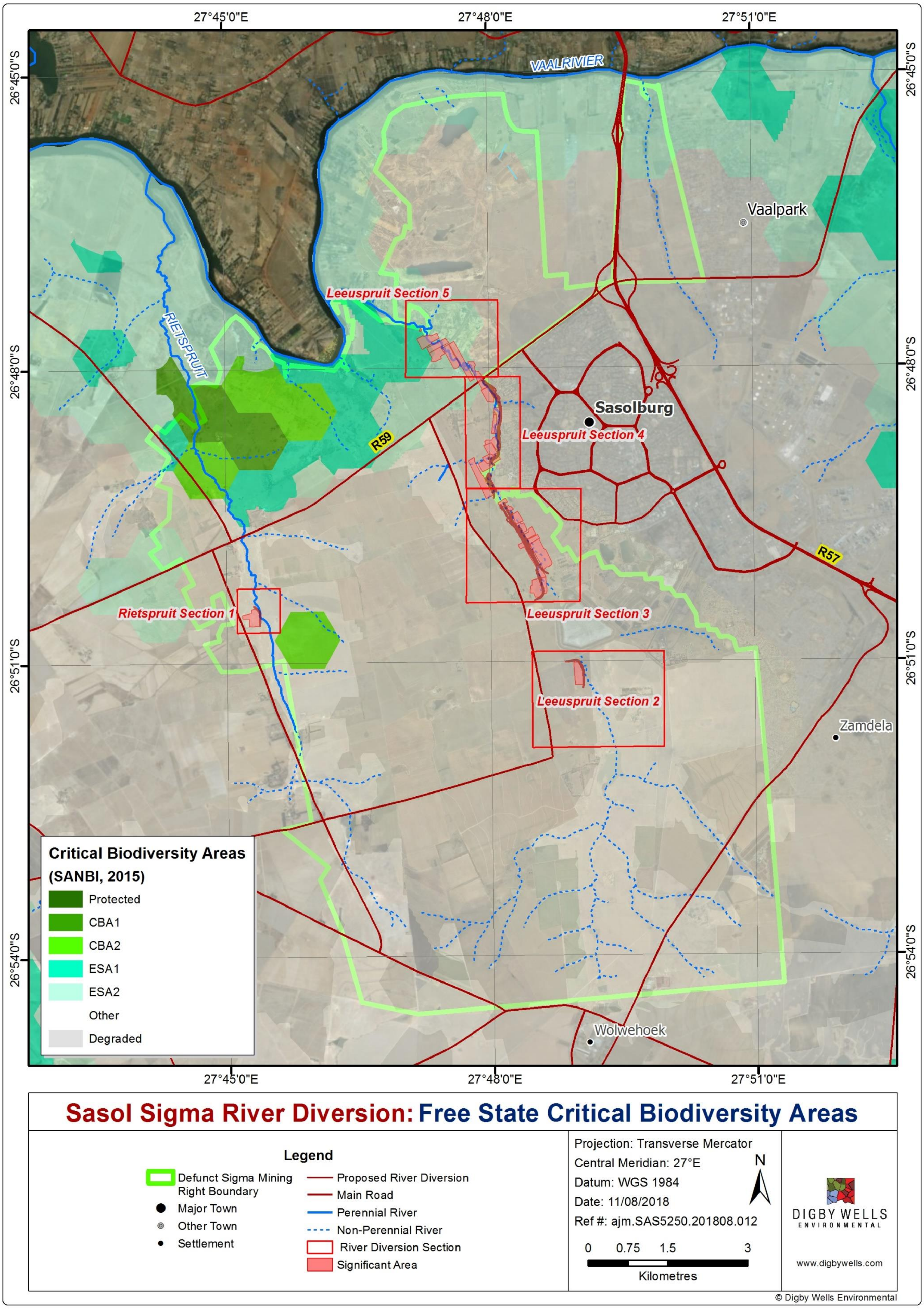

Figure 3-5: Free State Biodiversity Plan (2015)

4 Methodology

4.1 Wetland Approach

The following sections describe the methodology that was adopted during the field assessment and associated report that was conducted in 2016. The impact assessment in this report was conducted based on the information compiled in 2016 by Digby Wells, and updated by Wetland Consulting Services (WCS) in 2017.

4.1.1 The Wetland Identification and Classification

In accordance with DWAF guidelines (now Department of Water and Sanitation (DWS) (2005), wetlands are identified and classified into various Hydro-geomorphic (HGM) Units based on their individual characteristics. The HGM Unit system of classification focuses on the hydro-geomorphic setting of wetlands which incorporates geomorphology; water movement into, through and out of the wetland; and landscape / topographic setting. Once wetlands have been identified, they are categorised into HGM Units as shown in Table 4-1.

Table 4-1: Description of the various HGM Units for Wetland Classification

Hydromorphic wetland type	Diagram	Description
Floodplain		Valley bottom areas with a well-defined stream channel stream channel, gently sloped and characterised by floodplain features such as oxbow depression and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by the net loss of sediment. Water inputs from the main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and from adjacent slopes.
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.

Hydromorphic wetland type	Diagram	Description
Isolated hillslope seepage		Slopes on hillsides that are characterised by colluvial transport (transported by gravity) movement of materials. Water inputs are from sub-surface flow and outflow either very limited or through diffuse sub-surface flow but with no direct link to a surface water channel.
Pan/Depression		A basin-shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. It is inward draining). It may also receive subsurface water. An outlet is usually absent and so this type of wetland is usually isolated from the stream network.

4.1.1.1 Soil Form Indicator

Hydromorphic soils are taken into account for the Soil Form Indicator (SFI) which will display unique characteristics resulting from prolonged and repeated water saturation (DWAF, 2005). The continued saturation of the soils results in the soils becoming anaerobic and thus resulting in a change of the chemical characteristics of the soil. Iron and manganese are two soil components which are insoluble under aerobic conditions and become soluble when the soil becomes anaerobic and thus begin to leach out into the soil profile. Iron is one of the most abundant elements in soils and is responsible for the red and brown colours of many soils.

Resulting from the prolonged anaerobic conditions, iron is dissolved out of the soil, and the soil matrix is left a greying, greenish or bluish colour, and is said to be “gleyed”. Common in wetlands which are seasonally or temporarily saturated is a fluctuating water table, resulting in alternation between aerobic and anaerobic conditions in the soil (DWAF, 2005). Iron will return to an insoluble state in aerobic conditions which will result in deposits in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated (DWAF, 2005).

4.1.1.2 Soil Wetness Indicator

In practice, the Soil Wetness Indictor (SWI) is used as the primary indicator (DWAF, 2005). Hydromorphic soils are often identified by the colours of various soil components. The frequency and duration of the soil saturation periods strongly influences the colours of these components. Grey colours become more prominent in the soil matrix the higher the duration and frequency of saturation in a soil profile (DWAF, 2005). A feature of hydromorphic soils are coloured mottles which are usually absent in permanently saturated soils and are most prominent in seasonally saturated soils, and are less abundant in temporarily saturated soils (DWAF, 2005). The hydromorphic soils must display signs of wetness within 50cm of the soil surface, as this is necessary to support hydrophytic vegetation.

4.1.1.3 Vegetation Indicator

Plant communities undergo distinct changes in species composition along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas. Valuable information for determining the wetland boundary and wetness zone is derived from the change in species composition. A supplementary method for employing vegetation as an indicator is to use the broad classification of the wetland plants according to their occurrence in the wetlands and wetness zones (Kotze and Marneweck, 1999; DWAF, 2005). This is summarised in Table 4-2 below. When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWAF, 2005). Areas where soils are a poor indicator (black clay, vertic soils), vegetation (as well as topographical setting) is relied on to a greater extent and the use of the wetland species classification as per Table 4-2 becomes more important. If vegetation was to be used as a primary indicator, undisturbed conditions and expert knowledge are required (DWAF, 2005). Due to this uncertainty, greater emphasis is often placed on the SWI to delineate wetland areas. In this assessment, where possible, the SWI has been relied upon to delineate wetland areas due to the high level of anthropogenic impacts characterising the wetlands and freshwater resources of the general area. The identification of indicator vegetation species and the use of plant community structures have been used to validate these boundaries.

Table 4-2: Classification of Plant Species According to Occurrence in Wetlands

Type	Description
Obligate Wetland species (OW)	Almost always grow in wetlands: >99% of occurrences.
Facultative Wetland species (FW)	Usually grow in wetlands but occasionally are found in non-wetland areas: 67 – 99 % of occurrences.
Facultative species (F)	Are equally likely to grow in wetlands and non-wetland areas: 34 – 66% of occurrences.
Facultative dry-land species (FD)	Usually grow in non-wetland areas but sometimes grow in wetlands: 1 – 34% of occurrences.

(Source: DWAF, 2005)

4.1.2 Wetland Ecological Health Assessment (WET-Health)

According to Macfarlane *et al*. (2009) the health of a wetland can be defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. A level 1 WET-Health assessment was done on the wetlands in accordance with the method described by Kotze *et al.* (2007) to determine the integrity (health) of the characterised HGM units for the Project area. Level 1 was selected due to the large size of the Project area as well as due to the restricted site access, and in turn, limited in-field verification. A Present Ecological State (PES) analysis was conducted to establish baseline integrity (health) for the associated wetlands. The health assessment attempts to evaluate the hydrological, geomorphological and vegetation health in three separate modules to attempt to estimate similarity to or deviation from natural conditions.

Central to WET-Health is the characterisation of HGM Units, which have been defined based on geomorphic setting (e.g. hillslope or valley-bottom; whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated) and pattern of water flow through the wetland unit (diffusely or channelled) as described above.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. This takes the form of assessing the spatial *extent* of the impact of individual activities and then separately assessing the *intensity* of the impact of each activity in the affected area. The extent and intensity are then combined to determine an overall *magnitude* of impact. The impact scores and Present State categories are provided in Table 4-3.

Table 4-3: Impact Scores and Present Ecological State Categories used by WET-Health

Impact Category	Description	Combined Impact Score	PES Category
None	Unmodified, natural.	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota has taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.	6-7.9	E
Critical	Modifications have reached a critical level and ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

As is the case with the Present State, future threats to the state of the wetland may arise from activities in the catchment upstream of the unit or within the wetland itself or from processes downstream of the wetland. In each of the individual sections for hydrology, geomorphology and vegetation, five potential situations exist depending upon the direction and likely extent of change (Table 4-4).

Table 4-4: Trajectory of Change classes and scores used to evaluate likely future changes to the present state of the wetland

Change Class	Description	HGM change score	Symbol
Substantial improvement	State is likely to improve substantially over the next 5 years	2	↑↑
Slight improvement	State is likely to improve slightly over the next 5 years	1	↑
Remain stable	State is likely to remain stable over the next 5 years	0	→
Slight deterioration	State is likely to deteriorate slightly over the next 5 years	-1	↓
Substantial deterioration	State is expected to deteriorate substantially over the next 5 years	-2	↓↓

Once all HGM Units have been assessed, a summary of health for the wetland needs to be calculated. This is achieved by calculating a combined score for each component by area-weighting the scores calculated for each HGM Unit. Recording the health assessments for the hydrology, geomorphology and vegetation components provide a summary of impacts, Present State, Trajectory of Change and Health for individual HGM Units and for the entire wetland.

4.1.3 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) tool was derived to assess the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The purpose of assessing importance and sensitivity of water resources is to be able to identify those systems that provide higher than average ecosystem services, biodiversity support functions or are especially sensitive to impacts. Water resources with higher ecological importance may require managing such water resources in a better condition than the present to ensure the continued provision of ecosystem benefits in the long term. The methodology outlined by DWAF (1999) and updated in Rountree and Kotze, (2012), in Rountree *et al.* (2012) was used for this study

In this method there are three suites of importance criteria; namely:

- **Ecological Importance and Sensitivity:** incorporating the traditionally examined criteria used in EIS assessments of other water resources by DWS and thus enabling consistent assessment approaches across water resource types;

- **Hydro-functional Importance:** which considers water quality, flood attenuation and sediment trapping ecosystem services that the wetland may provide; and
- **Importance in terms of Basic Human Benefits:** this suite of criteria considers the subsistence uses and cultural benefits of the wetland system.

These determinants are assessed for the wetlands on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. It is recommended that the highest of these three suites of scores be used to determine the overall Importance and Sensitivity category of the wetland system, as defined in Table 4-5.

Table 4-5: Interpretation of Overall EIS Scores for Biotic and Habitat Determinants

Ecological Importance and Sensitivity Category (EIS)	Range of Median
Very high Systems that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4
High Systems that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Systems that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2
Low/marginal Systems that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1

4.2 Aquatic Ecology Assessment Approach

To enable an adequate description and the determination of the Present Ecological State (or Ecological Category) associated with the surrounding watercourses, it was envisaged that the following indicators be evaluated as part of the study:

- Stressor Indicators:
  - *In situ* water quality (Temperature, pH, Electrical Conductivity, and Dissolved Oxygen);

- Habitat Indicators:
  - Adapted Invertebrate Habitat Assessment System (IHAS, Version 2.2).
- Response Indicators:
  - Aquatic macroinvertebrates with the use of the South African Scoring System (SASS, Version 5) rapid bio-assessment protocol and the Macro-Invertebrate Response Assessment Index (MIRAI, Version 2);
  - Fish assemblages were assessed making use of the Fish Response Assessment Index (FRAI).

4.2.1 Water Quality Parameters

Selected *in situ* water quality variables were measured at each of the selected sampling sites using a water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter. Temperature, pH and electrical conductivity were recorded prior to sampling, while the time of day at which the measurements were assessed was also noted for interpretation purposes.

4.2.2 Invertebrate Habitat Assessment System (IHAS), Version 2.2

Assessment of the available habitat for aquatic macroinvertebrate colonisation at each of the sampling sites is vital for the correct interpretation of results obtained following biological assessments. It should be noted that the available methods for determining habitat quality are not specific to rapid biomonitoring assessments and are inherently too variable in their approach to achieve consistency amongst users.

Nevertheless, the Invertebrate Habitat Assessment System (IHAS) has routinely been used in conjunction with the South African Scoring System version 5 (SASS5) as a measure of the variability of aquatic macroinvertebrate biotopes available at the time of the survey (McMillan, 1998). The scoring system was traditionally split into two sections, namely the sampling habitat (comprising 55% of the total score) and the general stream characteristics (comprising 45% of the total score), which were summed together to provide a percentage and then categorized according to the values in Table 4-6.

However, the lack of reliability and evidence of notable variability within the application of the IHAS method has prompted further field validation and testing, which implies a cautious interpretation of results obtained until these studies have been conducted (Ollis *et al.*, 2006). In the interim and for this assessment, the IHAS method was adapted by excluding the assessment of the *general stream characteristics*, which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned table.

Table 4-6: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat

IHAS Score (%)	Description
>75	Excellent
65-74	Good
55-64	Adequate / Fair
<55	Poor

4.2.3 South African Scoring System, Version 5 (SASS5)

While there are many indicator organisms that are used within these assessment indices, there is a consensus that benthic macroinvertebrates are amongst the most sensitive components of the aquatic ecosystem. This was further supported by their largely non-mobile (or limited mobility) within reaches of associated watercourses, which also allows for the spatial analysis of disturbances potentially present within the adjacent catchment area. However, it should also be noted that their heterogeneous distribution within the water resource is a major limitation, as this results in spatial and temporal variability within the collected macroinvertebrate assemblages (Dallas and Day, 2004).

SASS5 is essentially a biological assessment index which determines the health of a river based on the aquatic macroinvertebrates collected on-site, whereby each taxon is allocated a score based on its perceived sensitivity/tolerance to environmental perturbations (Dallas, 1997). However, the method relies on a standardised sampling technique using a handheld net (300 mm x 300 mm, 1000-micron mesh size) within each of the various habitats available for standardised sampling times and/or areas. Niche habitats (or biotopes) sampled during SASS5 application include:

- Stones (both in-current and out-of-current);
- Vegetation (both aquatic and marginal); and
- Gravel, sand and mud.

Once collection is complete, aquatic macroinvertebrates are identified to family level and many assemblage-specific parameters are calculated including the total SASS5 score, the number of taxa collected, and the Average Score per Taxa i.e. SASS5 score divided by the total number of taxa identified (Thirion, Mocke and Woest, 1995; Davies and Day, 1998; Dickens and Graham, 2002; Gerber and Gabriel, 2002). The SASS bio-assessment index has been proven to be an effective and efficient means to assess water quality impairment and general river health (Dallas, 1997; Chutter, 1998).

4.2.4 Macroinvertebrate Response Assessment Index (MIRAI)

To determine the Present Ecological State (PES; or Ecological Category) of the aquatic macroinvertebrates collected/observed, the SASS5 data is used as a basic input (i.e. prevalence and abundance) into the recently improved MIRAI (Version 2, Thirion. C., *pers. comm.* 2015). This biological index integrates the ecological requirements of the macroinvertebrate taxa in a community (or assemblage) and their response to flow modification, habitat change, water quality impairment and/or seasonality (Thirion, 2008). The presence and abundance of aquatic macroinvertebrates are compared to a derived list of families/taxa that are expected to be present under natural, un-impacted conditions. Consequently, the aforementioned metric groups were combined within the model to derive the ecological condition of the site in terms of aquatic macroinvertebrates (Table 4-7).

Table 4-7: Allocation protocol for the determination of the Present Ecological State for aquatic macroinvertebrates following application of the MIRAI

MIRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function are less than the reference condition. Community composition is lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

4.2.5 Fish Response Assessment Index (FRAI)

The FRAI (Kleynhans, 2007) is based on the premise that “drivers” (environmental conditions) may cause fish stress which shall then manifest as changes in fish species assemblage. The index employs preferences and intolerances of the reference fish assemblage, as well as the response of the actual (present) fish assemblage to particular drivers to indicate a change from reference conditions. Intolerances and preferences are divided into metric groups relating to preferences and requirements of individual species.

This allows cause-effect relationships to be understood, i.e. between drivers and responses of the fish assemblage to changes in drivers. These metric groups are subsequently ranked, rated and finally integrated as a fish Ecological Category (EC) (Table 4-8 and Figure 4-1).

Table 4-8: Classification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural.
B	Largely natural, with few modifications.
C	Moderately modified.
D	Largely modified.
E	Extensively modified.
F	Critically modified.

(Source: Kleynhans, 1999)

Figure 4-1: Ecological categories (EC) eco-status A to F continuum approach employed

The fish community of each site was sampled for a period of 15 minutes by means of a battery operated electro-fishing device. Fish species identified were compared to those expected to be present at the site, which were compiled from a literature survey including Skelton (2001) and Kleynhans (2007).

Fish expected to occur in the system is summarised in Table 4-9. Comparisons between upstream and downstream points were made where applicable.

Table 4-9: Intolerance ratings for naturally occurring fish species expected to occur in the area

Species Name	Common Name	Intolerance Rating	Comments
Enteromius anoplus	Chubbyhead Barb	2.6	Widespread in Southern Africa.
Enteromius paludinosus	Straightfin Barb	1.8	Widespread in Southern Africa.
*Austroglanis sclateri**	Rock Catfish	2.7	Vaal-Orange System.
*Labeobarbus kimberleyensis**	Vaal-Orange Largemouth Yellowfish	3.6	Vaal-Orange System.

Species Name	Common Name	Intolerance Rating	Comments
Labeobarbus aeneus	Vaal-Orange Smallmouth Yellowfish	2.5	Vaal-Orange System.
Labeo umbratus	Moggel	2.3	Vaal-Orange System.
Labeo capensis	Orange River Mudfish	3.2	Vaal-Orange System.
Cyprinus carpio	Carp	1.4	Widespread introduced species
Clarias gariepinus	Sharptooth Catfish	1.2	Widespread.
Micropterus salmoides	Largemouth Bass	2.2	Widespread introduced species
Tilapia sparrmanii	Banded Tilapia	1.4	Widespread
Pseudocrenilabrus philander	Southern Mouthbrooder	1.3	Widespread.
Gambusia affinis	Mosquitofish	2.0	Scattered isolated populations throughout Southern Africa. Alien.

Physico-chemical intolerances: Tolerant: 1-2 Moderately tolerant :> 2-3 Moderately Intolerant: >3-4 Intolerant: >4

(Source: Skelton, 2001; Kleynhans, 2007)

* Species prefer deeper systems and thus may only be applicable to Site SDR11.

** Alien species expected to occur at the site, however, these have been accounted for on application of the FRAI.

4.3 Impact Assessment Methodology

Impacts and risks have been identified based on a description of the activities to be undertaken. Once impacts have been identified, a numerical environmental significance rating process will be undertaken that utilises the probability of an event occurring and the severity of the impact as factors to determine the significance of a particular environmental impact.

The severity of an impact is determined by taking the spatial extent, the duration and the severity of the impacts into consideration. The probability of an impact is then determined by the frequency at which the activity takes place or is likely to take place and by how often the type of impact in question has taken place in similar circumstances.

Following the identification and significance ratings of potential impacts, mitigation and management measures will be incorporated into the Environmental Management Programme (EMP).

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = CONSEQUENCE X PROBABILITY X NATURE

Where

Consequence = intensity + extent + duration

And

Probability = likelihood of an impact occurring

And

Nature = positive (+1) or negative (-1) impact

The matrix calculates the rating out of 147, whereby intensity, extent, duration and probability are each rated out of seven as indicated in Table 4-11. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation has been applied; post-mitigation is referred to as the residual impact. The significance of an impact is determined and categorised into one of seven categories (The descriptions of the significance ratings are presented in Table 4-12).

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, (i.e., there may already be some mitigation included in the engineering design). If the specialist determines the potential impact is still too high, additional mitigation measures are proposed.

Table 4-10: Impact Assessment Parameter Ratings

Rating	Intensity/ Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or **highly** sensitive environments. Irreplaceable damage to **highly sensitive** cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or **moderate to highly** sensitive environments. Irreplaceable damage to cultural/social resources of **moderate to highly** sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur.>65 but <80% probability.

Rating	Intensity/ Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss and/or damage to physical or biological resources or **highly** sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or **moderately** sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/ Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
3	Moderate loss and/or damage to biological or physical resources of **low to moderately** sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	<u>Local</u> Local including the site and its immediat surrounding area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	**Minor loss and/or effects** to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	<u>Limited</u> Limited extending only as far as the development site area.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low because of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/ Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	**Minimal to no loss** and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 4-11: Probability/Consequence Matrix

Significance																																					
-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Consequence

Table 4-12: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

5 Results and Discussion

5.1 Wetland Assessment

A wetland assessment was completed in 2016. For the detailed report, please see Appendix A. An update by WCS was made in 2017. Furthermore, a site visit was conducted on the 23rd and 24th of July 2018 to determine the impacts that the proposed project will have on the existing wetland systems.

This report provides a consolidation of the aforementioned assessments.

5.1.1 Leeuspruit Section 2

Leeuspruit Section 2 consists of 44.2 ha of floodplain wetland, where the berm will be located, and a small portion of seep which will remain unaffected by the proposed project. (Figure 5-2).

Impacts to the system include the dam upstream, the Fine Ash Dam (FAD), various road crossings and invasive species (see Figure 5-1 illustrating habitat), which have impacted on the health and functioning of the wetland. The PES and EIS of Section 2 are considered largely modified (D) and ‘moderate’, respectively (see Figure 5-3 for PES and Figure 5-4 for EIS).

Figure 5-1: Leeuspruit Section 2 wetland habitat

(A and B: Habitat adjacent to the FAD; C: Secondary channel; D: Main channel; E: culvert; F: *Azolla filiculoides*, an invasive species, can be seen as a red mat covering the water's surface)

5.1.1.1 Leeuspruit Section 2 Geomorphology

This section of the stream is impounded by a road with non- or limited culverts or piping (Figure 5-2) and then flows into the existing river diversion around the FAD. From a biogeomorphology point of view it forms an important wader area. The proposed berm will offset the permanently inundated section of the wetland to the south east but the habitat will remain.

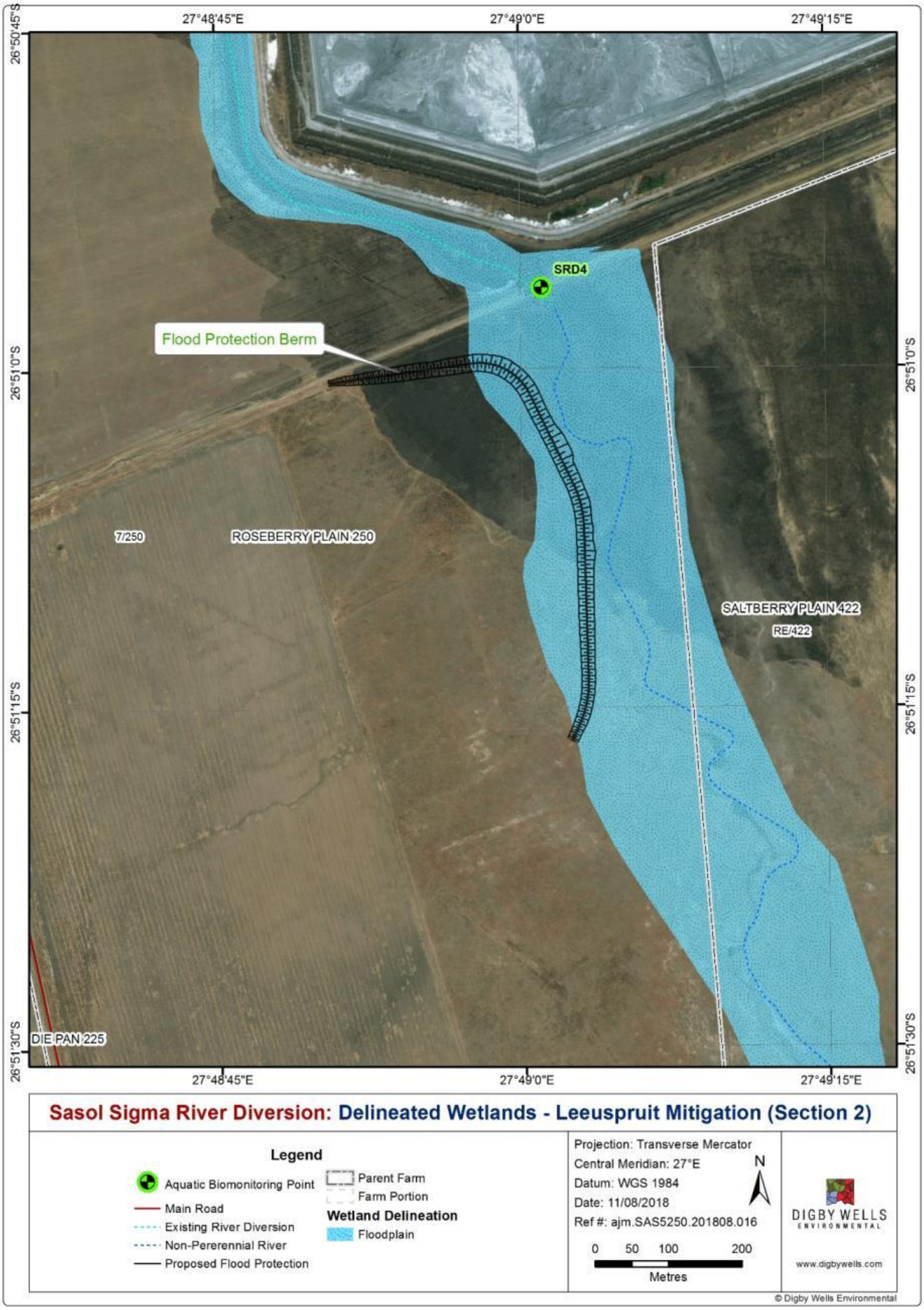

Figure 5-2: Leeuspruit Section 2 HGM units

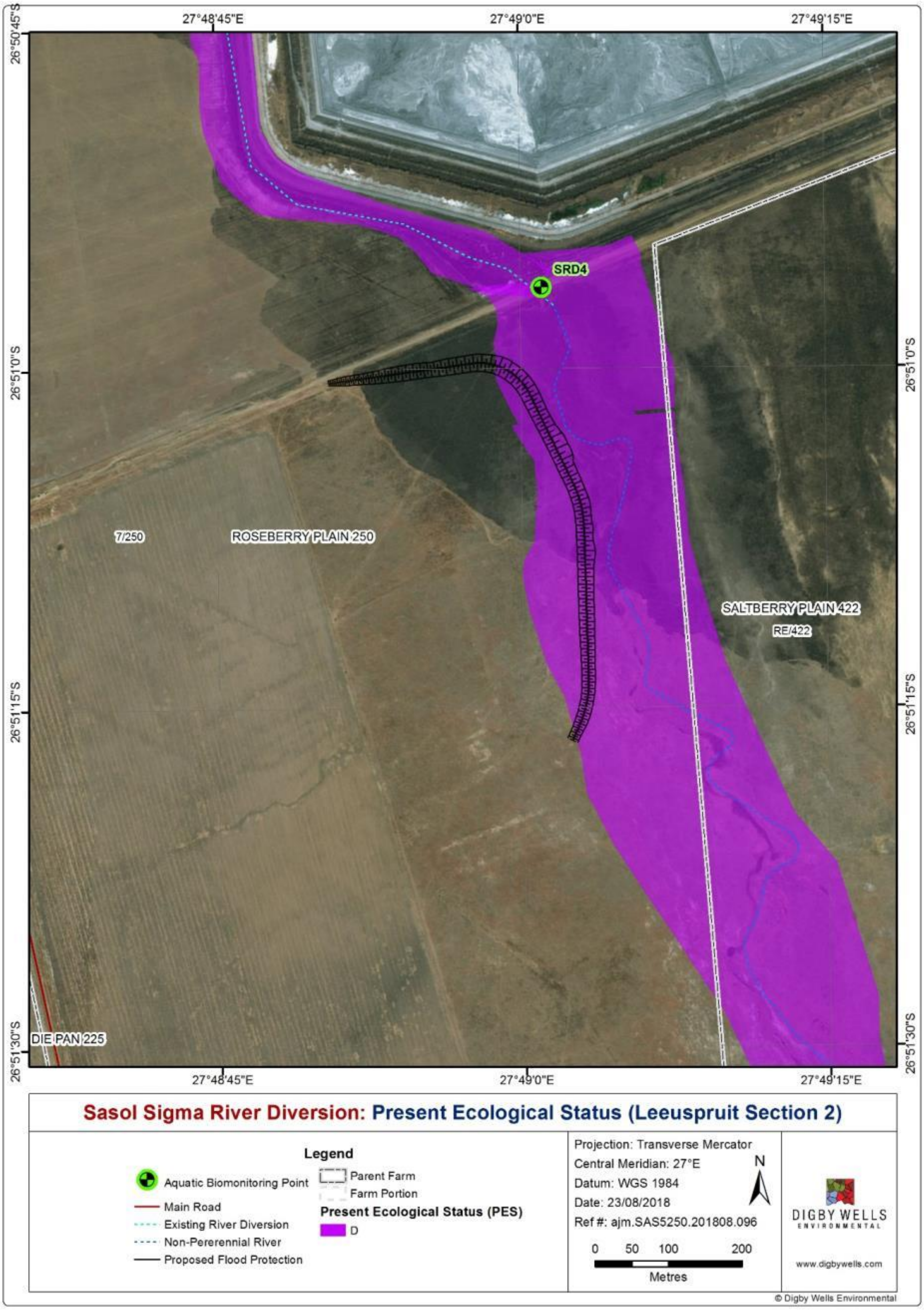

Figure 5-3: Leeuspruit Section 2 PES

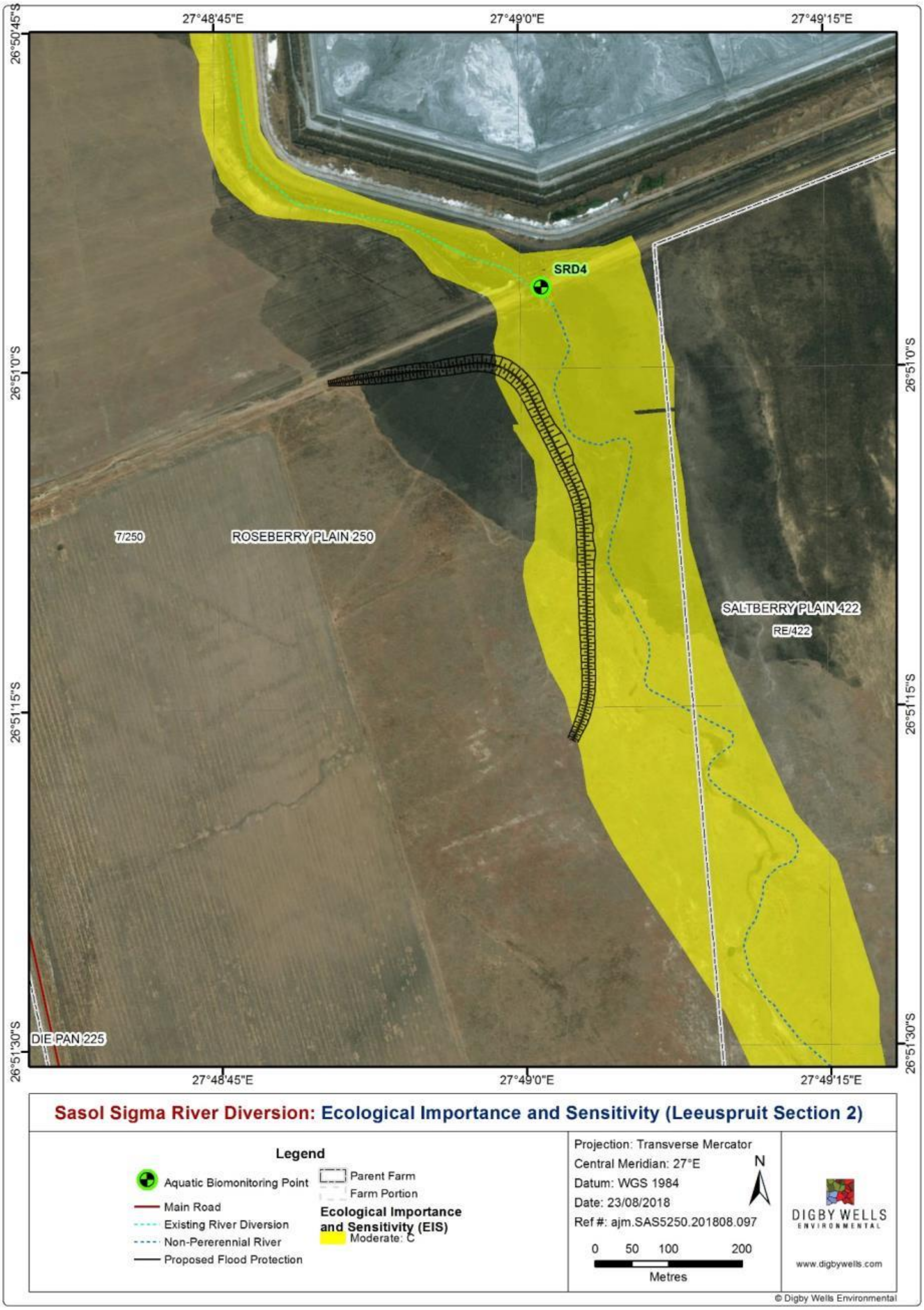

Figure 5-4: Leeuspruit Section 2 EIS

5.1.2 Leeuspruit Section 3

Leeuspruit Section 3 consists of floodplain predominantly (24.8 ha), however there are also channelled valley bottoms, hillslope seeps and artificial wetlands present (see Figure 5-6).

The impacts to the systems include subsidence, which has already occurred, various road crossings, berms, pipeline crossings, stormwater entry points and infrastructure associated with a school, which have impacted the floodplain wetland to a large extent (Figure 5-5). The PES and EIS of Section 3 are considered largely modified (D) and ‘moderate’ respectively (see Figure 5-7 for PES and Figure 5-8 for EIS). It is important to note that a large patch of *Kniphofia* species was observed to the north of Section 3. The individuals on site could not be identified to species level as it was not the flowering season, however, it is important that this area (identified in the Impact Assessment) be considered a no-go area and warrants further investigation as some Kniphofia species are classified as Critically Endangered (Species listed in terms of section 56(1)(a)).

Figure 5-5: Leeuspruit Section 3 wetland habitat

(A: Road crossing; B: *Kniphofia* species in abundance near the school field; C: *Azolla filiculoides* (an invasive species) covering open water; D: Stormwater entering the wetland; E: A pipeline crossing the wetland; F: Powerline servitude within the wetland)

5.1.2.1 Leeuspruit Section 3 Geomorphology

This floodplain has features that resemble oxbows in functionality and may have formed secondary channels at times. The driver in the area is the andesite outcropping to the east (south of the school) in conjunction with subsidence.

Below the outcrop, artificial systems have formed, driven by subsidence and fed by urban stormwater pipe outlets (Figure 5-9D).

This area has also formed habitats for Kniphofia plant species to be protected by a no-go zone referred to above.

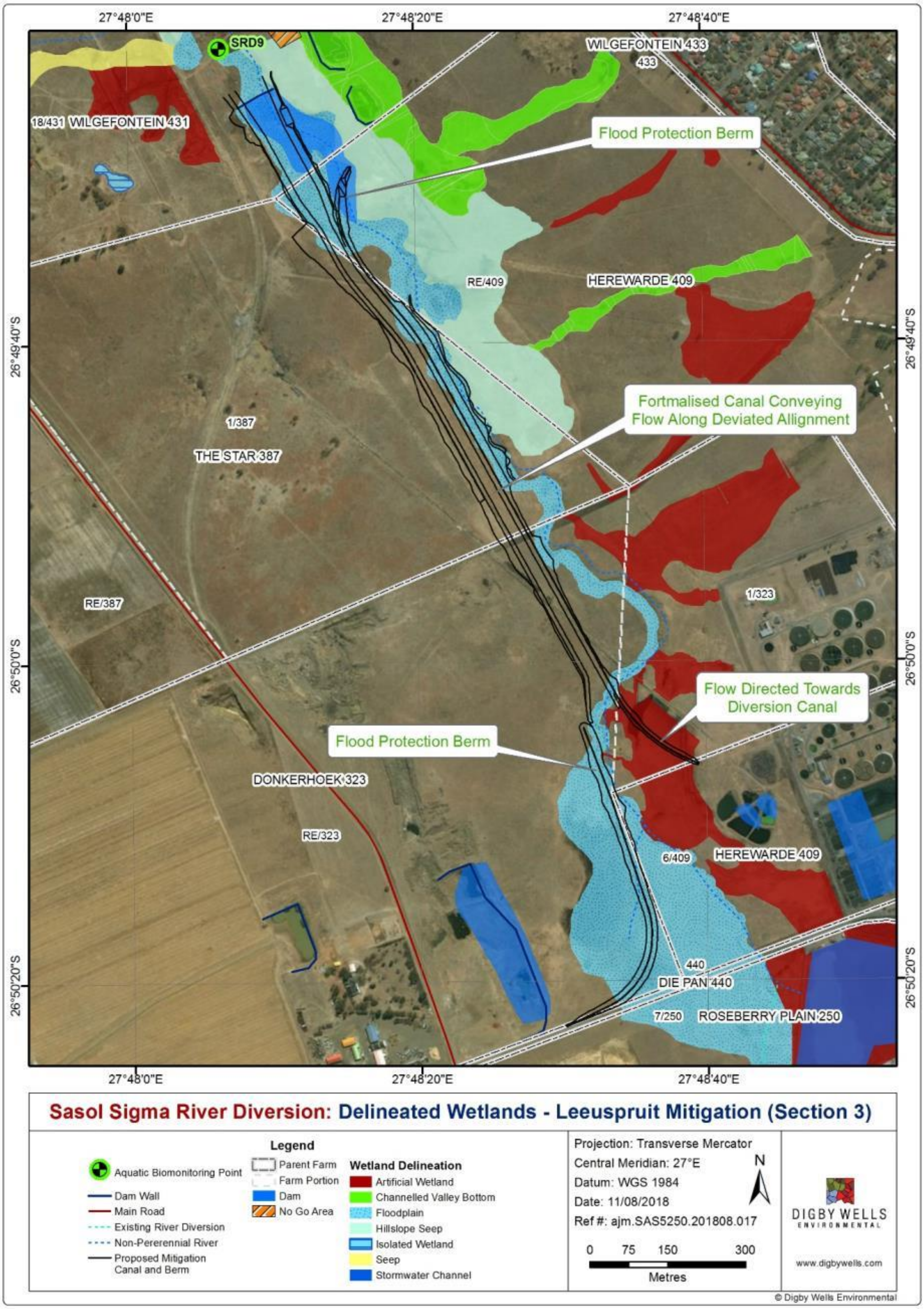

Figure 5-6: Leeuspruit Section 3 HGM units

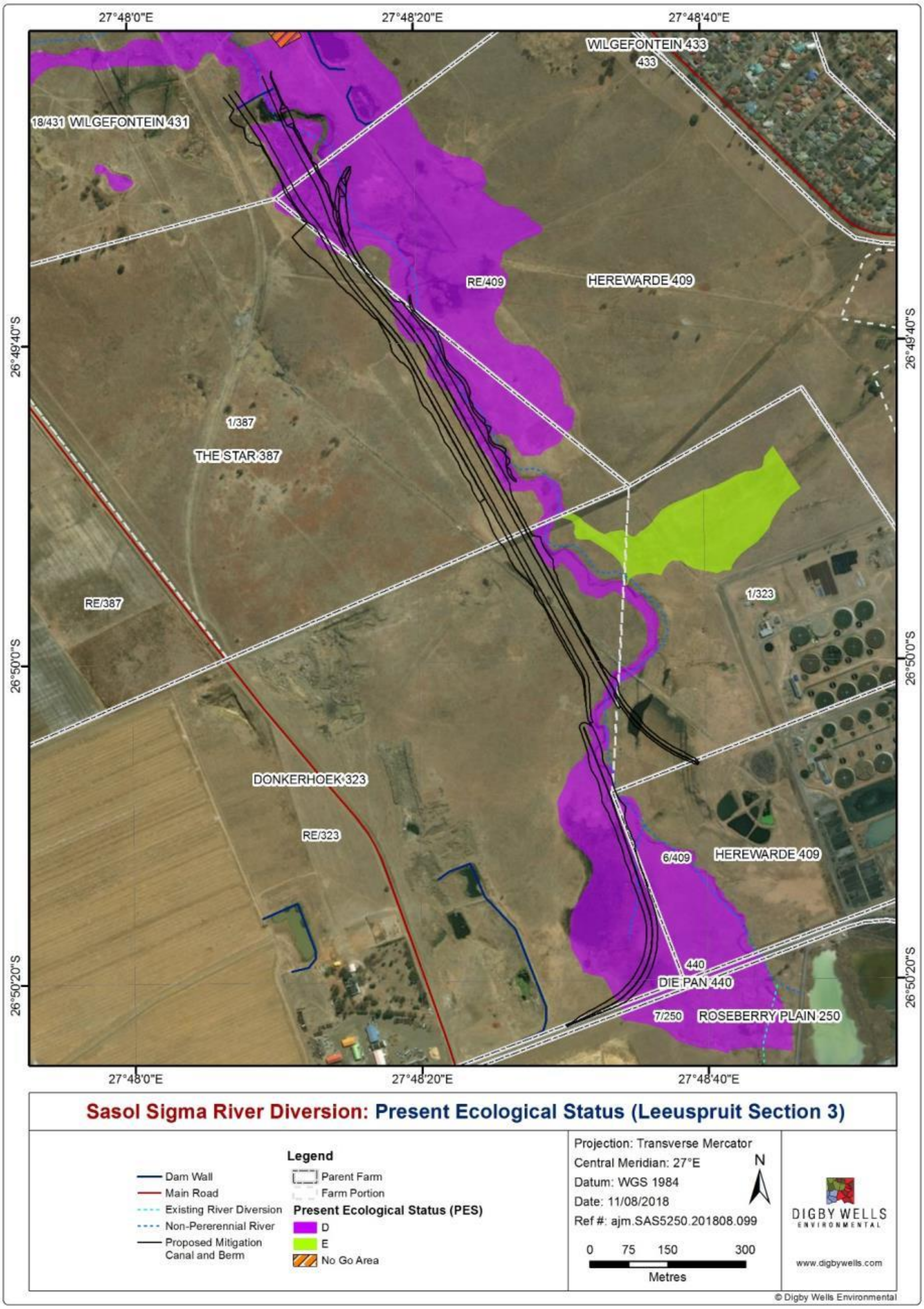

Figure 5-7: Leeuspruit Section 3 PES

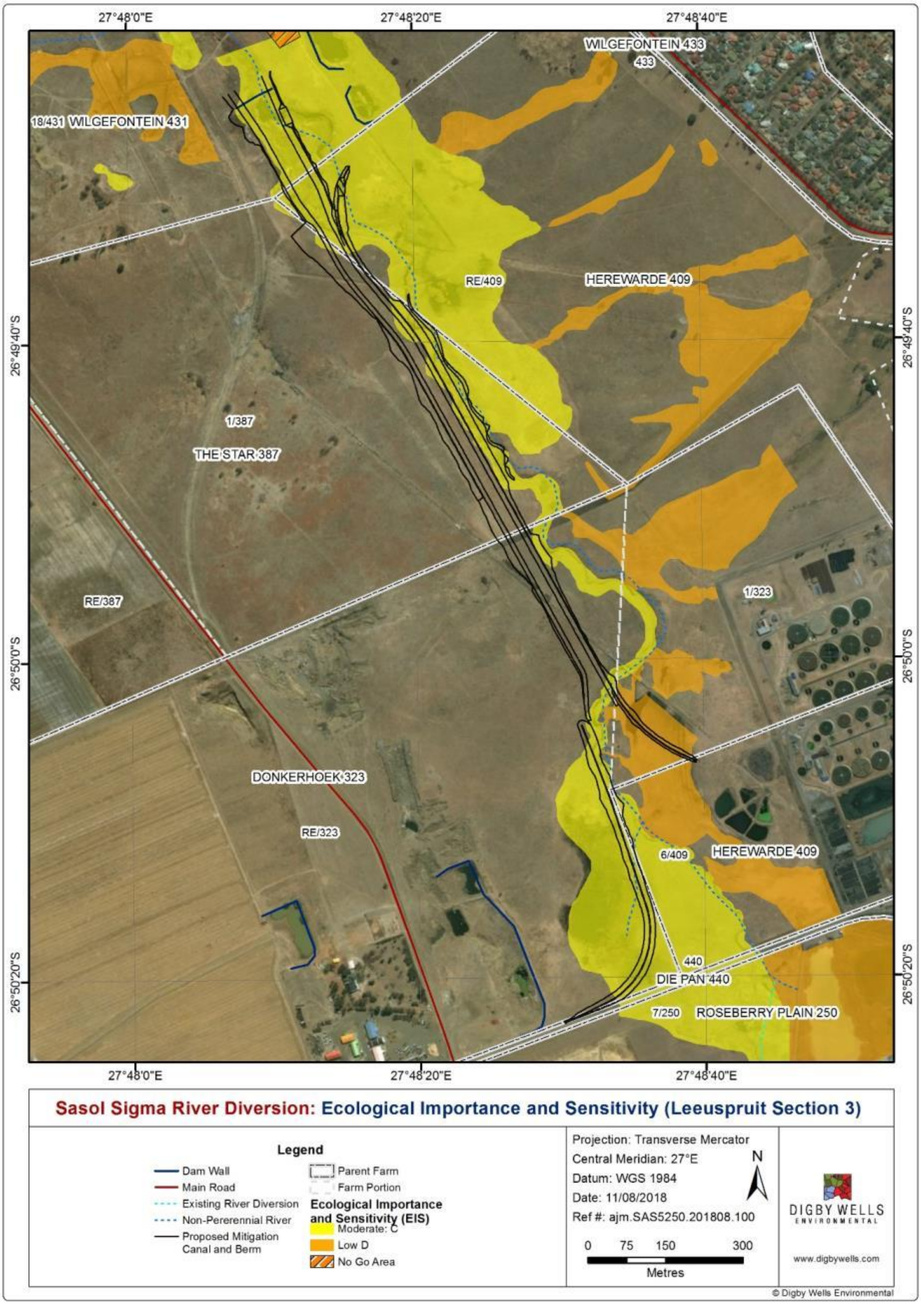

Figure 5-8: Leeuspruit Section 3 EIS

5.1.3 Leeuspruit Section 4

Leeuspruit Section 4 is a highly channelised floodplain wetland (35.2 ha) with associated hillslope seeps (8.2 ha), which will be impacted on by the proposed surface mitigation measures. Pans are also present, along with an artificial wetland and a channelled valley bottom, however, these will be unaffected by the proposed project (Figure 5-10).

The floodplain wetland is highly channelised and is impacted by subsidence in areas as well as road crossings and infrastructure (Figure 5-9). These have impacted on the health and functionality of the wetland to a great extent.

The PES and EIS of the impacted wetlands in Section 4 are considered largely modified (D) and 'moderate' respectively (see Figure 5-11 for PES and Figure 5-12 for EIS).

Figure 5-9: Leeuspruit Section 4 wetlands

(A and D: Highly channelized portions of the wetland; B: Wetland proximity to housing; C: Road crossing)

5.1.3.1 Leeuspruit Section 4 Geomorphology

In this area the stream channel is narrow and encrouched upon by urban development. Subsidence has formed artificial pans that form habitats of some local significance in terms of biodiversity. There are not many pans in the general area and these offer specific habitats for water birds as observed during numourous site visits. Again these features have similar functionality as oxbows.

In addition the wall mining panels are visiable through subsidence. This has significantly altered the floodplain and limits proposed mitigation activities of berms and diversion to the immediate stream channel area. The mined area can not be used for mitigation structures like berms or the diversion.

The urban runoff impacts of Section 3 are applicable in this section of the study area as well.

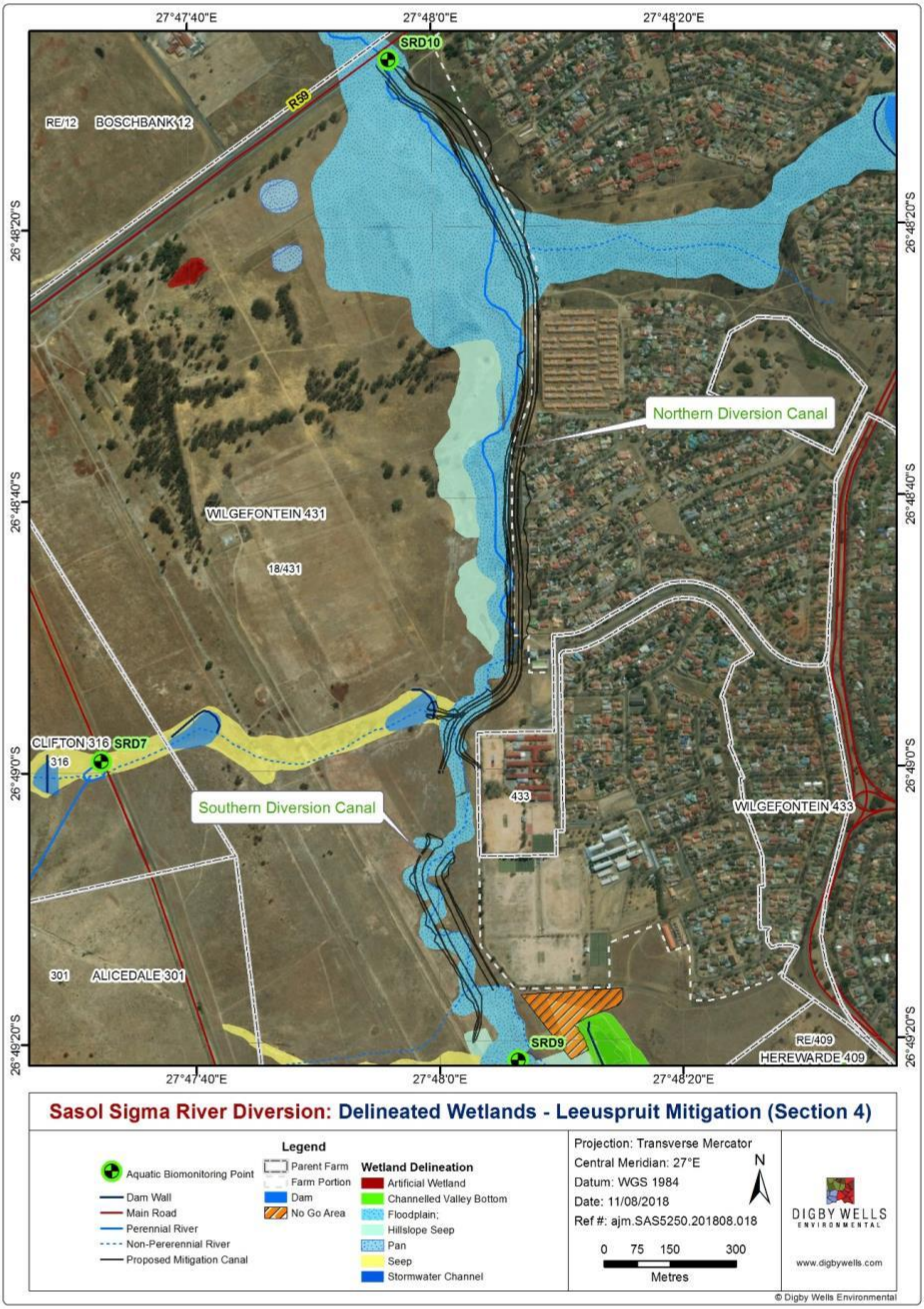

Figure 5-10: Leeuspruit Section 4 HGM units

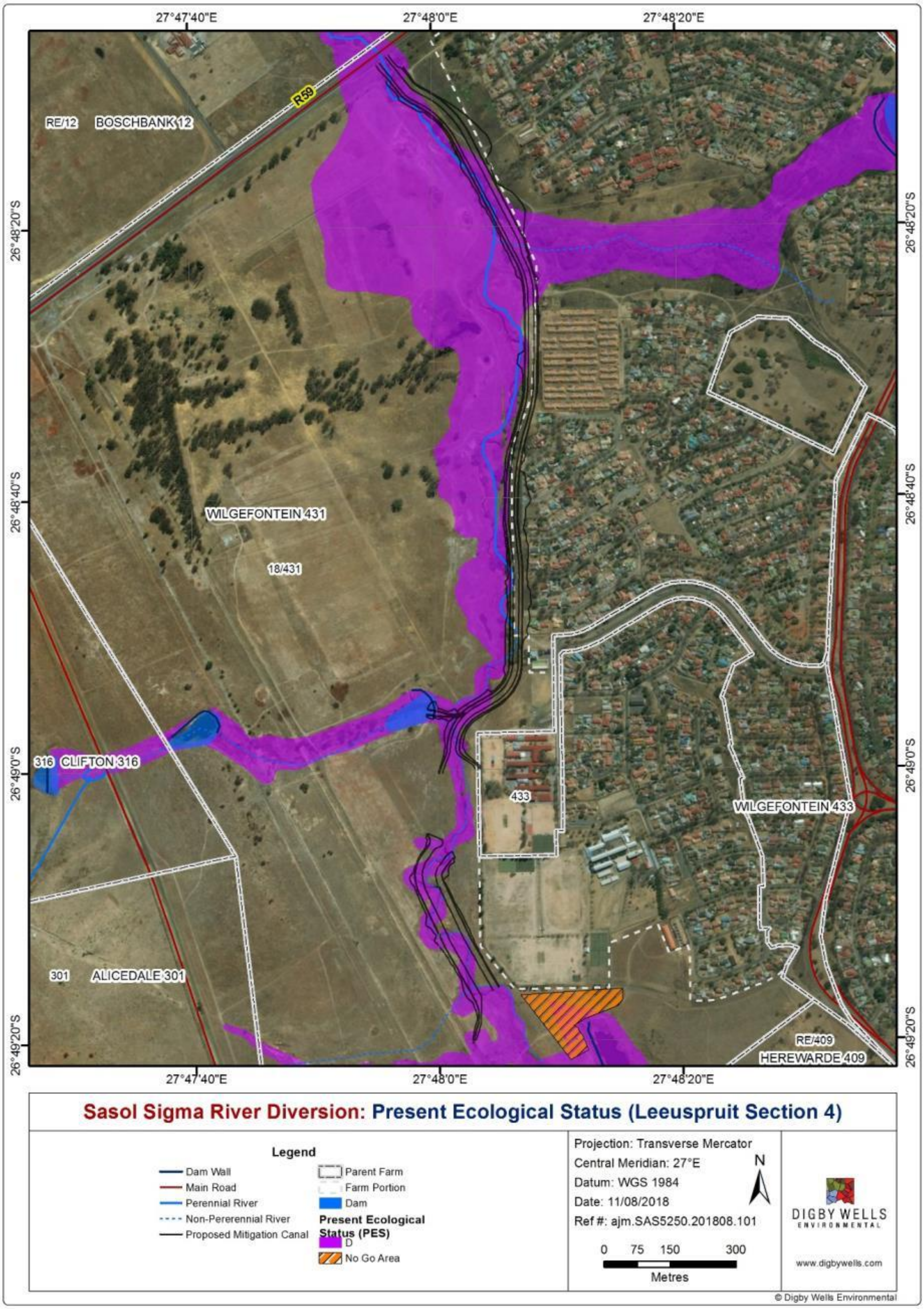

Figure 5-11: Leeuspruit Section 4 PES

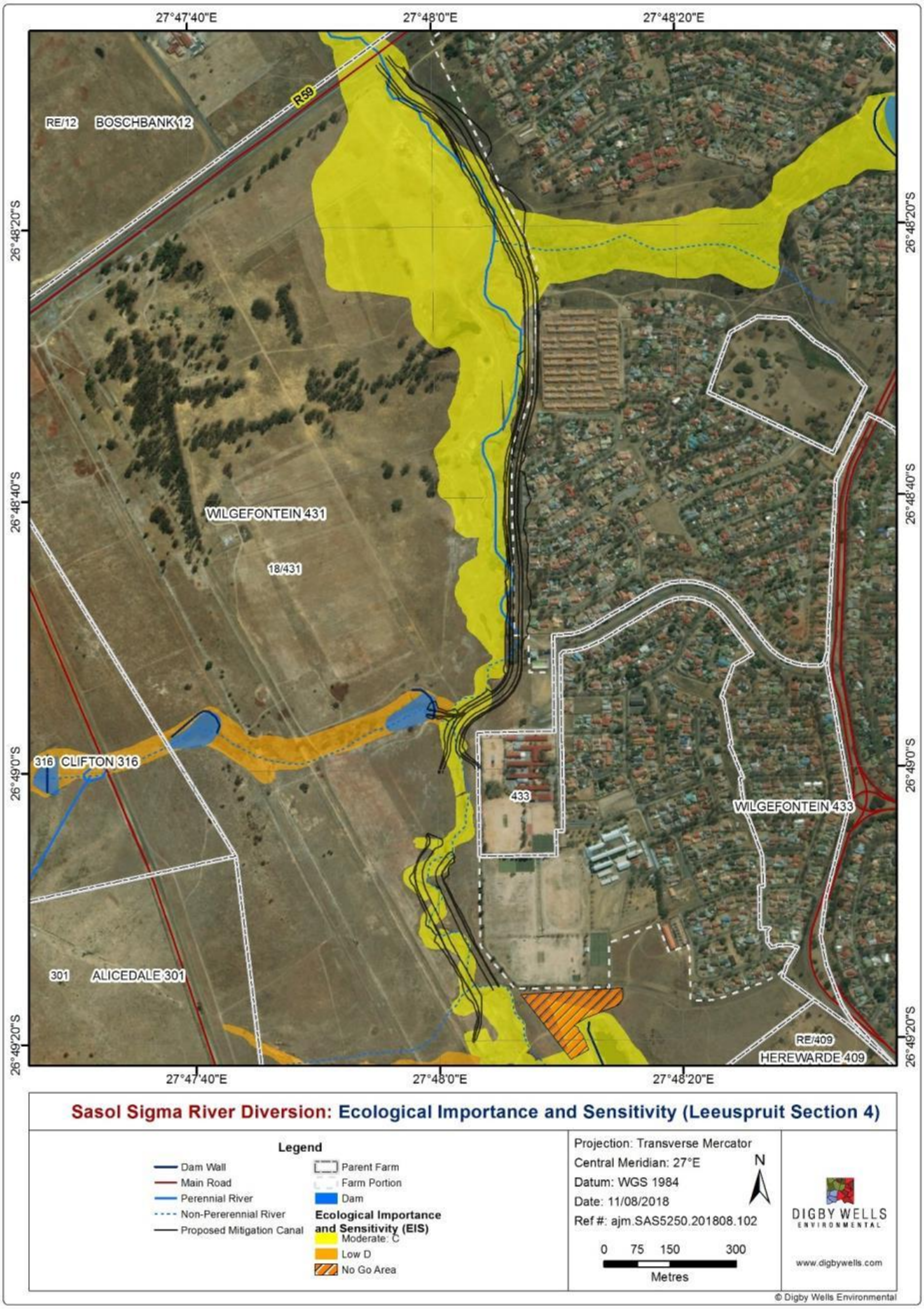

Figure 5-12: Leeuspruit Section 4 EIS

5.1.4 Leeuspruit Section 5

Leeuspruit Section 5 is characterised by a floodplain wetland and associate seeps. Artificial wetlands are also present (Figure 5-14).

This section has been heavily impacted on most notably by a sand mining operation as well as channelization due to the R59 culvert upstream and a large pipeline crossing. The PES value of the impacted wetlands in Section 5 are considered to be a D for all systems aside from the seep which has been categorised as an E (Figure 5-15). The EIS for the system may be regarded as moderate aside for the seep, which is categorised as low (Figure 5-16).

This section will not be directly impacted on by surface mitigation measures. Backfilling will be done and this has been addressed in a separate report.

Figure 5-13: Leeuspruit Section 5 wetlands

(A: habitat; B: large pipeline crossings)

5.1.4.1 Leeuspruit Section 5 Geomorphology

The R59 culvert could increase water speed and pressure during floods and may lead to downstream erosion with the water hammer or water canon effect. The water hammer or water canon effect refers to water being forced though a pipe or structure like a culvert which increases pressure and velocity and this increases the erosional force of the water drasticallly. Dissipation meansures and the a species plan needs to be implemented for this section. Dissipation can be achieved through upright concrete structures in the form of small pillars/poles or blocks. The species plan proposed must contain specific species that will help protect against erosional forces.

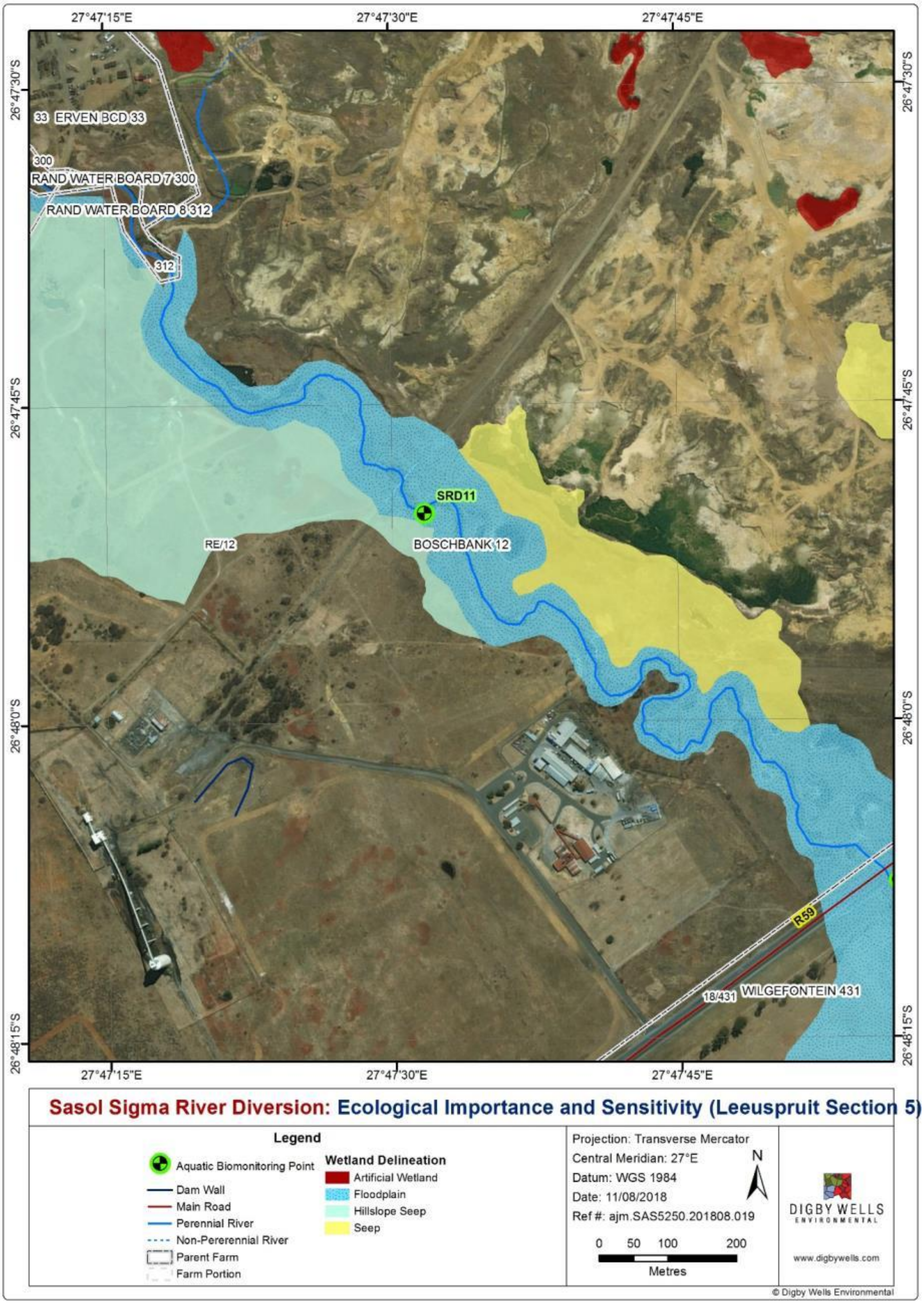

Figure 5-14: Leeuspruit Section 5 HGM units

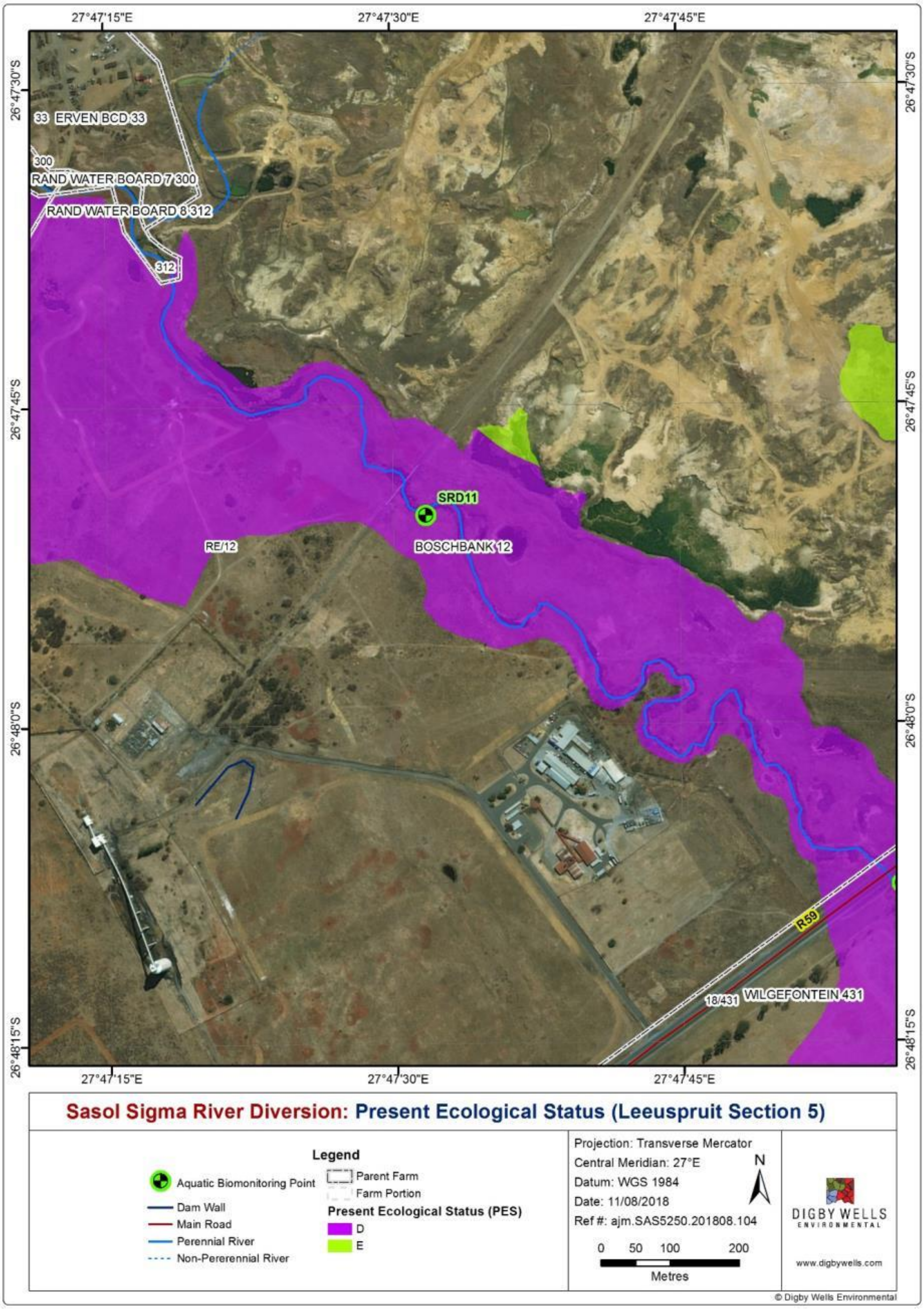

Figure 5-15: Leeuspruit Section 5 PES

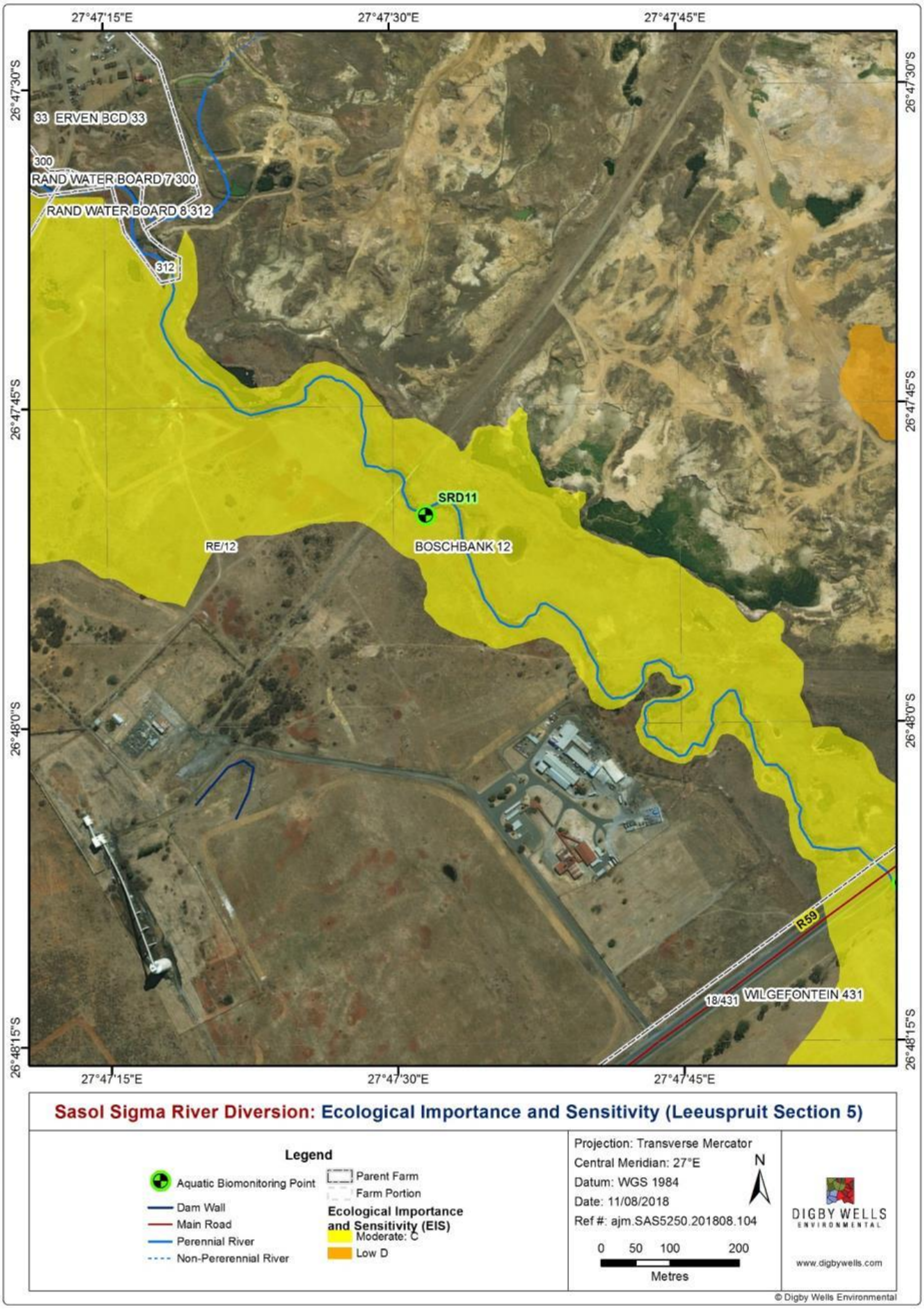

Figure 5-16: Leeuspruit Section 5 EIS

5.1.5 Rietspruit Section 1

Rietspruit 1 is characterised by a floodplain wetland and a channelled valley bottom wetland which is fed by two unchannelled valley bottom wetlands. An artificial wetland is also present (Figure 5-18).

The wetland has been impacted on by excavations, grazing and road crossings (Figure 5-17). The PES is considered a D for the impacted system (Figure 5-19) and the EIS is considered to be a moderate, except for the artificial wetland (Figure 5-20).

Figure 5-17: Rietspruit Section 1 wetlands

(A: a dry channel; B: Excavations within the wetland; C: Invasive alien species are present; D; a culvert with erosion)

5.1.5.1 Rietspruit Section 1 Geomorphology

Quarrying has taken place within this area. Additionally, two roads with associated culverts have altered the Rietspruit. The berm will deflect flow from the quarry and a wading habitat may form. This refers to muddy flats or muddy 'beach' type riparian zones that many birds prefer as feeding areas.

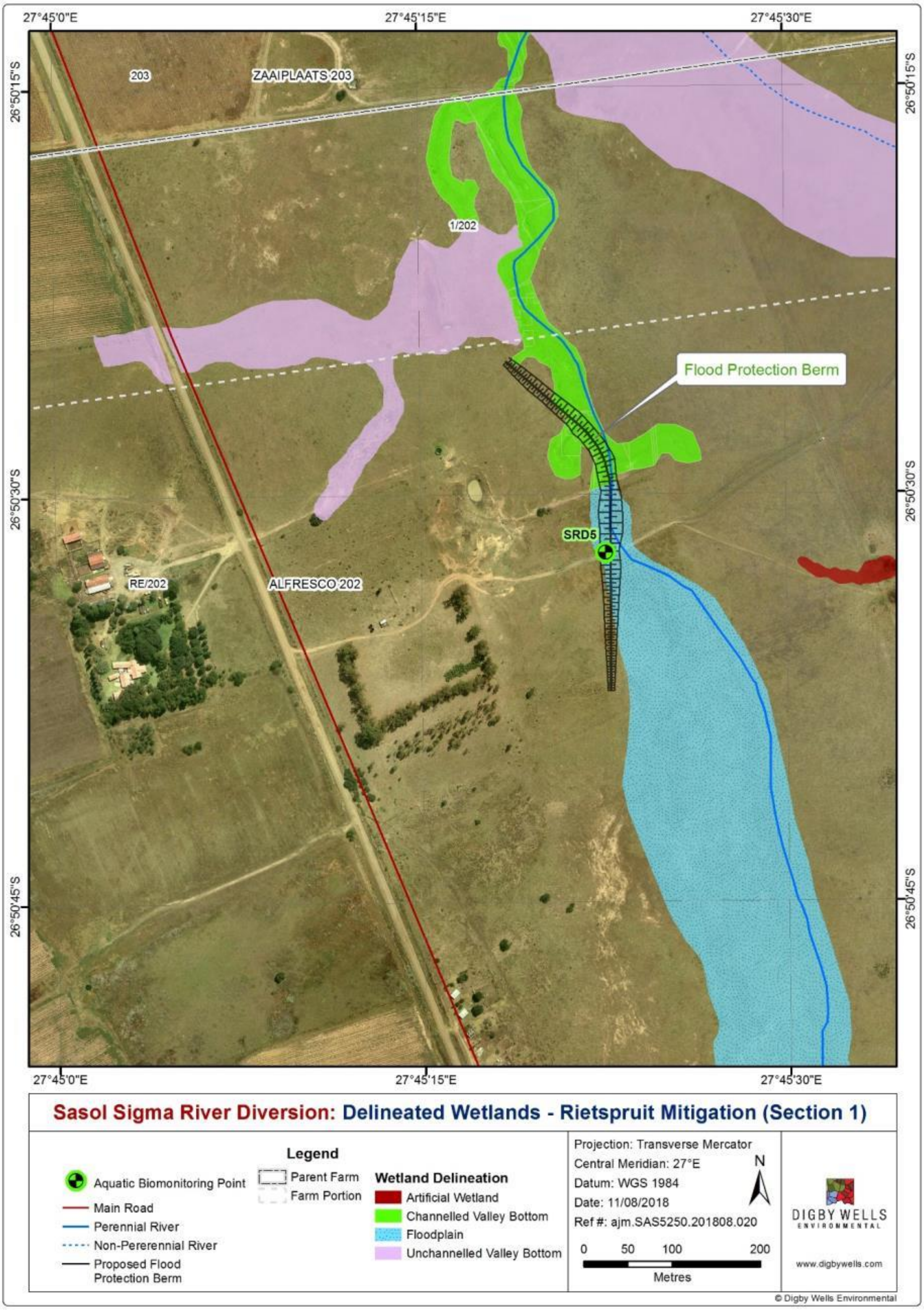

Figure 5-18: Rietspruit Section 1 HGM units

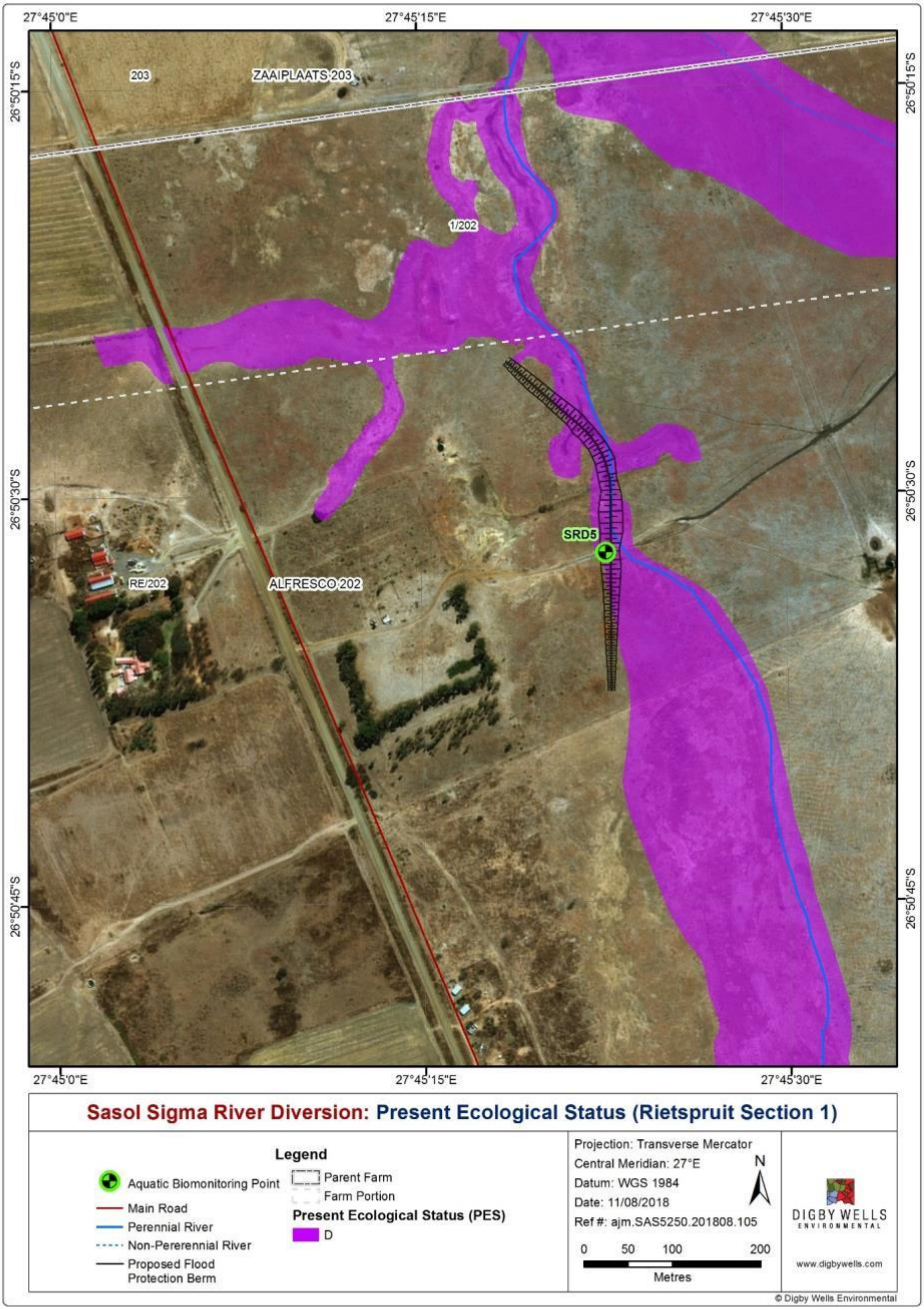

Figure 5-19: Rietspruit Section 1 PES

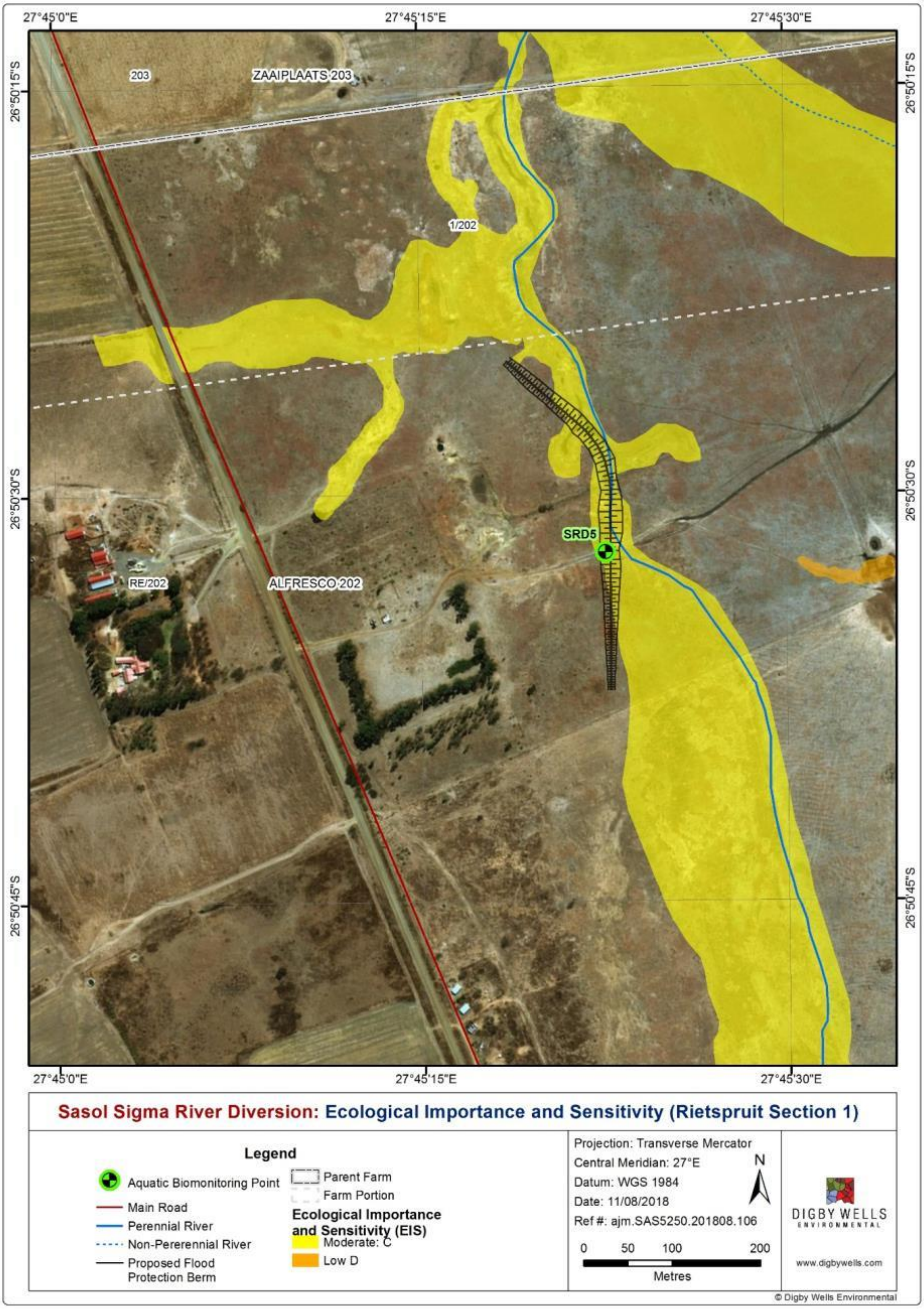

Figure 5-20: Rietspruit Section 1 EIS

5.2 Aquatic Ecology Assessment

5.2.1 Selection of Sampling Sites

Co-ordinates of the sampling sites utilised during this investigation were determined using a Garmin global positioning device (GPS) and presented graphically in Figure 5-21. Photographs of the sites sampled are provided in Appendix B.

Table 5-1: Location and description of the selected aquatic biomonitoring points

Site	Co-Ordinates	Description	Relevant field assessments
SRD1	26°51'48.41"S 27°49'22.59"E	Situated upstream of Leeuspruit Section 2. Located on the Leeuspruit, directly downstream of the impoundment and road crossing.	Visual assessment; Water quality; MIRAI; FRAI
SRD2	26°47'17.27"S 27°46'32.80"E	This point is located on the upper reaches of the Leeuspruit, directly downstream of a gravel road crossing and upstream of the impoundment.	Site dry, visual assessment only.
SRD3	26°53'8.34"S 27°49'31.80"E	Located on the upper reaches of the Leeuspruit, directly upstream of the impoundment.	Site dry, visual assessment only
SRD4	26°50'56.40"S 27°49'1.21"E	Situated on Leeuspruit Section 2. Located along the Leeuspruit directly upstream of a gravel road and the Sasol Sigma TSF.	Visual assessment; Water quality; MIRAI; FRAI
SRD5	26°50'32.15"S 27°45'22.74"E	Situated on the Rietspruit Section 1. Located along the Rietspruit. Site is situated on a small gravel road within a farm field mainly utilised for cattle grazing purposes.	Site dry, visual assessment only
SRD6	26°49'41.96"S 27°45'11.19"E	Situated downstream of the Rietspruit Section 1. Located along the Rietspruit, on a farm directly upstream of the R59.	Site dry, visual assessment only
SRD7	26°48'59.15"S 27°47'32.56"E	Situated on the Leeuspruit Section 4. Located along a gravel road, on a tributary of the Leeuspruit.	Site dry, visual assessment only
SRD8	26°52'13.88"S 27°49'24.05"E	Located on the impoundment situated downstream of SRD2 and SRD3 and upstream of SRD1	Visual assessment; Water quality; FRAI

Site	Co-Ordinates	Description	Relevant field assessments
SRD9	26°49'21.47"S 27°48'6.58"E	Situated downstream of the Leeuspruit Section 3 and upstream of the Leeuspruit Section 4. Located on the Leeuspruit, within a game farm area adjacent to the town of Sasolburg	Visual assessment; Water quality; MIRAI; FRAI
SRD10	26°48'7.64"S 27°47'56.67"E	Situated on the Leeuspruit Section 4. Located on the Leeuspruit at the R59 road crossing.	Visual assessment; Water quality; MIRAI; FRAI
SRD11	26°47'50.14"S 27°47'31.86"E	Situated on the Leeuspruit Section 5. Located on the Leeuspruit, directly upstream of a conveyor bridge crossing.	Visual assessment; Water quality; MIRAI; FRAI

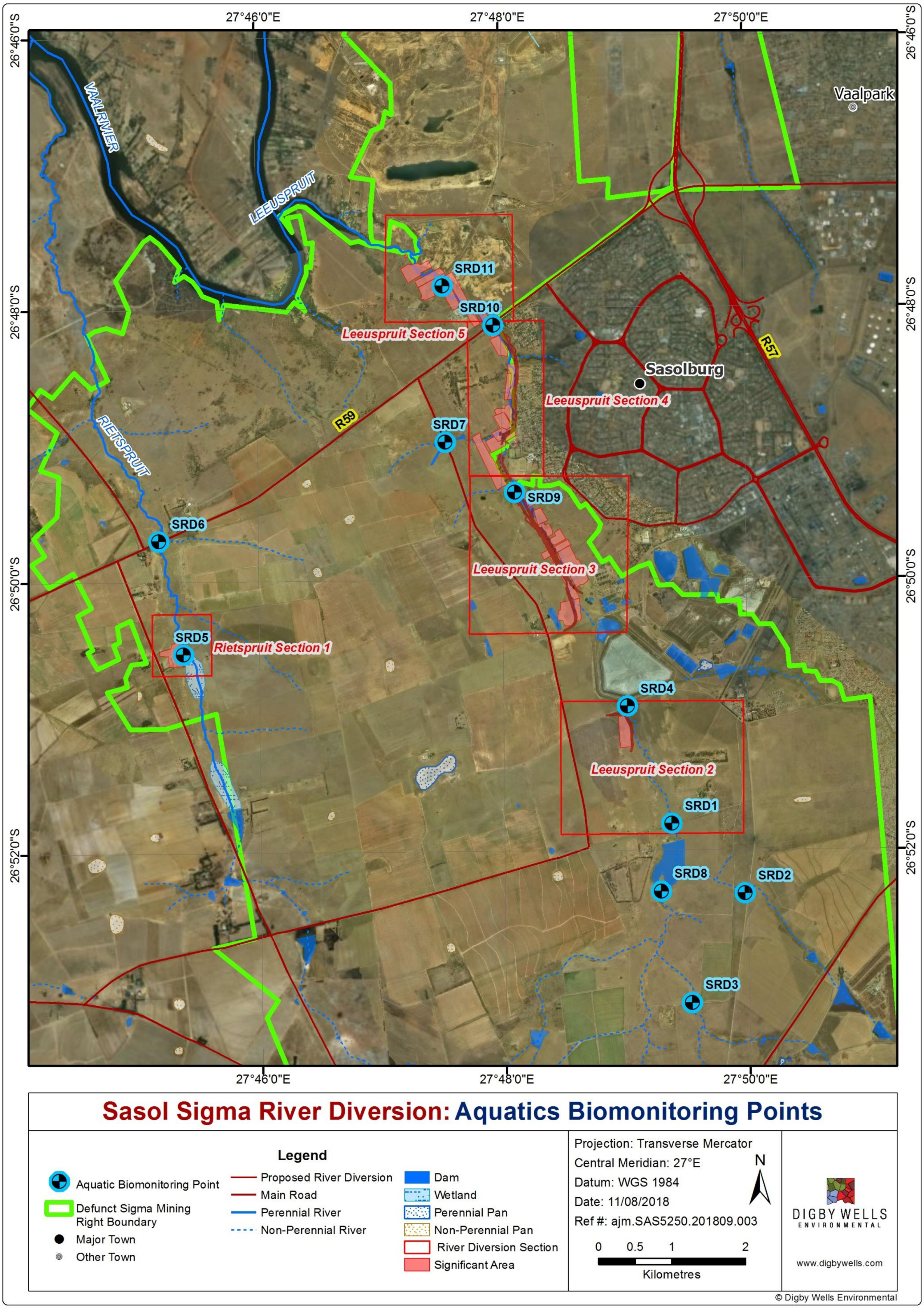

Figure 5-21: Aquatic Biomonitoring Points

5.2.2 Visual assessment

Detailed photographs of each site are provided in Appendix B. A brief description of key features observed at each site is indicated in Table 5-2 below.

Table 5-2: Visual assessment of the selected aquatic biomonitoring points

Site	Photograph	Aspect	Description
SRD1		Water clarity and odour	Discoloured, no odour
		Flow characteristics	Flow at this point was slow, dominated by pool-like habitat
		Substrate characteristics	Some stones out of current were present; however, benthic substrate was dominated by deposits of mud and organic matter.
		Bank cover and erosion potential	Vegetation cover was high on both banks, with little potential for erosion under high flow conditions
		Other observations	Proliferation of the alien (*Azolla filiculoides*) and dense stands of *Populus X canescens* were observed at this point.
SRD2		Water clarity and odour	Site was dry; Some stones were observed; however, benthic substrate will be dominated by mud and organic deposits at times of flow; Little potential for erosion due to the gradual gradient of the banks at this point and the relatively high basal cover observed.
		Flow characteristics	
		Substrate characteristics	
		Bank cover and erosion potential	
		Other observations	

Site	Photograph	Aspect	Description
SRD3		Water clarity and odour	Site was dry; Benthic substrate will be dominated by mud and organic deposits at times of flow; Little potential for erosion due to the gradual gradient of the banks at this point and the relatively high basal cover observed; Trampling by livestock.
		Flow characteristics	
		Substrate characteristics	
		Bank cover and erosion potential	
		Other observations	
SRD4		Water clarity and odour	Discoloured, no odour
		Flow characteristics	Extremely slow to still, the site consisted of a large pool at the time of the assessment.
		Substrate characteristics	Benthic substrate consisted of mud and sand deposits, with some isolated stones out of current.
		Bank cover and erosion potential	High basal cover on the banks, thereby reducing the potential for erosion at this point under high flow conditions.
		Other observations	None.

Site	Photograph	Aspect	Description
SRD5		Water clarity and odour Flow characteristics Substrate characteristics Bank cover and erosion potential Other observations	Site was dry; Benthic substrate will be dominated by mud and organic deposits at times of flow; Little potential for erosion due to the gradual gradient of the banks at this point and the relatively high basal cover observed; Trampling by livestock.
SRD6		Water clarity and odour Flow characteristics Substrate characteristics Bank cover and erosion potential Other observations	Site was dry; Benthic substrate will be dominated by mud and organic matter during times of flow; High potential for erosion due to loss of bankside cover because of livestock trampling and grazing activities.

Site	Photograph	Aspect	Description
SRD7		Water clarity and odour	As with site SRD6, the site was dry; Benthic substrate will be dominated by mud and organic matter during times of flow; High potential for erosion due to loss of bankside cover because of livestock trampling and grazing activities.
		Flow characteristics	
		Substrate characteristics	
		Bank cover and erosion potential	
		Other observations	
SRD8		Water clarity and odour	Opaque, no odour.
		Flow characteristics	No flow; this site comprises of an artificial dam.
		Substrate characteristics	Benthic substrate is dominated by mud deposits.
		Bank cover and erosion potential	High basal cover along the banks of the dam, thus limiting the potential for erosion under high flow conditions.
		Other observations	None

Site	Photograph	Aspect	Description
SRD9		Water clarity and odour	Clear, No odour.
		Flow characteristics	Moderate to low flows. The stream at this point was characterised by faster flowing glides, smaller, more gentle riffles and some pool habitat in the backwaters.
		Substrate characteristics	Large cobbles and boulders were present instream, with deposits of sand and gravel in some areas. Isolated deposits of mud.
		Bank cover and erosion potential	High basal cover on both banks, erosion potential at this point is very low.
		Other observations	None
SRD10		Water clarity and odour	Opaque, slight odour
		Flow characteristics	Flow at this point was moderate, the river was characterised by pools and slow laminar flows
		Substrate characteristics	Benthic substrate was dominated by mud and sand deposits, with isolated deposits of gravel under the bridge.
		Bank cover and erosion potential	Vegetation was absent in some areas, thus increasing the potential for erosion at this point under high flow conditions.
		Other observations	Some accumulation of debris in isolated areas.

Site	Photograph	Aspect	Description
SRD11		Water clarity and odour	Discoloured, no odour.
		Flow characteristics	Moderate flows; site was characterised by still pools and slow laminar flows at the time of the assessment.
		Substrate characteristics	Benthic substrates are dominated by mud deposits and sand towards the main channel.
		Bank cover and erosion potential	High basal cover, with little to no potential for erosion under high flow conditions.
		Other observations	None.

5.2.3 *In Situ* Water Quality

Due to the highly dynamic nature of lotic (or flowing) systems, water quality conditions have been known to vary on a temporal scale (e.g. seasonality) and along the longitudinal profile of the watercourse (Dallas and Day, 2004). Despite these variations, the assessment of *in situ* water quality variables is important for the interpretation of results obtained during biological investigations, as aquatic organisms are influenced by the environment in which they live. Table 5-3 provides the *in situ* water quality data obtained at each site assessed at the time of the field survey in July 2018.

Based on the *in situ* water quality variables recorded at the time of the survey, the elevated electrical conductivity values were expected to deter the colonisation and/or inhabitation of these watercourses by sensitive aquatic biota to some extent. However, it should be noted that extensive portions of this system were dominated by wetland habitat, the nature of which was expected to be a major driver of the elevated salt loads observed. As such, aquatic communities inhabiting these systems were expected to be relatively tolerant of the inherent water quality conditions observed.

Table 5-3: *In situ* water quality variables recorded at each of the sites assessed during the field survey in July 2018

Site	Time	Temp. (°C)	pH	Electrical Conductivity (µS/cm)
TWQR*		-	6.0 – 8.0	<700 µS/cm
SRD1	10h25	11.5	9.19	1281.0
SRD4	12h30	15.1	8.80	1212.0
SRD8	08h00	10.1	9.16	1306.0
SRD9	09h30	8.0	9.09	1293.0
SRD10	11h30	9.0	9.01	2009.0
SRD11	13h15	11.4	9.18	1894.0

* Target Water Quality Range (TWQR), as described in (Department of Water Affairs and Forestry, 1996)

Most aquatic systems within South Africa are relatively well-buffered, as a result of dissolved bicarbonate/carbonate ions originating from exposed geological formations and atmospheric deposits, and as such, these systems are expected to exhibit close-to-neutral pH levels (i.e. pH 6-8; Department of Water Affairs and Forestry, 1996; Dallas & Day, 2004). Consequently, the pH values observed along the length of the portion of the Leeuspruit assessed may be regarded as somewhat alkaline.

Each of the electrical conductivity values recorded at the time of the survey were observed to exhibit moderate to high levels, which to an extent, was to be expected within a system inherently dominated by wetland habitat. However, the increase in electrical conductivity observed between sites SRD9 and SRD10 of 55.4% may be regarded as notable. Some, as yet, unidentified point and diffuse sources of pollution may potentially have emanated from the residential area adjacent to the Leeuspruit between sites SRD9 and SRD10, however, confirmation of these suspicions would require further infield investigation.

Temperatures observed at each site may be regarded as largely natural on consideration of the natural seasonal and diurnal cycles at the time of the assessment and based on the inherent nature of the system at each point.

5.2.4 Invertebrate Habitat Assessment System

Due to the inherent nature of the valley-bottom and floodplain wetlands within the study area, which is largely derived from the topography of the area, stones as an available biotope were largely absent and the occurrence of hydraulic diversity within these wetlands systems was low. Consequently, each of the assessed sampling sites, except for Site SRD9, exhibited poor habitat availability with varying degrees of marginal and aquatic vegetation, as well as gravel-sand-mud, being the dominant biotopes present (Table 5-4). Site SRD9 was characterised by a variety of biotypes,

Table 5-4: Adapted IHAS values obtained during the July 2018 assessment

Site	Adapted IHAS Value (%)	Description
SRD1	38	Poor
SRD4	31	Poor
SRD9	69	Good
SRD10	47	Poor
SRD11	40	Poor

5.2.5 Aquatic Macroinvertebrates

Due to the differential sensitivities of aquatic macroinvertebrates, the composition of the aquatic macroinvertebrate community can provide an indication of changes in water quality and other ecological conditions within a watercourse. The use of the SASS has undergone numerous advances, culminating in Version 5 presently being utilised in river health studies along with the application of the MIRAI. However, it should be noted that the application of the SASS5 and MIRAI indices within wetland systems should be interpreted with caution, as these assessment indices were primarily designed to be used exclusively within lotic (or flowing) systems. Nevertheless, for standardising the assessment approach for the determination of the PES, the SASS5 and MIRAI methods were deemed sufficient.

Based on the derived reference list and distribution, a total of approximately 50 different aquatic macroinvertebrate families were to be expected within the study area (Inferred from

Dr C. Thirion, pers. comm., 2017 and specialist opinion based on site structure and experience). Of these aquatic macroinvertebrate families, a total of only 25 taxa were collected at the time of the survey (including an alien Physidae), ranging from 6 families at the Site SRD10 to 17 families at Site SRD4 (Table 5-5). Accordingly, the corresponding SASS5 scores ranged from a low 21 to moderate 84 at the same respective sampling sites. The highest Average Score Per Taxon (ASPT) values were observed at Sites SRD4 and SRD9 along the Leeuspruit, decreasing sharply downstream of Site SRD9. Only five taxa that were generally regarded as moderately sensitive to water quality impairment were collected, namely *Hydracarina* (Water Mites), *Aeshnidae* (Emperor Dragonflies), *Hydroptilidae* (Cased Caddisflies), *Ancylidae* (Limpets) and *Hydraenidae* (Minute Moss Beetles; Appendix C).

Table 5-5: SASS5 data obtained during the July 2018 assessment

Site	SASS5 Score	Number of Taxa	ASPT*
SRD1	53	13	4.1
SRD4	84	17	4.9
SRD9	64	13	4.9
SRD10	21	6	3.5
SRD11	28	8	3.5

* Average Score Per Taxon

Unsurprisingly, the lowest macroinvertebrate diversity obtained at the time of the survey was observed at Site SRD10. Both the SASS5 and ASPT scores thus reflect a direct impact to the Leeuspruit system as a result of impacts to the water quality observed at Sites SRD10 and SRD11. As mentioned above, some point and diffuse sources of pollution emanating downstream of Site SRD9 were deemed likely. The results of both the water quality assessment and well as the observed ASPT values, which are an indication of the general sensitivity of the colonised macroinvertebrate communities, serve as an indication, that water quality is a major driver within the Leeuspruit system.

5.2.5.1 Present Ecological State

Although Chutter (1998) originally developed the SASS5 protocol as an indicator of water quality, it has since become clear that the SASS5 approach gives an indication of more than mere water quality, but also a general indication of the current state of the macroinvertebrate community. While SASS5 does not have a particularly strong cause-effect basis for interpretation, as it was developed for application in the broad synoptic assessment required for the old River Health Programme (RHP), the aim of the MIRAI is to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic macroinvertebrate community (assemblage) from the reference condition (Thirion, 2008). This does not preclude the calculation of SASS5 scores, but encourages the application of MIRAI assessment. Accordingly, the SASS5 data obtained was used to determine the Present

Ecological State (PES, or Ecological Category) of the associated macroinvertebrate assemblage making use of the MIRAI (Table 5-6).

Table 5-6: Results obtained following the application of the Macroinvertebrate Response Assessment Index (MIRAI) at selected sampling sites during the July 2018 assessment

Site	REC*	MIRAI Value	Ecological Category	Description
SRD1	**D**	27.5	**E**	Seriously modified
SRD4	**E**	30.9	**E**	Seriously modified
SRD9	**E**	27.9	**E**	Seriously modified
SRD10	**E**	11.4	**F**	Critically modified
SRD11	**E**	19.9	**E/F**	Seriously to critically modified

* Recommended Ecological Category, as per historical data for the C22K-01812 sub-quaternary reach.

In relation to perceived reference conditions (Dr C. Thirion, pers. comm., 2017), it was determined that the ecological condition of the macroinvertebrate assemblages collected within the study area each exhibited seriously to critically modified conditions (i.e. Ecological Category E to F; Table 5-6). Further interrogation of the applied MIRAI indices suggested that the primary driver at each of the assessed sites was related to the limited available habitat present, which was to be expected for sites SRD1, SRD4 and SRD9, however, the results suggest some impact related to water quality at sites SRD10 and SRD11.

5.2.6 Fish Communities

Table 5-7provides the results of the fish community integrity assessment as observed at the time of the July 2018 survey.

Table 5-7: Results obtained following the application of the Fish Response Assessment Index (FRAI) for the Leeuspruit during the July 2018 assessment

FISH RESPONSE ASSESSMENT INDEX	
Fish species present (Collected)	*Gambussia affinis* (Mosquitofish)
Abundance	Present at 3 sites
Health	Good
Fish included but not collected (Based on habitat and infield observations)	*Clarius gariepinus* (Sharptooth catfish)
	Tilapia sparrmanii (Banded tilapia)
FRAI Score	24.1
Ecological Category	E
Description	Seriously modified

Only one fish species, *Gambussia affinis* (Mosquitofish; Figure 5-22), was captured during the field assessment. It is important to note however, that three out of the six sites sampled for fish, SRD8, SRD10 and SRD11, comprised of large areas too deep to safely assess making use of the electro-shocker. Therefore, based on habitat availability, infield observations, historical data, as well as tolerance of the fish species and professional opinion and experience, three additional species of fish were included in the application of the FRAI, *Clarias gariepinus, Tilapia sparrmanii*. An ecological category of E was thus assigned to this section of the Leeuspruit based on the results of the July 2018 survey.

Figure 5-22: *Gambussia affinis* (Mosquitofish)

6 Impact Assessment

The potential impacts/risks identified in this section are a result of both the environment in which the project activities take place, as well as the actual activities. The potential impacts/ risks are discussed per aspect, per River Section and per each phase of the project i.e. the Construction Phase. It is also noted that although the impacts for the construction phase of the various sections may be different the operational phase is predicted to be relatively similar for each section therefore only one operational phase for each aspect has been assessed. No decommissioning phase will be undertaken for this project as once the surface mitigation measures have been implemented these changes are proposed to be permanent.

The following activities for the proposed river diversion project that will be assessed are listed below.

Table 6-1: Project Activities

Significant Risk Area	Phase	Project Activity
Leeuspruit Section 2- 5 and Rietspruit Section 1	General Construction Activities	▪ Contractor Camp / Laydown Area Establishment; ▪ Site clearing, including the removal of topsoil and vegetation; ▪ Excavation of soils and sediment from water course ▪ Stockpiling of soil once excavated ▪ Water Management (ensure flow of river is not significantly impacted) ▪ Construction activities within water courses and wetlands (Heavy vehicles and excavators); ▪ Temporary storage of hazardous products, including fuel; and ▪ Storage of waste. ▪ Utilise existing roads to access the various river sections
Leeuspruit Section 2	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm
Leeuspruit Section 3	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm ▪ Construction of formalised canal
Leeuspruit Section 4	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm ▪ Construction of formalised canal
Leeuspruit Section 5	Construction Phase	▪ Ash backfilling has been assessed as a separate environmental authorisation project. Mitigation measures proposed from this project will be implemented in this section

Significant Risk Area	Phase	Project Activity
Rietspruit: Section 1	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm
Leeuspruit Section 2- 5 and Rietspruit Section 1	Operational Phase	▪ Revegetate area to ensure erosion does not occur ▪ Maintenance and monitoring activities ▪ Removal of all machinery and equipment utilised during construction phase ▪ Rehabilitate areas affected by laydown area and machinery ▪ Removal of waste

6.1 Construction Phase

6.1.1 Impact Description

The main activities during the construction phase that could result in impacts to the freshwater ecology of the area are associated with the construction of the flood protection berms in Leeuspruit Section 2, Leeuspruit Section 3 and Rietspruit Section 1, and the construction of canals in Leeuspruit Section 3 and Leeuspruit Section 4. Other impacts include those associated with site access such as site clearing, soil disturbance, crossing of wetland and river areas, increased vehicular movement, stockpiling of topsoil, storage and dumping of building materials associated with the development and construction of the various proposed berms and canals. Further impacts to the ecology of the Leeuspruit, with special mention of the river reach downstream of site SRD4, include fragmentation of the system, loss of catchment yield, loss of stream connectivity and associated migration routes and loss of habitat provision for biodiversity maintenance.

The impacts of the surface mitigation measures to the freshwater ecology are discussed for each section below:

6.1.1.1 Leeuspruit Section 2

The construction of flood protection berms at Leeuspruit Section 2 is likely to result in an alteration in the seasonality and flow of the wetlands and river reaches. A potential slight narrowing of the floodplain may take place as water is unlikely to flood over the berm area resulting in water contained within a smaller area and in turn, resulting in a direct and indirect loss of wetland habitat. The concentrated flow of water may also result in increased erosion and potential for gulley formation, loss of vegetation and increased potential for sedimentation of the freshwater resources downstream. In addition, the bare soil could potentially result in sedimentation and thereby alter water quality within the Leeuspruit.

Approximately 3.5 ha of floodplain are expected to be a potential loss, 1.3 ha directly and 2.2 ha indirectly, where the destruction of wetland for the berm footprint is considered a direct loss and the drying up of the floodplain portion that has been cut off from the main channel as indirect loss.

Figure 6-1 indicates the surface mitigation measures planned for Leeuspruit Section 2 and Table 6-2 summarises potential impacts to the freshwater ecology identified during the construction phase.

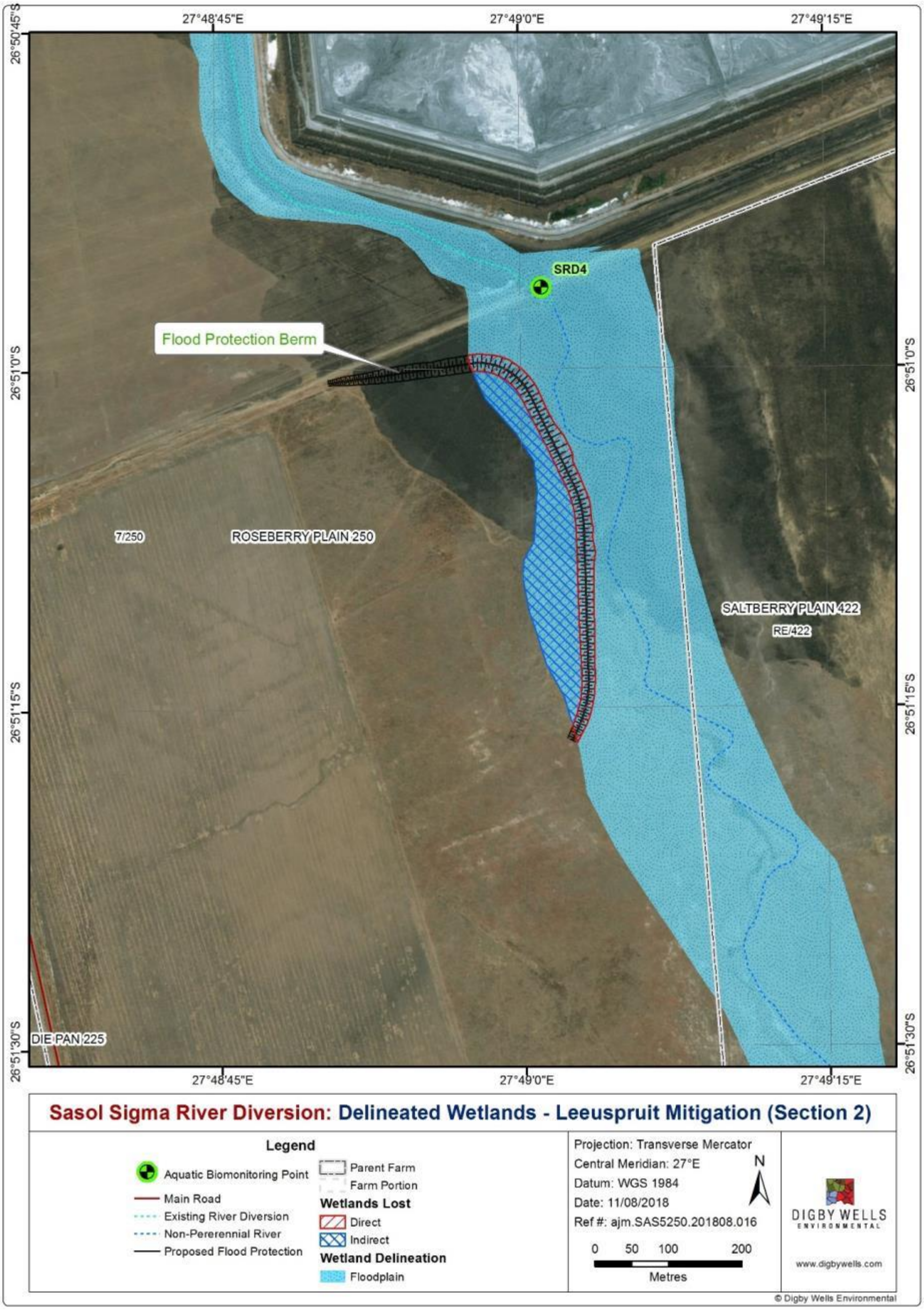

Figure 6-1: Leeuspruit Section 2 and proposed activity

Table 6-2: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 2

Dimension	Rating	Motivation	Significance
Activity and Interactions: Berm construction			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project.	Moderate (negative) – 84
Extent	Local (3)	Possible erosion, as well as degraded habitat due to water quality deterioration will affect the local watercourse and river reaches directly downstream.	
Intensity x type of impact	Serious medium term environmental effects (4)	Due to the already degraded nature of the systems present, should no management or mitigation measures be employed, activities could result in serious medium-term impacts.	
Probability	Almost certain (6)	Should no precautionary measures be implemented, further impacts to the systems present are considered highly probable.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	The impact is irreversible as the berms will alter the flow of the Leeuspruit.	Minor (negative) - 44
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the construction phase.	
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Due to the impacted nature of the systems present, should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the freshwater systems present	

Dimension	Rating	Motivation	Significance
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	
Nature	Negative		

6.1.1.2 Leeuspruit Section 3

The construction of flood protection berms at Leeuspruit Section 3 may result in an alteration in the seasonality and flow of the Leeuspruit. A slight narrowing of the floodplain may potentially take place as the natural seasonal flooding over the berm area is considered unlikely, thus resulting in the containment of water within a smaller area and an indirect loss of wetland habitat. The concentrated flow of water may also result in increased erosion and potential for gulley formation, loss of vegetation and increased potential for sedimentation downstream. The proposed activity is likely to result in the destruction of the portion of the wetlands (mostly floodplain and a small portion of hillslope seep) where they are covered by the proposed berm, in turn, resulting in a direct loss of wetland. In addition, the bare soil could result in sedimentation and thereby alter water quality within the wetland.

The largest potential impact is the excavation of the system to construct the canals. This activity is likely to result in a complete loss of wetland area as well as large impacts in the downstream reaches of the Leeuspruit such as erosion, sedimentation and altered water quality. Fragmentation of the system and loss of migration routes are also a risk.

Approximately 15.2 ha of floodplains (including a small portion of hillslope seep) are expected to be lost through construction of the berm and the canal, 4.8 ha directly and 10.5 ha indirectly, where the destruction of wetland for the berm and canal footprint is considered a direct loss and the drying up of the floodplain portion that has been cut off from the main channel as an indirect loss.

Figure 6-2 illustrates the surface mitigation measures planned for Leeuspruit Section 3 whilst Table 6-3 summarises potential impacts to the freshwater ecology identified during the construction phase.

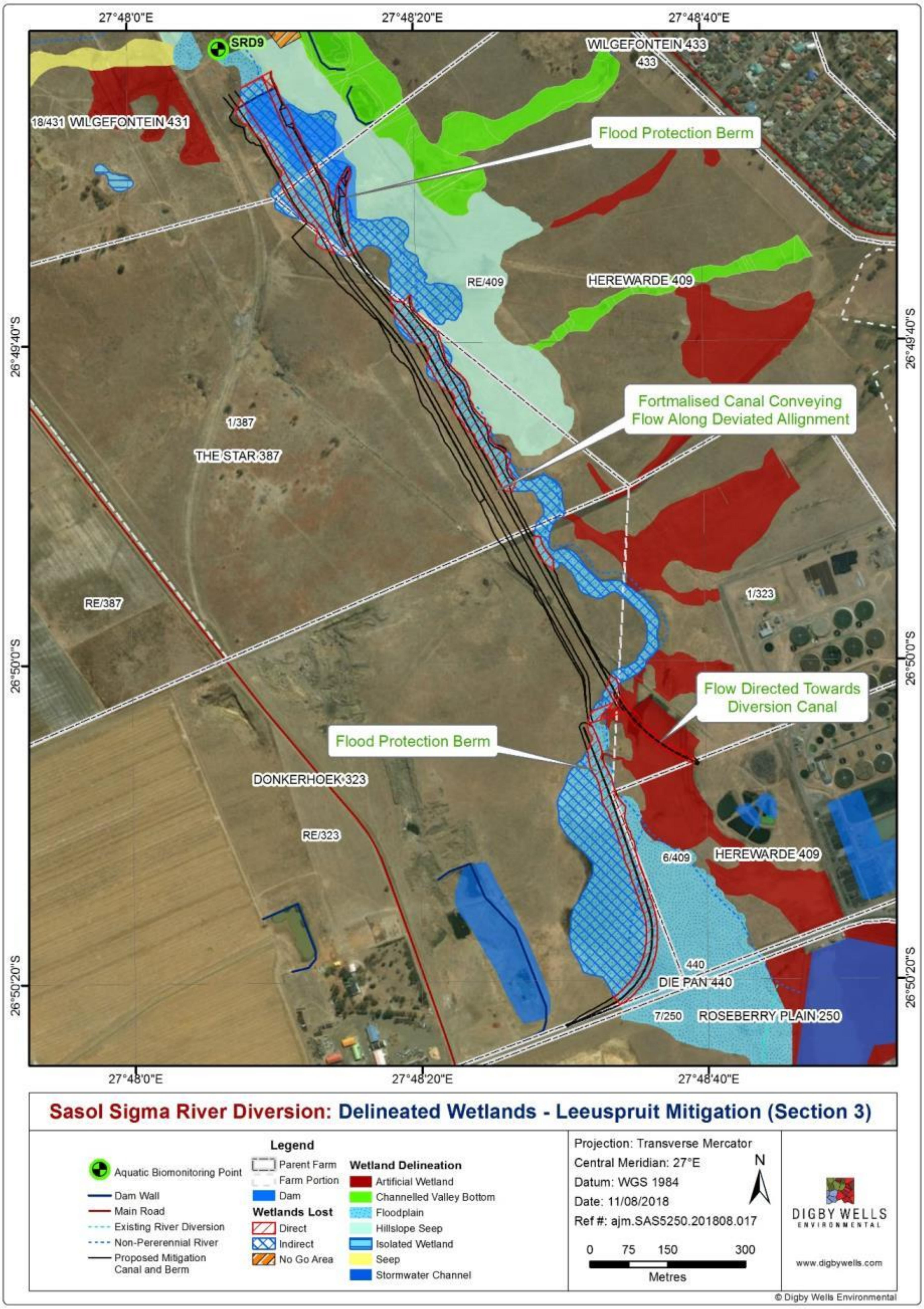

Figure 6-2: Leeuspruit Section 3 and proposed activity

Table 6-3: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 3 -canal construction

Dimension	Rating	Motivation	Significance
Activity and Interactions: Construction of the canals			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project. Freshwater resource habitat and function will be destroyed.	Major (negative) – 112
Extent	Local (3)	Habitat loss within the canals and the separation of parts of the floodplain will affect the watercourse and river reaches directly upstream and downstream of the Leeuspruit.	
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)	Natural habitat will be irreplaceably lost to armorflex surfaces, thereby limiting ecosystem form and function throughout the system. The risk of loss of stream connectivity and an alteration to the natural flow regimes exists.	
Probability	Definite (7)	The impact will occur, as the canal is being constructed in the wetland.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	No mitigation measures	Major (negative) – 112
Extent	Local (3)		
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)		
Probability	Definite (7)		
Nature	Negative		

Table 6-4: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 3 – instream ecology

Dimension	Rating	Motivation	Significance
Activity and Interactions: Construction of the canals – instream ecology			
Prior to Mitigation/Management			
Duration	Project Life of 1 year (3)	The impact will cease after the life of the project has been completed.	Moderate (negative) – 84
Extent	Local (3)	Habitat loss within the canals will affect entire watercourse and river reaches of the Leeuspruit.	
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)	Natural habitat will be irreplaceably lost to Armorflex surfaces, thereby limiting ecosystem form and function throughout the system.	
Probability	Definite (7)	The impact will occur, as the canal is replacing the wetland.	
Nature	Negative		
Post-Mitigation			
Duration	Project Life of 1 year (3)	No mitigation measures	Moderate (negative) - 84
Extent	Local (3)		
Intensity x type of impact	Irreplaceable loss or damage to biological or physical resources, limiting ecosystem function (6)		
Probability	Definite (7)		
Nature	Negative		

It should be noted that while these impact ratings are considered major to both the wetland and instream ecology for the duration of the construction phase of these canals, the impact to the instream ecology in terms of migration routes and flow connectivity is likely to be short-lived should the appropriate mitigation measures be implemented. In terms of wetland loss, the impact to portions of the wetlands lost will be irreplaceable, however, ultimately, the canals will serve to maintain the connectivity of the system in the long term.

Table 6-5: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 3

Dimension	Rating	Motivation	Significance
Activity and Interactions: Berm construction			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project.	Moderate (negative) – 84
Extent	Local (3)	Erosion as well as degraded habitat due to water quality deterioration will affect the watercourse and river reaches near the proposed construction.	
Intensity x type of impact	Serious medium term environmental effects (4)	Due to the already degraded nature of the systems present, should no management or mitigation measures be employed, activities could result in serious medium-term impacts.	
Probability	Almost certain (6)	Should no precautionary measures be implemented, further impacts to the Leeuspruit system are considered highly probable.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	The impact is irreversible as the berms will alter the flow of the Leeuspruit.	Minor (negative) – 44
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the construction phase.	

Dimension	Rating	Motivation	Significance
Activity and Interactions: Berm construction			
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Due to the impacted nature of the systems present, should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the Leeuspruit.	
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	
Nature	Negative		

6.1.1.3 Leeuspruit Section 4

The construction of flood protection berms at Leeuspruit Section 4 has the potential to result in an alteration in the seasonality and flow of the Leeuspruit. A narrowing of the floodplain may take place as the proposed berm area is likely to restrict water movement and result in the concentration and canalisation of the water within a smaller area, resulting in an indirect loss of wetland habitat. The concentrated flow of water may also result in increased erosion and potential for gulley formation, loss of vegetation and increased potential for sedimentation downstream. The portion of the wetlands (mostly floodplain and a small portion of seep) that are covered by the berm will be destroyed, resulting in a direct loss of wetland. In addition, the bare soil could result in sedimentation and thereby alter water quality within the Leeuspruit.

The largest potential impact is the excavation of the system to construct the canals. This activity is likely to result in a complete loss of wetland area, as well as large impacts downstream such as erosion, sedimentation and altered water quality. The floodplain waters are to be directed into the canal and therefore the meanders that fall outside of the canal have the potential to be cut off from their supply and ultimately lost. A potential risk to the instream ecology exists in terms of loss of flow connectivity, loss of habitat provision and loss of natural migration routes for aquatic fauna.

Approximately 32 ha of floodplain and hillslope seep are expected to be potentially lost through construction of the berm and the canal, 3.3 ha directly and 28.7 ha indirectly, where the destruction of wetland for the berm and canal footprint is considered a direct loss and the drying up of the floodplain portion that has been cut off from the main channel as an indirect loss.

Figure 6-3 illustrates the surface mitigation measures planned for Leeuspruit Section 4 whilst Table 6-6 summarises potential impacts to the freshwater ecology identified during the construction phase.

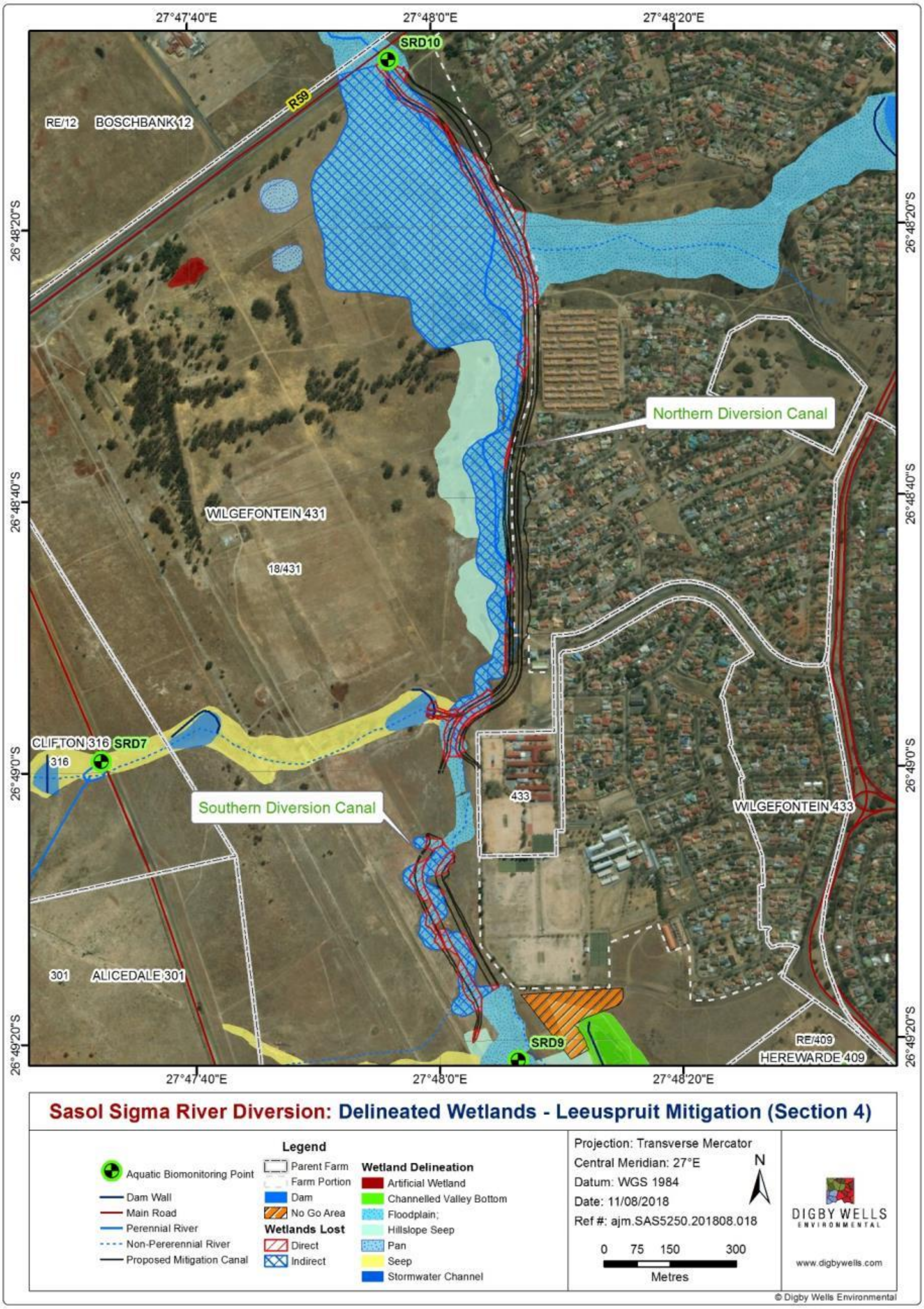

Figure 6-3: Leeuspruit Section 4 and potential activities

Table 6-6: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 4 -wetland ecology

Dimension	Rating	Motivation	Significance
Activity and Interactions: Construction of the canals – wetland ecology			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project. Freshwater resource habitat and function will be destroyed.	Major (negative) – 112
Extent	Local (3)	Habitat loss within the canals will affect entire watercourse and river reaches of the Leeuspruit.	
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)	Natural habitat will be irreplaceably lost to Armorflex surfaces, thereby limiting ecosystem form and function throughout the system.	
Probability	Definite (7)	The impact will occur, as the canal is being constructed in the wetland.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	No mitigation measures	Major (negative) - 112
Extent	Local (3)		
Intensity x type of impact	Irreplaceable loss or damage to biological or physical resources, limiting ecosystem function (6)		
Probability	Definite (7)		
Nature	Negative		

Table 6-7: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 4 – instream ecology

Dimension	Rating	Motivation	Significance
Activity and Interactions: Construction of the canals – instream ecology			
Prior to Mitigation/Management			
Duration	Project Life of 1 year (3)	The impact will cease after the life of the project has been completed.	Moderate (negative) – 84
Extent	Local (3)	Habitat loss within the canals will affect entire watercourse and river reaches of the Leeuspruit.	
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)	Natural habitat will be irreplaceably lost to Armorflex surfaces, thereby limiting ecosystem form and function throughout the system.	
Probability	Definite (7)	The impact will occur, as the canal is being constructed in the wetland.	
Nature	Negative		
Post-Mitigation			
Duration	Project Life of 1 year (3)	No mitigation measures	Moderate (negative) - 84
Extent	Local (3)		
Intensity x type of impact	Irreplaceable loss or damage to biological or physical resources, limiting ecosystem function (6)		
Probability	Definite (7)		
Nature	Negative		

As with Section 3 above, it should be noted that while these impact ratings are considered major to both the wetland and instream ecology for the duration of the construction phase of these canals, the impact to the instream ecology in terms of migration routes and flow connectivity is likely to be short-lived should the appropriate mitigation measures be implemented. In terms of wetland loss, the impact to portions of the wetlands lost will be irreplaceable, however, ultimately, the canals will serve to maintain the connectivity of the system in the long term.

Table 6-8: Impact assessment parameter ratings for the construction phase for Leeuspruit Section 4

Dimension	Rating	Motivation	Significance
Activity and Interactions: Berm construction			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project.	Moderate (negative) – 84
Extent	Local (3)	Erosion and sedimentation, as well as degraded habitat due to water quality deterioration will affect the watercourse and river reaches of the Leeuspruit directly upstream and downstream of the proposed activities.	
Intensity x type of impact	Serious medium term environmental effects (4)	Due to the already degraded nature of the systems present, should no management or mitigation measures be employed, activities could result in serious medium-term impacts.	
Probability	Almost certain (6)	Should no precautionary measures be implemented, further impacts to the wetlands present are considered highly probable.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	The impact is irreversible as the berms will alter the flow of the wetland.	Minor (negative) - 48
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the construction phase.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Due to the impacted nature of the systems present, should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the wetland systems present	
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	
Nature	Negative		

6.1.1.4 Leeuspruit Section 5

The backfilling of various polygons is planned for the Leeuspruit Section 5; no surface mitigation measures are planned. The backfilling has been addressed in a separate report. Figure 6-4 illustrates the surface mitigation measures planned for Leeuspruit Section 5.

It must be noted, however, that should the R59 culvert not be sufficient for a 1:10 year flood (as is the current situation), it could cause damage to the bridge and road and this may impact on the wetlands and the instream habitat in Leeuspruit Section 5.

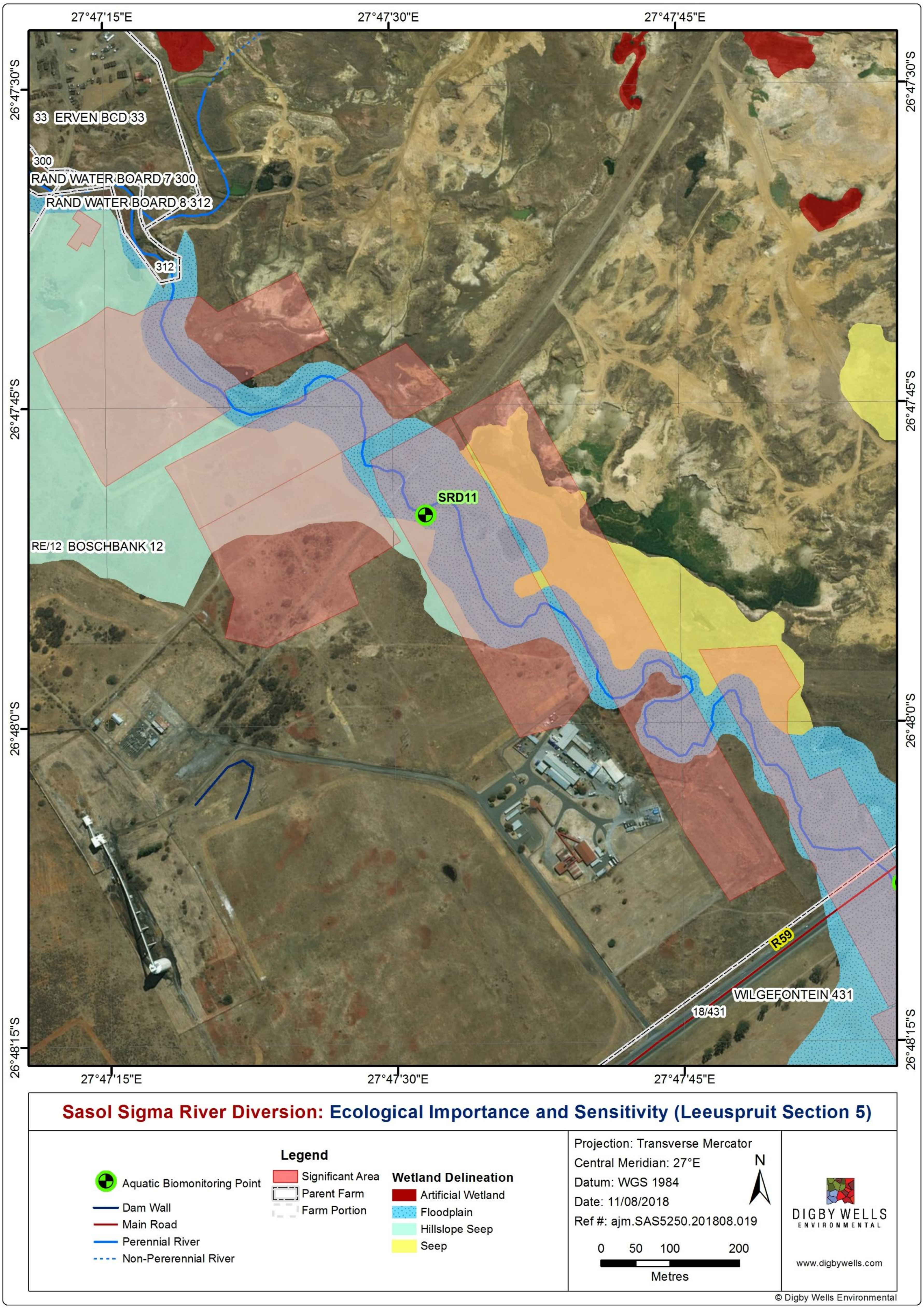

Figure 6-4: Leeuspruit Section 5 and proposed activities

6.1.1.5 Rietspruit Section 1

The construction of flood protection berms at Rietspruit Section 2 has the potential to result in an alteration in the seasonality and flow of the wetlands and instream ecology. A narrowing of the floodplain and channelled valley bottom may take place as the proposed berm area is likely to restrict water movement and result in the concentration and canalisation of the water, thus potentially resulting in a direct and indirect loss of wetland habitat. The concentrated flow of water may also result in increased erosion and potential for gulley formation, loss of vegetation and increased potential for sedimentation downstream. In addition, the bare soil of the berm could result in sedimentation and thereby alter water quality within the wetland.

Approximately 0.8 ha of floodplain and channelled valley bottom are expected to be potentially lost, 0.5 ha directly and 0.3 ha indirectly, where the potential destruction of wetland for the berm footprint is considered a direct loss and the drying up of the floodplain portion that has been cut off from the main channel as potential indirect loss.

Figure 6-5 illustrates the surface mitigation measures planned for Rietspruit Section 5, whilst Table 6-9 summarises potential impacts to the freshwater ecology identified during the construction phase.

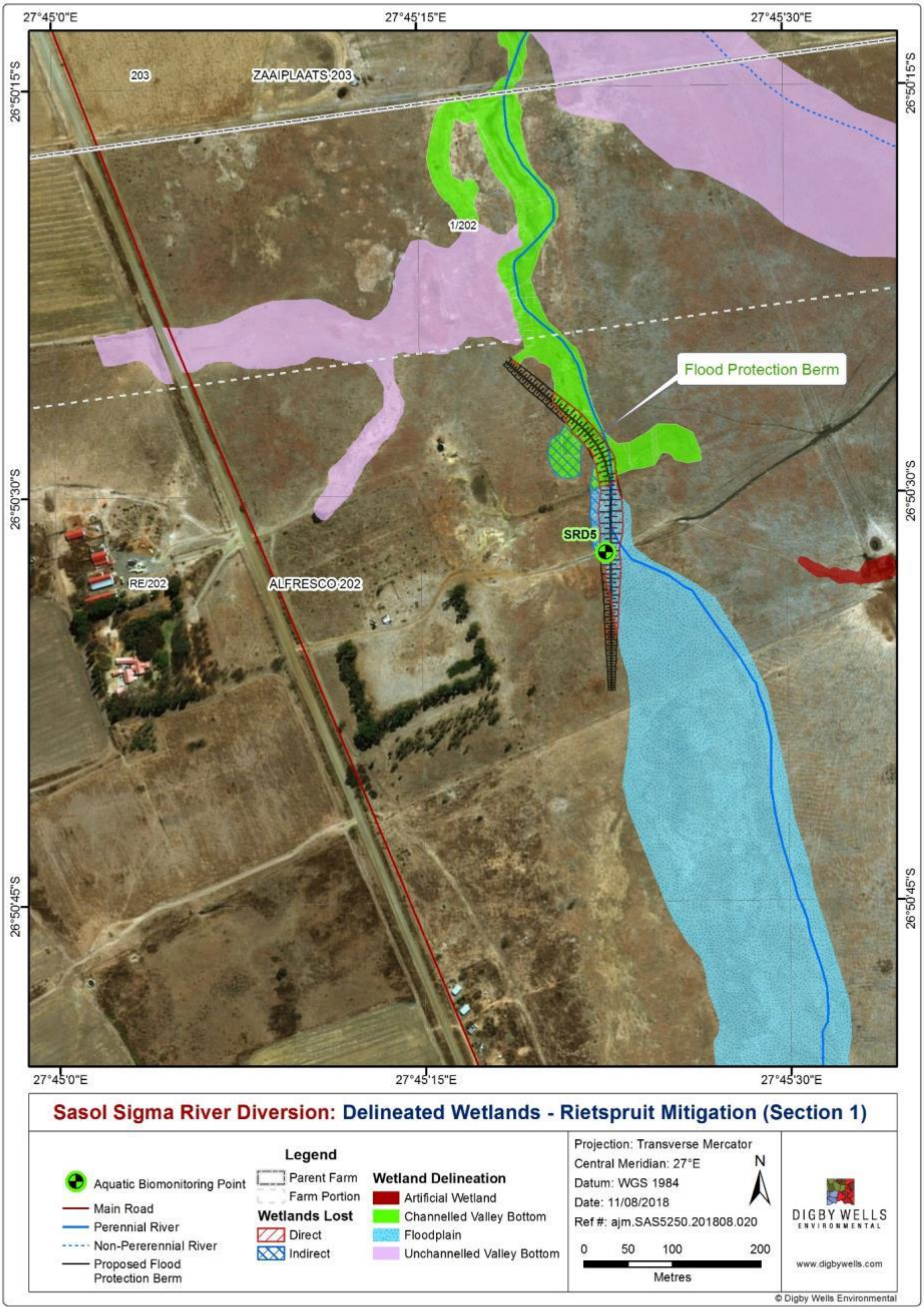

Figure 6-5: Rietspruit Section 1 and proposed activities

Table 6-9: Impact assessment parameter ratings for the construction phase for Rietspruit Section 1

Dimension	Rating	Motivation	Significance
Activity and Interactions: Berm construction			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project.	Moderate (negative) – 90
Extent	Local (3)	Erosion and sedimentation, as well as degraded habitat due to water quality deterioration will affect the local watercourse and river reaches.	
Intensity x type of impact	Serious medium term environmental effects (4)	Due to the already degraded nature of the systems present, should no management or mitigation measures be employed, activities could result in serious medium-term impacts.	
Probability	Almost certain (6)	Should no precautionary measures be implemented, further impacts to the wetlands present are considered highly probable.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	The impact is irreversible as the berms will alter the flow of the system.	Minor (negative) - 44
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the construction phase.	
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Due to the impacted nature of the systems present, should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the systems present	
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	

Dimension	Rating	Motivation	Significance
Nature	Negative		

6.1.1.6 All sections

Activities associated with the construction of these Leeuspruit river diversion measures includes site clearing, soil disturbance, topsoil stockpiling, storage and dumping of building materials, compaction of soils and crossing of the wetland and river systems. Associated potential impacts include erosion and sedimentation, the potential further loss of biodiversity and habitat, fragmentation of the systems present a potential loss of catchment yields, loss of migration routes and surface water recharge to the systems further downstream. Among the impacts associated with the proposed construction phase are minor potential impacts to soil and water quality because of the ingress of hydrocarbons. Larger impacts include compaction of soils, potential loss of vegetation and the increased potential for erosion and sedimentation in the vicinity of any cleared areas and resulting in impacts further downstream. Removal of vegetation and disturbance of soils in the vicinity of the construction footprint is likely to give rise to an increased potential for encroachment by robust pioneer species and Alien Invasive Plants (AIPs), which are already prolific in the area, further altering the natural vegetation profiles of the freshwater resources encountered in the vicinity of the project footprint.

Furthermore, in terms of instream ecology, large potential impacts related to loss of flow connectivity, fragmentation of the system, loss of natural migration routes and the loss of natural habitat and substrates has the potential to limit the biodiversity of the instream ecology of this portion of the Leeuspruit.

Table 6-10 summarises potential impacts to the freshwater ecology identified during the construction phase.

Table 6-10: Impact assessment parameter ratings for the construction phase for all sections

Dimension	Rating	Motivation	Significance
Activity and Interactions: Site access and disturbance			
Prior to Mitigation/Management			
Duration	Project life (5)	The impact will cease after the life of the project has been completed	Minor (negative) – 72
Extent	Local (3)	General scouring from sedimentation, as well as degraded habitat due to water quality deterioration will affect local watercourse and river reaches.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Serious medium term environmental effects (4)	Due to the already degraded nature of the systems present, should no management or mitigation measures be employed, activities could result in serious medium-term impacts.	
Probability	Almost certain (6)	Should no precautionary measures be implemented, further impacts to the systems present are considered highly probable.	
Nature	Negative		
Post-Mitigation			
Duration	Project life (5)	The impact will cease after the project has been completed.	Minor (negative) - 36
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the construction phase.	
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Due to the impacted nature of the systems present, should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the wetland systems present	
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	
Nature	Negative		

Table 6-11: Impact assessment parameter ratings for the construction phase for all sections

Dimension	Rating	Motivation	Significance
Activity and Interactions: Instream freshwater biodiversity destruction			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project. Freshwater resource habitat and function will be destroyed.	Major (negative) - 112
Extent	Local (3)	Habitat loss within the canals will affect the local watercourse and river reaches.	
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)	Natural habitat will be irreplaceably lost, thereby limiting ecosystem form and function throughout the system and reducing the habitat for instream ecology	
Probability	Definite (7)	The impact will occur, as the canal and berms are being constructed.	
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project. Freshwater resource habitat and function will be destroyed.	Moderate (negative) - 84
Extent	Local (3)	Habitat loss within the canals will affect the local watercourse and river reaches.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Serious loss and of biological resources or moderately sensitive environments, limiting ecosystem function. (4)	Habitat loss within the canals will affect entire watercourse and river reaches.	
Probability	Highly Probable (6)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered highly probable.	
Nature	Negative		

6.1.2 Construction Phase Mitigation and Management Measures

The following mitigation and management measures have been prescribed for the construction phase:

6.1.2.1 Berms

- Sufficient drains need to be installed to facilitate seepage underneath berms;
- Berms should be monitored after large rainfall events to ensure that they are draining sufficiently;
- Berms should be reseeded with indigenous grasses to prevent erosion (see Appendix C for the plant species plan);
- Cattle and other grazing animals must be kept off the erosion berms whilst vegetation is establishing. Non-palatable species have also been included in the species mix to deter grazing.
- In high erosion areas, mulch or hessian should be used to protect the soil and growth of new seedlings; and
- All erosion noted along berms should be remedied immediately and included as part of an ongoing rehabilitation plan.

6.1.2.2 Canal

- It should be ensured that energy dissipation measures be installed to slow and spread the flow of water at discharge points to reduce the potential for erosion and to assist with infiltration;

- Special care should be taken to provide suitable habitat and refuge for aquatic fauna. Suitable vegetation and river cobbles should be strategically placed in such a manner as to provide refuge and habitat to the various species likely to occur in this reach of the Leeuspruit system;
- Furthermore, it is deemed critical that regular care and maintenance of the canal be undertaken to ensure no build-up of litter and debris, which would affect the flow of the system and negate any efforts at maintaining migrations routes and flow connectivity;
- Indigenous species should be hand planted within the canal to provide habitat for freshwater ecology.

6.1.2.3 General

- Ensure soil management programme is implemented and maintained to minimise erosion and sedimentation;
- During the construction phase, erosion berms should be installed on roadways and downstream of stockpiles to prevent gully formation and siltation of the freshwater resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has a slope of less than 2%, berms every 50m should be installed;
  - Where the track slopes between 2% and 10%, berms every 25m should be installed;
  - Where the track slopes between 10%-15%, berms every 20m should be installed; and
  - Where the track has slope greater than 15%, berms every 10m should be installed.
- Limit the footprint area of the construction activities to what is essential to minimise impacts as a result of vegetation clearing and compaction of soils (all areas but critically so in wetland areas);
- If it is unavoidable that any of the wetland or instream areas present (not withstanding those already accounted for in the proposed activities) will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the wetland and instream features present takes place;
- All erosion noted within the construction footprint should be remedied immediately and included as part of an ongoing rehabilitation plan;

- Active rehabilitation, re-sloping, and re-vegetation of disturbed areas immediately after construction;
- All soils compacted because of construction activities should be ripped/scarified (<300mm) and profiled (see the Soil Specialist Report for more information);
- Implement and maintain a suitable AIP control programme to prevent further encroachment because of disturbance to the surrounding terrestrial zones (see the Fauna and Flora Specialist Study for more information);
- Permit only essential personnel within the 100m zone of regulation for all freshwater features identified;
- No unnecessary crossing of the wetland features and their associated buffers should take place and the substrate conditions of the wetlands and downstream stream connectivity must be maintained;
- No material may be dumped or stockpiled within any rivers, tributaries or drainage lines;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any wetland or instream areas and their associated zones of regulation (notwithstanding those areas to be directly impacted upon as a result of the proposed activities). All vehicles must remain on demarcated roads and within the construction footprint. The No-go zone should be avoided;
- All vehicles must be regularly inspected for leaks;
- Re-fueling must take place at a diesel facility, on a sealed surface area away from wetlands to prevent ingress of hydrocarbons into topsoil;
- All spills should be immediately cleaned up and treated accordingly;
- Wetlands should be monitored monthly during construction;
- The no-go area indicated in the map must be avoided;
- Appropriate sanitary facilities must be provided for the duration of the construction activities and all waste must be removed to an appropriate waste facility; and
- A wetland offset strategy should be developed to compensate for the loss of wetland and instream areas due to the canals and berms. Ideally, the PES and EIS of wetlands and instream areas within Sasol's mining lease area should be improved.

6.2 Operational Phase

6.2.1 Impact Description

The main activities during the operational phase that could result in impacts to the freshwater ecology of the area are associated with the monitoring and maintenance activities.

Associated potential impacts could include compaction of soils and hardening of surfaces, loss of catchment yield and surface water recharge, erosion and sedimentation, the potential loss of biodiversity and habitat, loss of natural migration routes for instream fauna and further fragmentation of the systems present. Further to this, the potential for ongoing contamination of the freshwater resources present are deemed likely based on the ingress of hydrocarbons associated with increased vehicular activity. Removal of indigenous vegetation is likely to give rise to an increased potential for encroachment by robust pioneer species and AIPs, further altering the natural vegetation profiles of the freshwater resources encountered in the vicinity of the project footprint. Hardened surfaces have the potential to result in sheet runoff and there is likely to be a loss in wetland service provision in terms of flood attenuation, sediment trapping and assimilation of toxicants and other pollutants. Storage of water, which is an important service, provided by wetlands in this area, will be compromised. Further alterations to the natural flow regimes will take place and is likely to result in the creation of preferential flow paths over time, which may give rise to erosion and sedimentation, thus affecting the instream ecology of this portion of the Leeuspruit and the downstream resources.

Table 6-12 summarises potential impacts to the freshwater ecology identified during the operational phase.

Table 6-12: Impact assessment parameter ratings for the operational phase

Dimension	**Rating**	**Motivation**	**Significance**
Activity and Interactions: Site access for maintenance and monitoring purposes			
Prior to Mitigation/Management			
Duration	Project life (5)	The impact will cease after the life of the project has been completed.	Minor (negative) – 48
Extent	Local (3)	Hydrocarbon spills as well as degraded habitat due to water quality deterioration from maintenance activities will affect the local watercourses and river reaches.	
Intensity x type of impact	Serious medium term environmental effects (4)	Due to the already degraded nature of the systems present, should no management or mitigation measures be employed, activities could result in serious medium-term impacts.	
Probability	Probable (4)	Should no precautionary measures be implemented, further impacts to the Leeuspruit are considered probable.	
Nature	Negative		
Post-Mitigation			

Dimension	Rating	Motivation	Significance
Duration	Project life (5)	The impact will cease after the project has been completed.	Negligible (negative) – 18
Extent	Limited (2)	Impacts will be limited only to the project footprint area and will be rehabilitated accordingly on completion of the operational phase.	
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Due to the impacted nature of the systems present, should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the wetland systems present.	
Probability	Improbable (2)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are considered improbable.	
Nature	Negative		

6.2.2 Operational Phase Mitigation and Management Measures

The following mitigation and management measures have been prescribed for the operational phase:

6.2.2.1 Berms

- Flood protection berms should be monitored after large rainfall events / monthly to ensure that they are not being eroded by the stream channels (Leeuspruit Section 2, Section 3 and Rietspruit Section) thereby reducing the functionality and health of the wetlands;
- Slow release outlet pipes installed within the berm should be monitored to ensure that any blockages are discovered and removed; and
- Berms should be monitored for erosion. Erosion must be remedied. If recurring erosion is taking place, alternatives should be explored.

6.2.2.2 Canal

- Monitoring the effectiveness of the canals by a suitably qualified engineer; and
- Biomonitoring to be conducted by suitably qualified wetland and aquatic ecologists.

6.2.2.3 General

- Limit the footprint area of the operational activities to what is essential to minimise impacts as a result of any potential vegetation clearing and compaction of soils (all areas but critically so in freshwater areas);
- If it is unavoidable that any of the freshwater areas present will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the freshwater features present takes place because of the proposed operational activities;
- All erosion noted within the operational footprint as a result of any potential surface activities should be remedied immediately and included as part of the ongoing rehabilitation plan (see Rehabilitation Report);
- A suitable AIP control programme must be put in place to prevent further encroachment as a result of disturbance to the surrounding terrestrial zones (see the Fauna and Flora Specialist Study for more information);
- All areas of increased ecological sensitivity should be designated as “No-Go” areas and be off limits to all unauthorised vehicles and personnel;
- No unnecessary crossing of the wetland features, instream areas and their associated buffers, as well as the constructed berms or canals should take place and the substrate conditions of the wetlands, instream areas and downstream stream connectivity must be maintained;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must remain on demarcated roads;
- All vehicles must be regularly inspected for leaks;
- Re-fuelling must take place on a sealed surface area away from freshwater features to prevent ingress of hydrocarbons into topsoil;
- All spills should be immediately cleaned up and treated accordingly;
- Appropriate sanitary facilities must be provided for the duration of the operational activities and all waste must be removed to an appropriate waste facility;
- Monitor all systems for erosion and incision;
- All erosion noted within the footprint should be remedied immediately and included as part of an ongoing rehabilitation plan;
- Ensure soil management programme is implemented and maintained to minimise erosion and sedimentation;
- All soils compacted because of construction activities should be ripped/scarified (<300mm) and profiled (see the Soil Specialist Report for more information);

- If significant rehabilitation measures are required, mitigation measures of the construction phase must be implemented;
- Permit only essential personnel within the 100 m zones of regulation for all freshwater features identified; and
- Ongoing wetland rehabilitation is necessary during the operational phase as stipulated in the monitoring section.

7 No Go Alternative

Areas identified to have a significant potential for pillar failure can result in subsidence. Should the proposed project not go ahead, there is an increased risk that water will be lost from the freshwater resources due to subsidence. Subsidence could potentially result in loss of freshwater habitat and a disruption, and sometimes a complete sever, in the hydrological links between freshwater systems on site, resulting in a desiccation of some areas. The degradation of wetlands and aquatic habitat will reduce biodiversity, increase erosion and reduce the capacity of wetlands to provide services such as nutrient cycling, water purification and flood attenuation. Should the subsidence result in the merging of surface and groundwater, this could result in contamination of the wetland and freshwater systems.

Table 7-1: No-go alternative impact assessment parameter ratings for all sections

Dimension	Rating	Motivation	Significance
Activity and Interactions: No-go alternative – potential pillar failure resulting in subsidence			
Prior to Mitigation/Management			
Duration	Permanent (7)	The impact may be irreversible and has the potential to remain after the life of the project. Freshwater resource habitat and function may be destroyed.	Major (negative) - 126
Extent	Region (5)	The no-go option may have a regional impact due to decreased catchment yield to the Vaal River.	
Intensity x type of impact	Irreplaceable loss or damage to biological resources, limiting ecosystem function (6)	Loss of water, decline in water quality and loss of natural habitat may be irreplaceably lost, thereby limiting ecosystem form and function throughout the system and reducing the habitat for instream ecology	
Probability	Definite (7)	Severe impacts to the system may occur should no mitigation measures be implemented to prevent pillar failure resulting in subsidence.	

Dimension	Rating	Motivation	Significance
Nature	Negative		
Post-Mitigation			
Duration	Permanent (7)	The impact is irreversible and will remain after the life of the project. Freshwater resource habitat and function will be destroyed.	Moderate (negative) -98
Extent	Local (3)	Habitat loss within the canals will affect the local watercourse and river reaches directly downstream.	
Intensity x type of impact	Serious loss and of biological resources or moderately sensitive environments, limiting ecosystem function. (4)	Habitat loss within the canals will affect entire watercourse and river reaches.	
Probability	Definite (7)	Severe impacts to the system may occur	
Nature	Negative		

8 Cumulative Impacts

The freshwater resources in this area are currently impacted because of extensive historical (Sasol) and current mining (sand) activities in the area. This has caused altered topography including subsidence which has resulted in fragmentation of systems. In addition, other impacts to freshwater resources present in the vicinity of the proposed project include agricultural cultivation, urban settlements, industrial development, road construction, coal conveyors, powerlines and associated servitudes.

9 Monitoring

9.1 Wetland Monitoring

Monitoring to be conducted by an independent suitably qualified wetland specialist. The timing of such monitoring audits should be as follows:

- Monthly during the construction phase;
- Quarterly for the first three years after construction;

- Annually for a minimum of two years should any ongoing issues be observed within the three years post-construction.

It is highly recommended that ongoing monitoring of the wetlands in the vicinity of the Sigma Defunct Colliery continue to identify any emerging trends in terms of improvements or degradations in the ecological integrity and functioning of these systems. This data should be compared to the results obtained in both this and historical studies to guide the management process going forward.

9.2 Aquatic Biomonitoring

Monitoring to be conducted by an independent suitably qualified aquatic specialist. The timing of such monitoring audits should be as follows:

- Quarterly during the construction phase;
- Biannually for a minimum of three years thereafter.

Monitoring is required upstream and downstream of the proposed activities and should include as a minimum: water quality, macro-invertebrate integrity, fish community integrity (On the lower reaches of the Leeuspruit system) and habitat suitability assessments. It is highly recommended that ongoing monitoring of the instream integrity in the vicinity of the Sigma Defunct Colliery continue to identify any emerging trends in terms of improvements or degradations in the ecological integrity and functioning of these systems, with special relevance to maintenance of biodiversity. It is advisable that the same assessor be utilised for ongoing monitoring purposes to minimise fluctuations and irregularities in the results because of variations in sampling times and efficiency.

10 Conclusion

10.1 Wetland Assessment

There are 413.9 ha of wetlands within the project specific sections. These wetlands have been categorised PES values ranging from D to E and EIS values ranging from moderate to low.

Approximately 51.5 ha have the potential to be lost through the implementation of the surface mitigation measures at Sigma Defunct Colliery. Of this, 9.8 ha has the potential to be lost directly and 41.7 indirectly, where direct loss constitutes the loss due to the infrastructure footprint and indirectly constitutes the drying out of the floodplain portions due to separation from the main channel as a result of the berm and canal. These surface mitigation measures will result in a decline in the PES and EIS of the wetland HGM units.

In addition to various mitigation measures, it is suggested that a Wetland Offset Strategy be implemented to account for the loss of wetlands due to the implementation of the project.

It is suggested that monitoring take place monthly during the construction phase, quarterly for the first three years after construction.

Armourflex or a similar product (e.g.Terraforce) will be used, filled with soil and planted. Please refer to the wetlands section of this report as well as the Rehabilitation and Soils reports for the berms.

10.2 Aquatic assessment

The upper reaches of both the Leeuspruit and the Rietspruit are comprised largely of wetland habitat. In many instances, a defined instream channel was absent. Therefore, of the eleven potential biomonitoring points assessed for the determination of the PES of the aquatic resources present within the study area, only six sites were considered suitable for water quality analysis and the application of the FRAI in the assessment of the fish community integrity; and only five sites were considered suitable for the application of the SASS5 and MIRAI methodologies used in the assessment of the macro-invertebrate community integrity within the study area. Nevertheless, data collected was deemed sufficient to determine the ecological status of the instream aquatic resources present within the study area.

10.2.1 Water Quality

Based on the *in situ* water quality variables recorded at the time of the survey, the elevated electrical conductivity values were expected to deter the colonisation and/or inhabitation of these watercourses by sensitive aquatic biota to some extent. However, it should be noted that extensive portions of this system were dominated by wetland habitat, the nature of which was expected to be a major driver of the elevated salt loads observed. As such, aquatic communities inhabiting these systems were expected to be relatively tolerant of the inherent water quality conditions observed.

pH values observed along the length of the portion of the Leeuspruit assessed may be regarded as somewhat alkaline. Electrical conductivity values recorded at the time of the survey were observed to exhibit moderate to high levels, which to an extent, was to be expected within a system inherently dominated by wetland habitat. However, an increase in electrical conductivity observed between sites SRD9 and SRD10 serve as an indication of some unidentified point and diffuse sources of pollution potentially emanating from the residential area adjacent to the Leeuspruit between sites SRD9 and SRD10, however, confirmation of these suspicions would require further infield investigation. Temperatures observed at each site may be regarded as largely natural on consideration of the natural seasonal and diurnal cycles at the time of the assessment and based on the inherent nature of the system at each point.

10.2.2 Aquatic Macro-Invertebrate Integrity

Based on the derived reference list and distribution, a total of approximately 50 different aquatic macroinvertebrate families were to be expected within the study area. Of these aquatic macroinvertebrate families, a total of only 25 taxa were collected at the time of the survey, ranging from 6 families at the Site SRD10 to 17 families at Site SRD4. Accordingly, the corresponding SASS5 scores ranged from a low 21 to moderate 84 at the same respective sampling sites. The highest Average Score Per Taxon (ASPT) values were observed at Sites SRD4 and SRD9 along the Leeuspruit, decreasing sharply downstream of Site SRD9.

Unsurprisingly, the lowest macroinvertebrate diversity obtained at the time of the survey was observed at Site SRD10. Both the SASS5 and ASPT scores thus reflect a direct impact to the Leeuspruit system because of impacts to the water quality observed at Sites SRD10 and SRD11. Some point and diffuse sources of pollution emanating downstream of Site SRD9 were deemed likely. The results of both the water quality assessment and well as the observed ASPT values, which are an indication of the general sensitivity of the colonised macroinvertebrate communities, serve as an indication, that water quality is a major driver within the Leeuspruit system.

On application of the MIRAI, the index suggested that the primary driver at each of the assessed sites was related to the limited available habitat present, which was to be expected for sites SRD1, SRD4 and SRD9 (Ecological Category E), however, the results suggest some impact related to water quality at sites SRD10 and SRD11 (Ecological Category F and E/F, respectively.

10.2.3 Fish Community Integrity

On application of the FRAI, the results indicated both poor diversity and abundance within the Leeuspruit system at the time of the assessment. An ecological category of E was thus assigned to this section of the Leeuspruit based on the results of the July 2018 survey.

The results of the July 2018 survey correspond with the historical data available for this portion of the Leeuspruit system. While many potential impacts related to the proposed activities (i.e. construction of the canal and berms) are likely to have a negative impact on the biodiversity of this portion of the Leeuspruit.

Special care will be required to minimise the loss of stream connectivity and fragmentation of the Leeuspruit system. In addition, strict monitoring will be required both in the study area as well as downstream of the proposed activities to ensure impacts are not expressed further downstream and to ensure no further loss to the ecological integrity of the system over the long term.

It is, however, important to note that should the proposed project not be permitted to proceed, the impacts relating to potential for pillar failure which can result in subsidence of the Leeuspruit and Rietspruit systems have the potential to outweigh the impacts relating to the system should the proposed rehabilitation and mitigation measures be granted.

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Appendix A: Ecological Assessment of Wetlands Associated with the Sasol Defunct Sigma Coal Mine: For Mine Closure

(Digby Wells, 2016)

Appendix B: Photographs

Photograph 1: Downstream of Leeuspruit (SRD1)

Photograph 2: Local site of Leeuspruit (SRD1)

Photograph 3: Upstream of Leeuspruit (SRD1)

Photograph 4: Downstream of Leeuspruit (SRD2)

Photograph 5: Local of Leeuspruit (SRD2)

Photograph 6: Upstream of Leeuspruit (SRD2)

Photograph 7: Downstream of Leeuspruit (SRD3)

Photograph 8: Upstream of Leeuspruit (SRD3)

Photograph 9: Downstream of Leeuspruit (SRD4)

Photograph 10: Local of Leeuspruit (SRD4)

Photograph 11: Upstream of Leeuspruit (SRD4)

Photograph 12: Downstream of Rietspruit (SRD5)

Photograph 13: Upstream of Rietspruit (SRD5)

Photograph 14: Downstream of Rietspruit (SRD6)

Photograph 15: Upstream of Rietspruit (SRD6)

Photograph 16: Downstream of tributary of Leeuspruit (SRD7)

Photograph 17: Upstream of tributary of Leeuspruit (SRD7)

Photograph 18: Dam (SRD8)

Photograph 19: Downstream of Leeuspruit (SRD9)

Photograph 20: Local of Leeuspruit (SRD9)

Photograph 21: Upstream of Leeuspruit (SRD9)

Photograph 22: Downstream of Leeuspruit (SRD10)

Photograph 23: Local of Leeuspruit (SRD10)

Photograph 24: Upstream of Leeuspruit (SRD10)

Photograph 25: Downstream of Leeuspruit (SRD11)

Photograph 26: Local of Leeuspruit (SRD11)

Photograph 27: Upstream of Leeuspruit (SRD11)

Appendix C: Plant Species Plan

PLANT SPECIES PLAN

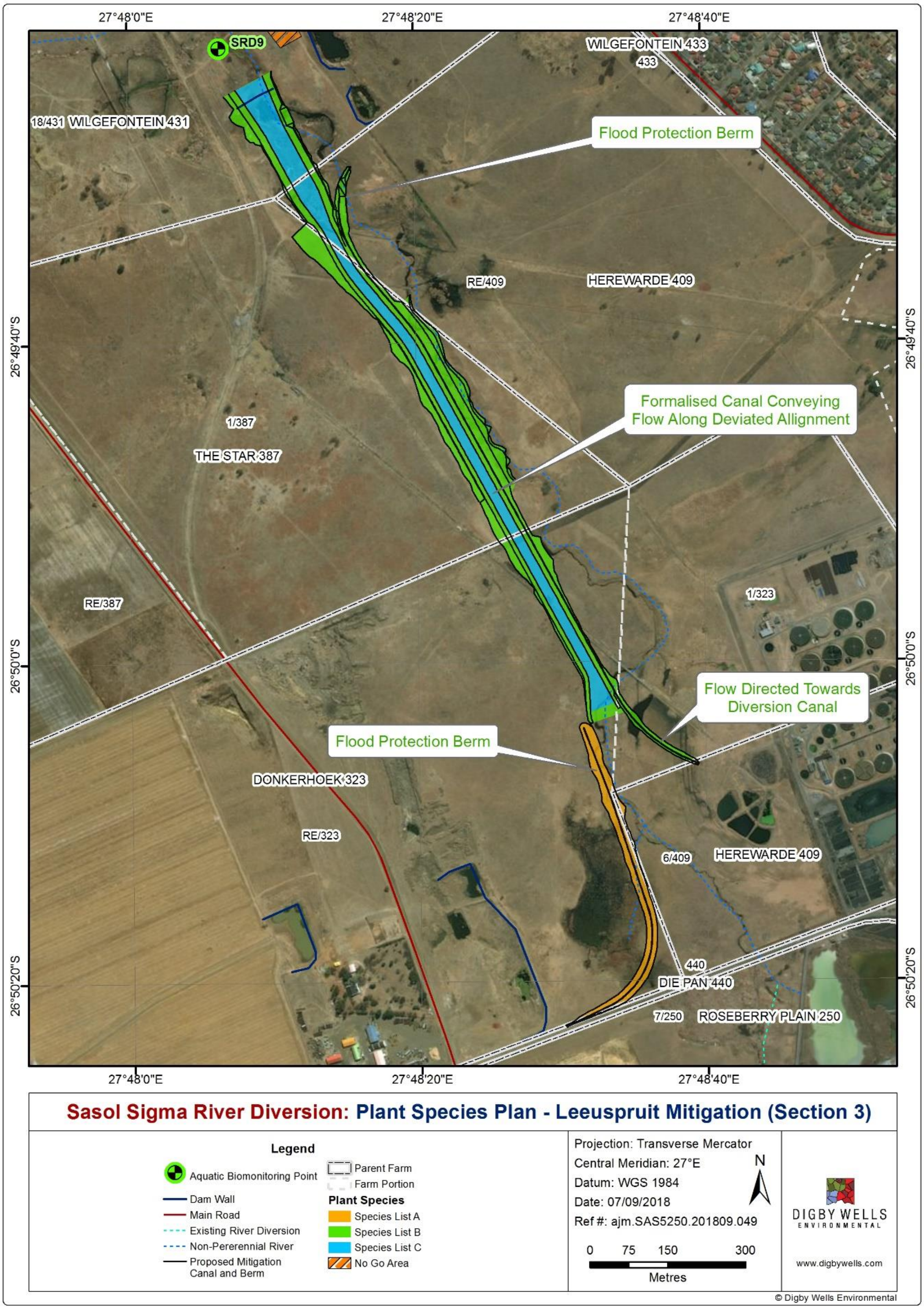
Revegetation is required as part of the mitigation measures of the project. For the erosion berms and canal, plants that offer good ground cover for erosion control and that establish and spread easily are ideal. A species such as *Cynodon dactlyon* is stoloniferous and aids in erosion control. It is also important that cattle and other grazing animals are kept off the erosion berms whilst vegetation is establishing. Non-palatable species have also been included in the species mix. Hydromorphic species will need to be planted within the canal and these species must be able to withstand fast flow and frequent inundation. The table below lists plant species suitable for revegetation of the canals and erosion berms. Species Group A are for the erosion berms and Species Group B for the edges of the canals, whilst Species Group C is for the permanent wetland area of the canal. It is advisable that hydromorphic plant species are planted as 'plugs' in a 1x1 m^2 grid in the gaps of the armorflex. Species such as *Typha capensis and Imperata cylindrica* will naturally colonise and spread from the initial plantings.

Plant Species Plan

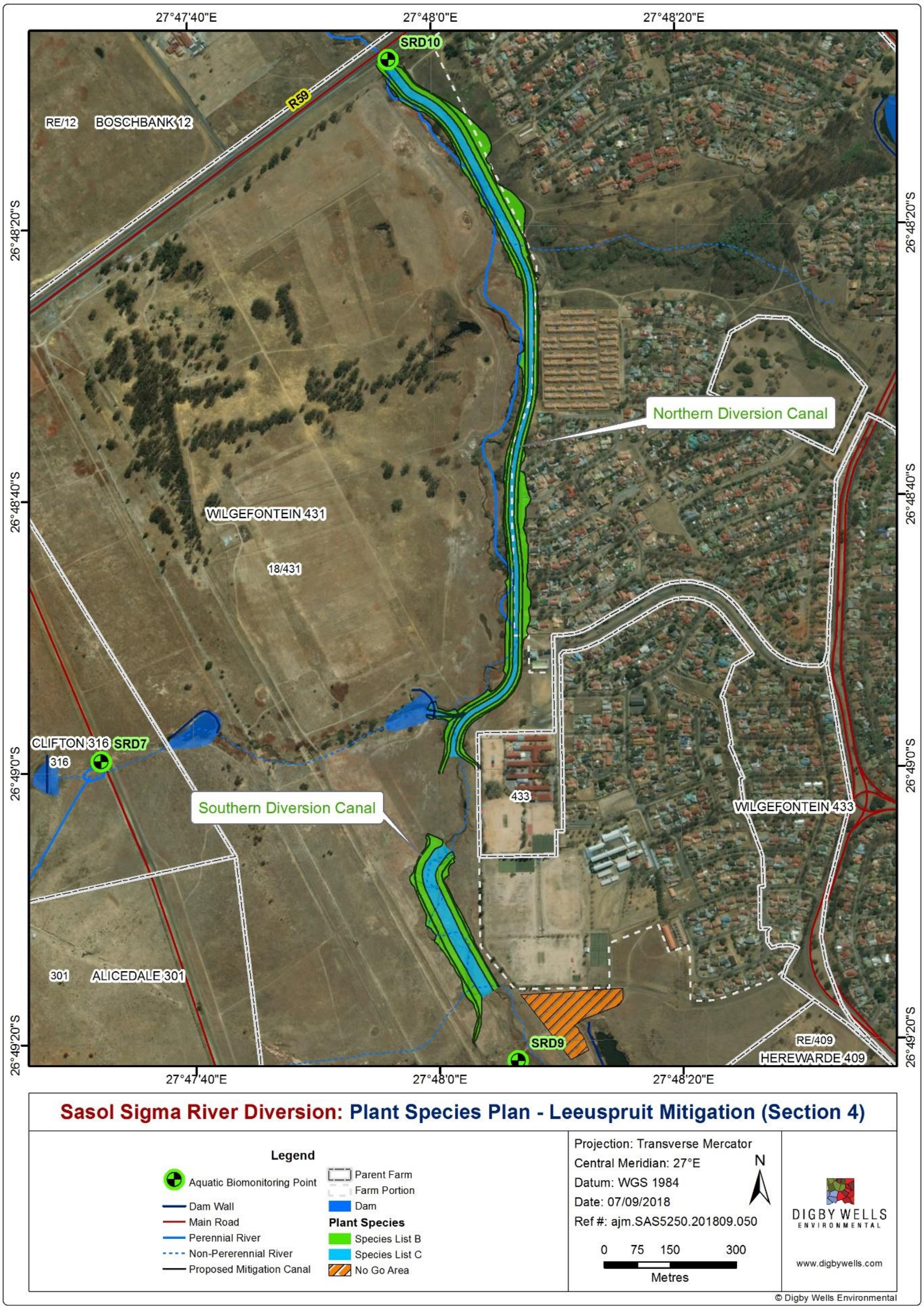
	Species Group A (Erosion berms)	**Species Group B (Canal edges)**	**Species Group C (Canal bed)**
Cynodon dactylon	X	X	
Hyparrhenia hirta	X		
Chloris gayana	X		
Digitaria erianthra	X	X	
*Melinis repens**	X	X	
*Pogonarthria squarrosa**	X	X	
Typha capensis			X
Imperata cylindrica			X
Schoenoplectus sp.			X

*dependent on seed availability

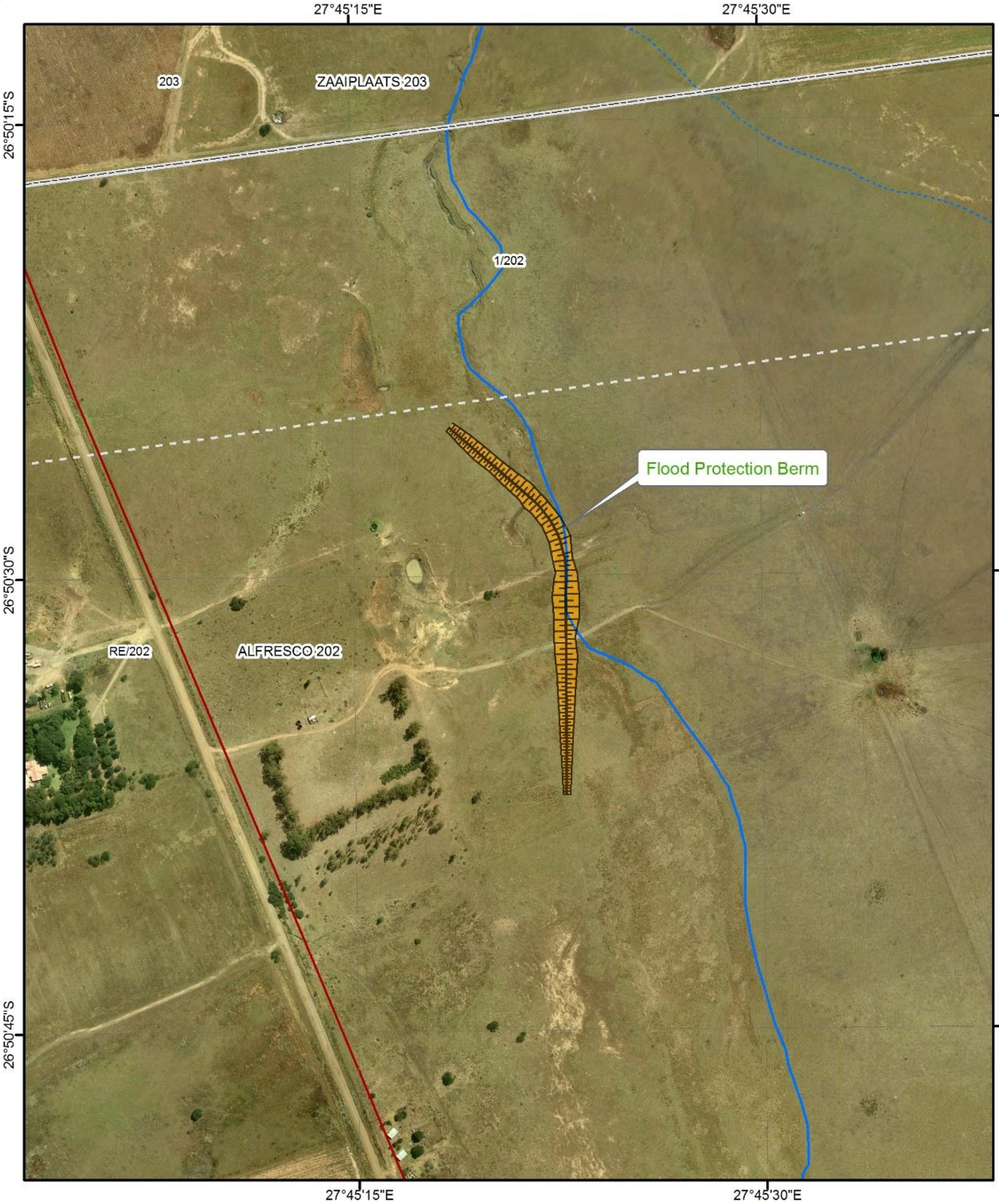
Plan 1: Plant Species Plan for Leeuspruit Section 2



Plan 2: Plant Species Plan for Leeuspruit Section 3



Plan 3: Plant Species Plan for Leeuspruit Section 4



Sasol Sigma River Diversion: Plant Species Plan - Rietspruit Mitigation (Section 1)

Legend
Main Road
Perennial River
Non-Pererennial River
Proposed Flood Protection Berm
Parent Farm
Farm Portion
Plant Species
Species List A

Projection: Transverse Mercator
Central Meridian: 27°E
Datum: WGS 1984
Date: 07/09/2018
Ref #: ajm.SAS5250.201809.051
N
0 50 100 200
Metres

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Plan 4: Plant Species Plan for Rietspruit Section 1