APPENDIX 31

HYDROPEDOLOGICAL ASSESSMENT

MARCH 2025

ZIMPANDE
RESEARCH COLLABORATIVE

Hydropedological Assessment

FOR THE PROPOSED CAPE WINELANDS AIRPORT DEVELOPMENT IN FISANTEKRAAL, WESTERN CAPE PROVINCE.

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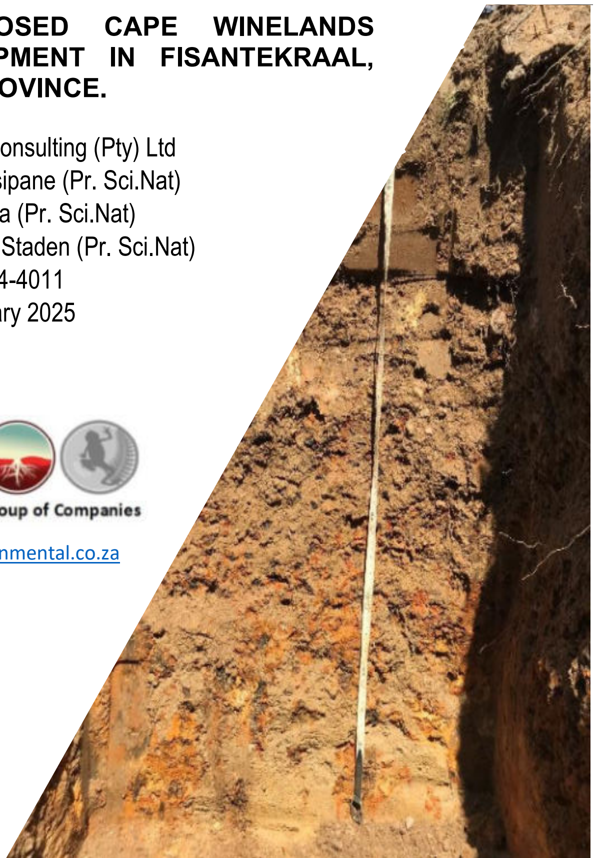

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EXECUTIVE SUMMARY

The Zimpande Research Collaborative (ZRC) was to undertake a hydropedology assessment as part of the Water Use License Authorisation (WULA) and Environmental Impact Assessment (EIA) processes for the proposed Cape Winelands Airport (CWA) development, located outside Fisantekraal, in the Western Cape Province. The development boundary for the proposed airport will henceforth be referred to as the "study area".

The preferred alternative for the proposed CWA development entails developing the existing airport and adjacent plots of land into a commercial and aviation hub, supporting flight operations domestically as well as regionally, serving as a "reliever" airport to the Cape Town International Airport, with a particular focus on non-aeronautical revenue streams.

The activities associated with the CWA development may intercept the subsurface flows in the vadose zone feeding the occurring watercourses as well as affect vadose zone recharge mechanisms. Thus, it was deemed necessary to investigate the recharge mechanism of the watercourse within and in close proximity to the study area to ensure that development planning takes cognisance of the hydropedologically important areas and hence enable informed decision making, construction design and support the principles of sustainable development. Recommendations considering mitigation were then considered and presented.

The objective of this study was to:

- Define the identified soil types and map them according to their hydropedological characteristics;
- Investigate the hydropedological drivers of the watercourses;
- Present a conceptual hydropedological model to assist in understanding water movement in the landscape;
- Determine the risk of the proposed activities on the watercourses;
- Quantify the hydropedological losses;
- Determine a suitable scientific buffer to minimise impact on wetland and avoid a change of PES/EIS class and functionality; and
- Present mitigation measures.

The proposed development area is associated with watercourse systems which traverse the study area and are in proximity to the proposed activities, thus it is deemed important to understand the status of the affected wetland in terms of their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) to ensure that the necessary protection is afforded.

According to FEN (2024), numerous wetlands (seep and channelled valley bottom (CVB) wetlands) are located within the study area and northern and eastern extent of the investigation area, although not all wetlands will be impacted by the proposed CWA development. However, the freshwater assessment by FEN (2024) quantitatively assessed a representative set of the wetlands that will be directly impacted by the proposed CWA development, whereas wetlands that may be indirectly impacted by the proposed CWA development are discussed qualitatively. The following freshwater systems were identified by the freshwater assessment within the study area:

- A seep wetland (seep wetland 1) was identified within the central portion of the study area. This seep wetland is indirectly linked, via an agricultural drain, to a channelled valley bottom (CVB) wetland located to the east and outside of the study and investigation areas;
- Three CVB wetlands were identified east of the study area. The larger CVB wetland (referred to as CVB wetland 1) is associated with the unnamed tributary of the Klapmuts River was identified running parallel with the eastern portion of the study area;

- No freshwater ecosystem indicators were identified within the central western portion of the study area;
- A quarry associated with historical open-pit clay mining activities (quarry) is located within the central portion of the study area;
- An artificial impoundment, connected to the CVB wetland 1 via a stormwater channel and agricultural drain, was identified along the eastern boundary of the study area.
- CVB wetland 4 was identified outside the study area and will not be directly impacted by the proposed development.

The majority of the study area has been subject to large scale transformation through historical clay mining, on-going agricultural practices, excavation and infilling activities. Thus, limiting or reducing the hydrological functioning and linkage of historic freshwater systems within the study area to the valley bottom wetlands identified outside the study area (i.e., Mosselbank River and the unnamed tributary of the Klapmuts River). Hydrological, geomorphological and vegetation modifications have occurred within the identified freshwater systems, in varying degrees. The PES of the identified CVB and Seep wetland systems were found to be in seriously modified and a largely modified state respectively. Table A below summaries the PES/EIS results of the identified HGM units with the study and investigation areas.

Table A: Summary of the overall scores per watercourse, as well as the calculated REC. (FEN,2024).

Resource	Present Ecological State (PES) Category	Ecological function and service provision	Ecological Importance and Sensitivity (EIS)	Recommended Ecological Class (REC)
CVB wetlands 2 and 3	Category E (Seriously modified)	Very Low	Low	D
Seep wetland 1 and 2	Category D (Largely modified)			

The study area is largely dominated by secondary accumulations of powdery gypsum and cemented horizons containing silica as the cementing agent. These soils typically occur under arid to extremely arid conditions with a high evaporative demand and are generally associated with calcareous soils. Deep drainage of water is typically restricted or limited in these soils, although infiltration occurs readily in the sandy surface horizons. Therefore, the hydrological flow path in these soils is upwards driven by evapotranspiration and have a very slow recharge rate. The soils associated with the seep wetlands included the soils characterised by uniform matrix colours resulting from a loss of colloidal matter, silicate clay and humus. These conditions typically result from the underlaying horizon restricting infiltration of water and thus facilitating the build-up and storage of water and release of water in a predominantly lateral direction. Deep interflow soils characterised by flow along the soil-rock interface were also observed as such the lithic material below the topsoil horizon was characterised by redoximorphic features.

The modelling exercise using the SWAT+(v 1.2.3) model was undertaken in effort to quantify the losses with specific mention of the lateral flow which can be anticipated as a result of the proposed development. The modelling exercise was undertaken at three (3) different scales namely, the Basin scale, the Landscape Unit scale as well as the Hydrological Response Unit scale (HRU). Detailed results of losses are presented in Section 7.4.

At the HRU scale, the site clearing activities and establishment of surface infrastructure will result in a decrease in the evapotranspiration component and an increase in direct evaporation from bare soil. The evapotranspiration component is regarded as the dominant water outflow mechanism since it accounts for approximately 78.71% of the overall water balance. This is thus supported by the type of soils identified within the study area which are largely associated with a high evapotranspiration demand. This is evident through the soils which are characterised by the presence of calcium carbonates, gypsum, cementation and lime in some instances.

The streamflow and surface runoff components depict an increase of 13.62% and 14.26% respectively in the post development scenario as a result of impervious surfaces from the proposed development and also soils with a low storage capacity which in the favourable conditions (intense rainfall and inclined slopes) will likely result in overland flow due to the low hydraulic conductivity of these soils. It is however notable that the pattern flow and timing of water movement in the landscape will be changed and as far as possible this impact must be managed with the Stormwater Management Plan ensuring that natural recharge and discharge processes are recreated, as far as possible.

The model predicts that the lateral flow component will remain fairly constant at this scale given the limited loss of approximately 0.4%, and with the percolation component decreasing by 4.35%. The profile available water slightly increases from initial conditions and thus the model predicts an increase in moisture as a result of the proposed development and this should be taken into consideration during the design and planning phase of the proposed development, especially with an increase in surface runoff as well. Overall, the hydropedological processes are predicted to remain largely unmodified in the post development scenario, and the functionality of the wetlands identified within the catchment area will likely remain unchanged, provided that stormwater is appropriately managed.

Table B: Summary of the water balance pre- and post-development at HRU scale.

	Before (mm)	% of WB	After (mm)	% of WB	Change	% Weighted Loss	Anticipated PES/EIS Change
Rainfall	623,2841		623,2841				No Change anticipated.
Streamflow	67,3854	10,8113	76,5647	12,2841	13,6220	1,6733	
Surface runoff	64,2743	10,3122	73,4410	11,7829	14,2618	1,6805	
Lateral flow	3,1111	0,4991	3,1237	0,5012	0,4049	0,0020	
Percolation	5,6349	0,9041	5,3896	0,8647	-4,3519	-0,0376	
ET	502,2760	80,5854	477,0062	76,5311	-5,0311	-3,8503	
eCanopy	5,9388	8,8132	6,5827	8,5975	10,8422	0,9322	
Transpiration	35,6774	5,7241	42,8946	6,8820	20,2289	1,3922	
Evaporation	460,6597	73,9085	427,5289	68,5929	-7,1920	-4,9332	
ET0	1576,6309		1576,6309				
Profile available water	1,2272		1,2425		1,2470		
Topsoil available water	9,1629		8,9367		-2,4678		

A scientifically derived buffer was developed to ensure that appropriate consideration of the hydropedological drivers in the study area is given in support of the principles of Integrated Environmental Management (IEM) and sustainable development. A buffer zone can be defined as a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another. As a result, the bigger the buffer the greater the results thereof. This is to allow a large enough area to allow for subsurface or surface flow of water to provide a steady but slow recharge to the groundwater or the downslope watercourse.

Based on the above, the buffer was developed to minimise impact in line with the mitigation hierarchy. The approach to the development of the scientific buffer considered the following;

- The hydropedologically important soils;
- Anticipated losses of lateral flows based on the SWAT+ Model;
- Edge effect of the proposed development; and
- The catchment area of the impact wetland.

Based on the CWA design practicality and consideration of the mitigation hierarchy, total avoidance of the potential impact on the interflow soils (Constantia) associated with the Seep 1 wetland according to the FEN Freshwater report (2024) as well as the buffer will not be possible. Given the geometric requirements of the airport and associated runway complex, avoidance of the scientific buffer is not practical. Thus, an offset investigation should be undertaken to identify suitable target wetland areas to be rehabilitated to compensate for the wetland habitat and functionality loss as a result of the proposed CWA development, which may counteract the negative impact associated with the loss of the interflow/seep wetland area.

Although the hydropedological losses are anticipated to be minimal, mitigation measures and recommendations have been compiled and these include but not limited to:

- All development footprint areas should remain within the demarcated areas as far as possible and disturbance of soil profiles to be limited to what is essential with a compact footprint;
- Subsurface lateral flow of water through the landscape (under seep wetlands and interflow soils) has to be taken into account and buildings/structures should accommodate waterproofing and water management structures to divert laterally seeping water away from foundations into the gardens or storm water structures.
- Increased surface sealing as a result of the proposed development will result in decreased infiltration as bulk of the stormwater from sealed or paved surfaces are generally discharged in stormwater systems. The exception to this is where runoff is localised and directed to unsealed surfaces or adjacent watercourses in an attenuated manner;
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed development;
- Only the designated access routes are to be used to reduce any unnecessary compaction;
- Water from clean water diversion structures should be discharged back into the adjacent wetland features in an attenuated manner; and
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed project.

The proposed project can be considered for authorisation from a hydropedological perspective as it is not anticipated to cause an unacceptable impact of the wetland recharge mechanisms based on the type of soils identified as well as the quantification of hydropedological losses. The PES/EIS and functionality will likely remain unchanged once mitigations have been implemented.

This document should be used as a guideline to manage water in the landscape surrounding the CWA operation by guiding the positioning, extent, design, management and rehabilitation of the disturbed areas.

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GLOSSARY OF TERMS

Alluvial soil:	A deposit of sand, mud, etc. formed by flowing water, or the sedimentary matter deposited thus within recent times, especially in the valleys of large rivers.
Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials e.g. gravel, sand, or silt, that contains and transmits groundwater.
Base flow:	Long-term flow in a river that continues after storm flow has passed.
Catena	A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic condition, but having different characteristics due to variation in relief and drainage.
Catchment:	The area where water is collected by the natural landscape, where all rain and run-off water ultimately flow into a river, wetland, lake, and ocean or contributes to the groundwater system.
Chroma:	The relative purity of the spectral colour which decreases with increasing greyness.
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.
Fluvial:	Resulting from water movement.
Gleying:	A soil process resulting from prolonged soil saturation which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix.
Groundwater:	Subsurface water in the saturated zone below the water table.
Hydromorphic soil:	A soil that in its undrained condition is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).
Hydro period	Duration of saturation or inundation of a wetland system.
Hydrology:	The study of the occurrence, distribution and movement of water over, on and under the land surface.
Hydromorphy:	A process of gleying and mottling resulting from the intermittent or permanent presence of excess water in the soil profile.
Intermittent flow:	Flows only for short periods.
Mottles:	Soils with variegated colour patterns are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.
Pedology	The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.
Perched water table:	The upper limit of a zone of saturation that is perched on an unsaturated zone by an impermeable layer, hence separating it from the main body of groundwater.
Runoff	Surface runoff is defined as the water that finds its way into a surface stream channel without infiltration into the soil and may include overland flow, interflow and base flow.
Swelling clay:	Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried.
Vadose zone	The unsaturated zone between the ground surface and the water table (groundwater level) within a soil profile.
Watercourse:	In terms of the definition contained within the National Water Act, a watercourse means: • A river or spring; • A natural channel which water flows regularly or intermittently; • A wetland, dam or lake into which, or from which, water flows; and • Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse; • and a reference to a watercourse includes, where relevant, its bed and banks

ACRONYMS

°C	Degrees Celsius.
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
ET	Evapotranspiration
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
HGM	Hydrogeomorphic
m	Meter
MAP	Mean Annual Precipitation
NEMA	National Environmental Management Act
NWA	National Water Act
PSD	Particle Size Distribution
SACNASP	South African Council for Natural Scientific Professions
ZRC	Zimpande Research Collaborative
WMA	Water Management Areas
WULA	Water Use Licence Application

1. INTRODUCTION

The Zimpande Research Collaborative (ZRC) was to undertake a hydropedology assessment as part of the Water Use License Authorisation (WULA) and Environmental Impact Assessment (EIA) processes for the proposed Cape Winelands Airport (CWA) development, located outside Fisantekraal, in the Western Cape Province. The development boundary for the proposed airport will henceforth be referred to as the “study area”.

The study area development is located on Portions 3, 4 and RE of Farm 474, Joostenberg Kloof, Portions 23, 10 and the RE of the Farm 724 Joostenberg Vlakte, and Portion 7 of Farm 942, Kliprug, Fisantekraal, within the City of Cape Town (CoCT) District Municipality. The study area is located approximately 11 km northeast of the suburb of Durbanville and 25 km northeast of the Cape Town International Airport. More specifically, the study area is situated north of the R312, to the east of R302 and to the west of R304. Figure 1 depicts the location of the study area in relation to surrounding areas.

Figure 1: Locality map depicting the Study area and surrounding areas.

1.1 Project Description

The study area has been subject to historical mining and agricultural activities, and more currently, activities associated with the existing Cape Winelands Airport. The existing airport, confined to the southern portion of the study area, is a former South African Air Force airfield built circa 1943 and is currently operational as a general flying airfield used for flight training, aircraft maintenance, private charter flights, hangarage for private plane owners, and the sale of aviation fuel.

While no site or activity alternatives exist, four development layout alternatives for the proposed CWA exist:

1. A “no-development” option;
2. An initial phased development alternative (alternative 2);
3. A revised phased development option (alternative 3); and
4. An amended phased development option (the preferred alternative 4).

The preferred alternative for the proposed CWA development entails developing the existing airport and adjacent plots of land into a commercial and aviation hub, supporting flight operations domestically as well as regionally, serving as a “reliever” airport to the Cape Town International Airport, with a particular focus on non-aeronautical revenue streams. Four concrete air strips currently exist on site, each of 90 m width and of varying lengths, and referred to as air strips 01-19, 05-23, 14-32 and 03-21 (Figure 2)

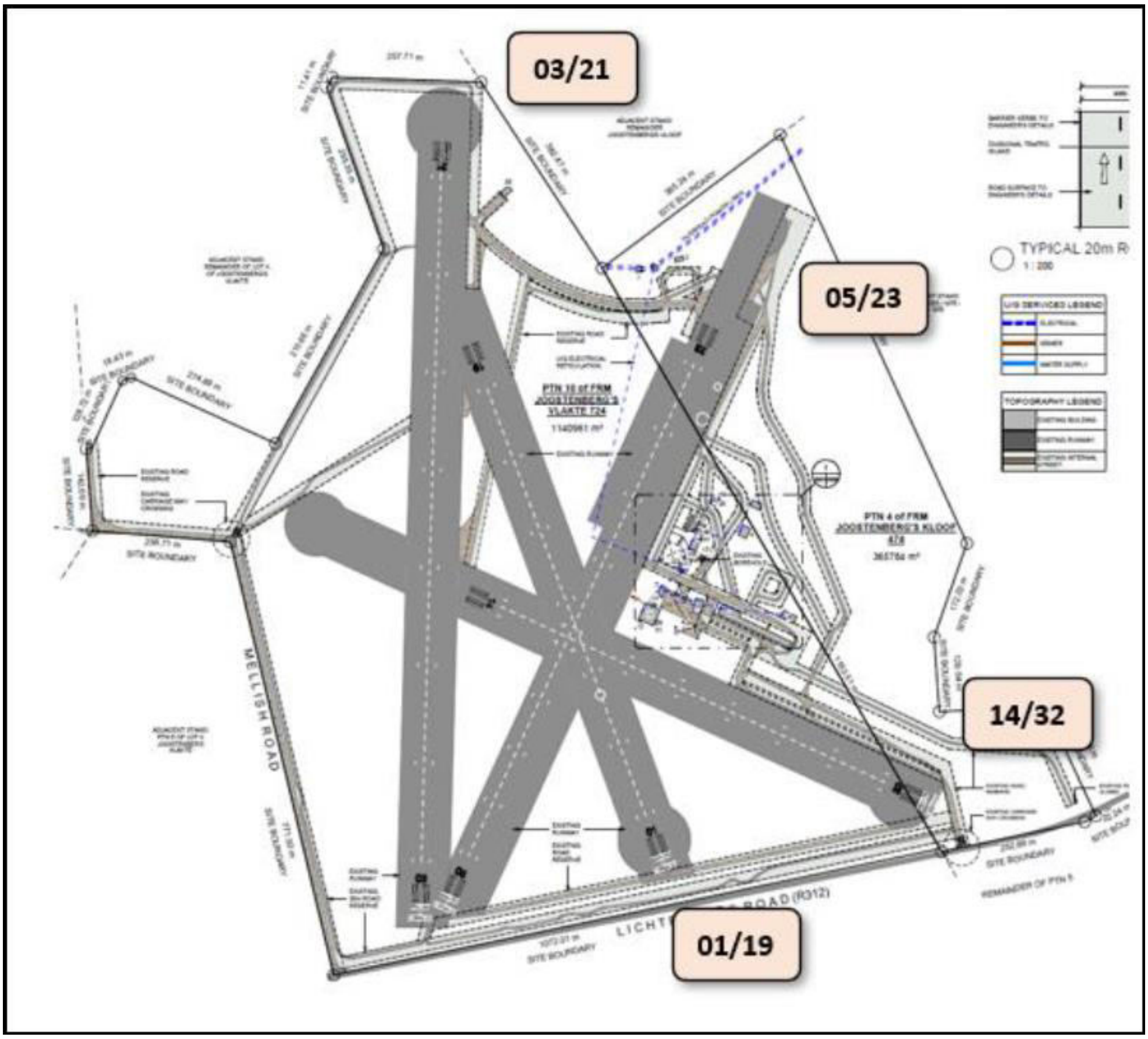

Figure 2: Existing concrete air strips located within the southern portion of the study area.

The most significant differences between the preferred alternative and alternative 2 are the omission of the crosswind runway (airstrip 14-32) from the first phase of the preferred alternative. In addition, layout changes within the study area are also proposed which includes the addition of a solar photo-voltaic (PV) facility in the south-eastern portion of the study area, as well as other technology and design alternatives which were not included in the alternative 2. The risk of the four development alternatives is outlined and discussed in Section 8 below.

The preferred alternative of the CWA development is divided into four precincts – Air Side, Landside, General Aviation and Services, which are all described in detail below. The below project description was provided by the EAP (PHS Consulting, *pers. comm.*).

Airside Precinct Development

During Phase 1, the airport will feature a single runway with an orientation of 01-19 and a length of 3.5 km, designed to accommodate Code 4F instrument operations. This runway will serve all types of operators, including both scheduled commercial and general aviation flights. To enhance efficiency for general aviation, intersection take-off points will be implemented on the runway.

The airside development in Phase 1 will also include various systems such as a CAT III Instrument Landing System, Precision Approach Path Indicators, Glidepath Antennas, Meteorological Systems, Airfield Ground Lighting, and Remote Digital Control Tower Systems.

Additional proposed developments for Phases 1 and 2 of the Airside Precinct include:

- **Aircraft Parking Aprons**: Passenger terminal apron, general aviation and Fixed Base Operators (FBO) aprons, isolation pad, cargo apron (Phase 2), and maintenance, repair and overhaul (MRO) apron (Phase 2).
- **Aircraft Parking Stands**: These will range from International Civil Aviation Organization (ICAO) Code B to Code F. The development anticipates 11 Multiple Aircraft Ramp System stands (equivalent to 21 Code C stands), some of which will have passenger boarding bridges and will be capable of accommodating up to Code F aircraft. Additional remote stands will be provided, accessible by bus or on foot. One Code E cargo aircraft stand and two Code E MRO stands are also planned.
- **Airside Service Roads and Security**: Service roads will be built to facilitate vehicle access to airport assets. A security fence will be erected in accordance with aviation security standards.
- **Electricity Supply**: The bulk electricity supply will be terminated within the CWA site at a connection point comprising an Eskom local substation, housed in a secure enclosure measuring approximately 5 000 mm by 4 000 mm.

Landside Precinct Development

Phase 1 and 2 of the Landside Precinct will include several key developments:

- **Passenger Terminal Building (PTB):** (Phase 1) The PTB will serve as the hub for airport operations, bridging airside and landside areas, and will be designed to handle both domestic and international passengers, with a capacity of 5.2 million passengers per annum. The design will comply with ICAO Annexes and the International Air Transport Association Airport Development Reference Manual (12th edition, May 2022). The building will include specialized facilities for check-in, bag drop, security screening, and customs and immigration for international traffic. A Very Important Person (VIP) processing facility will provide direct access to the airside for government officials, VIPs, and Commercially Important Persons.
- **Commercial Developments:** (Phases 1 and 2) Approximately 350 000 m² of lettable area will be available for various commercial uses. The terminal precinct will feature a terminal plaza with hotels, an aviation museum, hangars, aviation clubs, a training centre, workshops, logistics, warehousing, and light manufacturing.
- **Additional Developments:** Petrol service station, hotel, internal road system, drop-and-go facilities, car rental services, parking (multi-storey and at-grade), pedestrian walkways, substations, billboards, droneport, vertiports, gardens, public transport facilities (Phase 2), and car park/ vertical take-off and landing facilities (Phase 2).

General Aviation Precinct

The General Aviation Precinct for Phases 1 and 2, including business aviation, will be located on the southern side of the airport. Facilities for FBOs will be situated along a dedicated taxi lane providing direct access to the main runway via a parallel taxiway. The precinct will also feature a general aviation kerbside refuelling station for AV-gas at the southernmost corner and a clubhouse with airside views and adjacent grass parking for visiting aircraft. Helicopter operations will be conducted from dedicated Final Approach and Take-Off areas.

Proposed developments for the General Aviation Precinct in Phases 1 and 2 include:

- FBO hangars;

- General aviation hangars;
- Clubhouse area;
- Final Approach and Take-Off infrastructure;
- AVGAS station;
- Substation; and
- Remote digital control tower.

Services Precinct

Key airport support facilities are located within the Services Precinct, primarily on the western side of the airport, accessible via the secondary landside road system. These facilities include aircraft rescue and firefighting services, airport maintenance, ground support equipment staging, cargo handling, aircraft MRO, and aircraft fuel facilities. The precinct also accommodates renewable energy installations such as solar PV and a biodigester.

Planned developments for Phases 1 and 2 of the Services Precinct include:

- **Fuel Facilities:** A bulk fuel depot, general aviation kerbside refuelling station, commercial/retail service station (Phase 1), and an underground fuel line from the bulk depot to the aprons (Phase 2).
- **Aircraft Rescue and Fire Fighting:** (Phase 1) Positioned near the runway centre to ensure rapid response within the required ICAO standards of two to three minutes.
- **Cargo Facility:** (Phase 1) Located airside, near the passenger terminal building, to handle both belly cargo and full freighter aircraft. Initially, full freighter aircraft will use the main apron, with a dedicated freighter stand added as traffic increases.
- **Airport Maintenance Facilities:** (Phase 1) Located in the Services Precinct, with access to both airside and landside.
- **GSE Staging Areas:** (Phase 1) Located close to the main apron, with two designated areas for parking.
- **MRO Facility:** (Phase 1) Positioned in the northern part of the airport, with a widebody aircraft parking position, associated hangar, and additional space for more aircraft.
- **Catering Building:** (Phase 2) Located in the northern area, with direct access to both airside and landside.
- **Renewable Energy:** (Phases 1 and 2) Provision for solar PV and bio-digester.
- **Airport Operations Centre:** (Phase 1) A multi-storey building with space for key airport support services, government offices, and an air traffic control centre.
- **Air Traffic Control Centre:** (Phase 1) Located on the upper floors of the Airport Operations Centre.
- **Additional Developments:** (Phases 1 and 2) Potable water reservoir, groundwater treatment infrastructure, water pump station, solid waste storage, wastewater treatment works (WWTW), substation, and cargo apron (Phase 2).

The proposed layout of Phase 1 and Phase 2 of the development (preferred alternative) is indicated in Figure 3 and Figure 4.

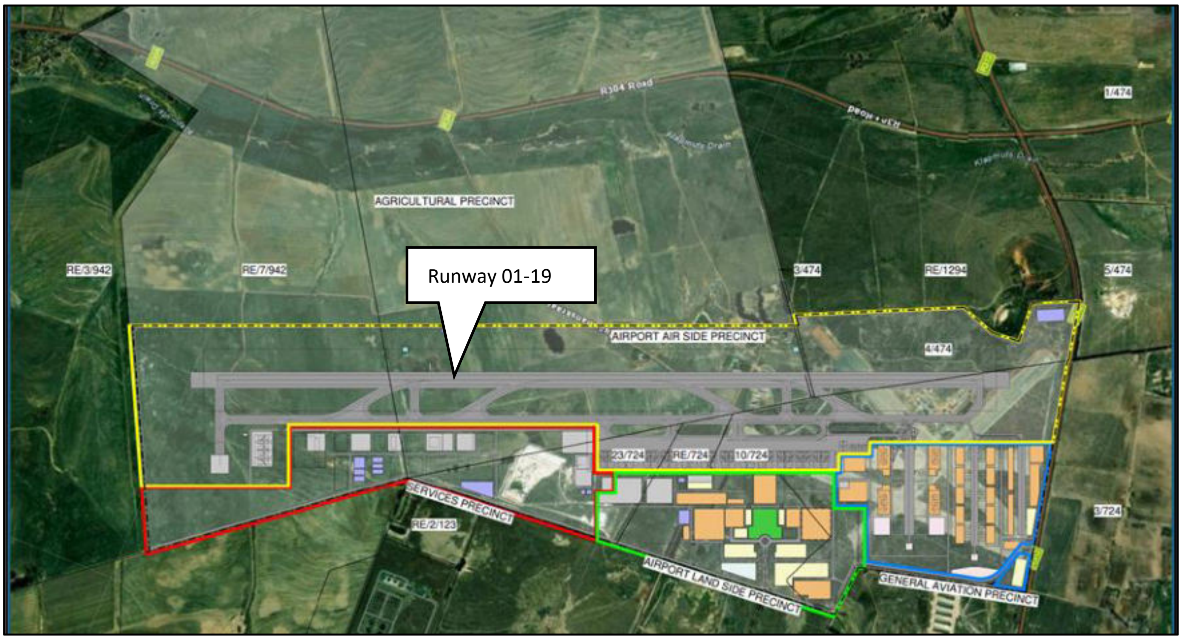

Figure 3: Proposed layout of the CWA development during Phase 1 of the preferred alternative.

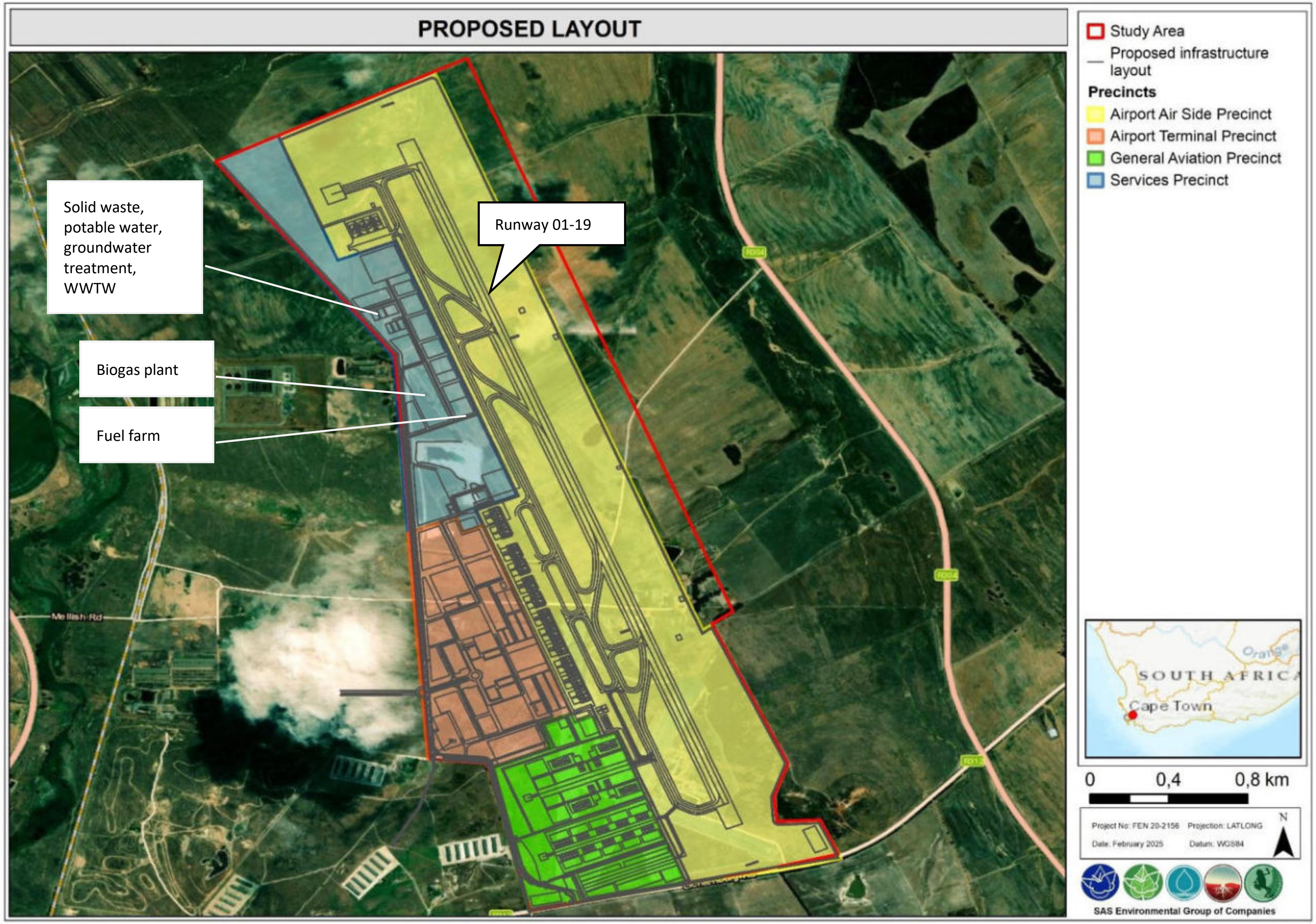

Figure 4: Proposed layout of the CWA development during Phase 2 of the preferred alternative.

The following is of note regarding the bulk service requirements for the proposed CWA development as depicted on Figure 5 below:

Water Supply and Reticulation:

- There is very limited nearby council watermains in the vicinity and there are no existing municipal potable pipelines in close proximity to the study area, the closest supply point is in the Fisantekraal Settlement booster pumpstation, approximately 3 km away from the study area;
- The existing buildings are currently serviced through boreholes; and
- The strategy of water supply to the CWA development in the short to medium term is one of a phased approach which includes the continued use of groundwater in the short-term until such time that sufficient supply is available from municipal supply from the Muldersvlei and / or Spes Bona reservoirs. It is still being determined whether the booster pumpstation has sufficient capacity to supply the proposed CWA development, as described below:
  - Phase 1: an on-site borehole solution, is currently being considered for the proposed CWA development as a short term solution or as the primary supply, with the inclusion of the use of a water treatment plant to treat water abstracted from the boreholes to SANS 241 standard. According to Zutari (2024a), these boreholes have been drilled;
  - Phase 2: connection to the municipal supply in Lichtenberg Road, initially through the trunk main connected to the Spes Bona reservoir, and then directly to the Muldersvlei reservoir once available.

Sewer Reticulation and Treatment:

- Existing infrastructure is serviced through septic tanks; and
- The nearest Waste Water Treatment Works (WWTW), i.e., the Fisantekraal WWTW, is 3 km from the study area. A few options are being investigated in terms of connecting the sewer reticulation and treatment of the proposed CWA development to the Fisantekraal WWTW. This includes:
  - Option 1: constructing a pumpstation and associated rising main to pump the sewage;
  - Option 2: constructing an onsite package sewerage treatment plant to treat sewage on site, designed as a closed system; and
  - Option 3: a dual treatment approach, optimising sewage treatment with an onsite package sewerage treatment plant and reusage of non-potable water on site, while using a primary pumpstation and raising main to direct remaining sewage to the Fisantekraal WWTW for further treatment and disposal (preferred). This option would also include a lifting station for non-potable water, a sludge processing area and an emergency overflow pond, as well as an emergency overflow to the primary sewer pump station from the package sewerage treatment plant, directing all development demands to the Fisantekraal WWTW in case of failure.

Stormwater:

- It is proposed that stormwater be managed through a network of underground pipes that carry stormwater to dry stormwater and attenuation ponds. Various catchment and attenuation options are being considered for the proposed CWA development;
- The quarry located within the northern portion of the study area is currently being investigated for use as a stormwater retention facility for the proposed CWA development; and
- It is proposed that the western precinct be reshaped so that most of the stormwater flows towards the quarry.

It is proposed that seven (7) dry stormwater attenuation ponds will be constructed within the CWA development footprint to which stormwater from the development will be directed. The size of the dry stormwater attenuation ponds will range between 350 m^3 and 10 800 m^3. The quarry will be converted into a wet pond, with a capacity of 95 000 m^3.

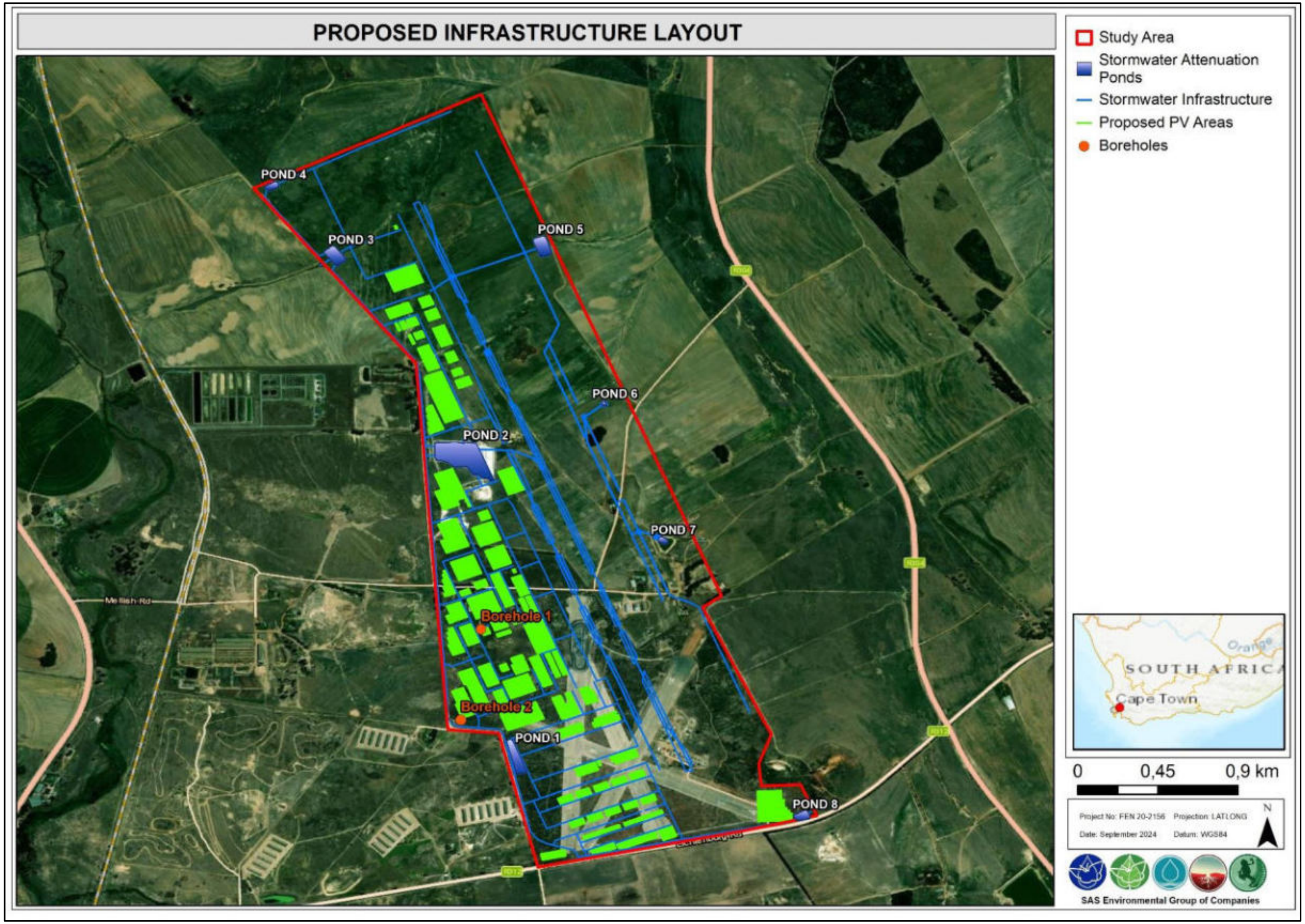

Figure 5: Location of the proposed stormwater infrastructure, PV facilities and boreholes associated with the CWA development.

Electricity:

The bulk mains electrical supply to the CWA development will be connected to the Eskom Grid as described below.

The connection will be completed using two feeders which will be routed to the site using 66 000 V feeder cables. The final routing of the Eskom connection is yet to be determined. The bulk electricity supply will terminate within the CWA development in two high voltage substations, one in the southwest corner of the airport, and one in the mid-west portion. The connection points will comprise an Eskom high voltage substation, Consumer Substations fitted with 66000:11000 Volt Step-Down Power Transformers, and Medium Voltage Power Distribution Systems.

Numerous primary energy sources are considered to be used at the CWA development. The first option is to construct a bio-digester plant using sewage effluent. The bio-digester plant will be designed to provide 1-MW of continuous power through the creation of biogas which is accumulated into a bladder system and converted into electricity. Approximately 15 tons of energy crop (Napier grass) are required per day, which will be diluted with 200 m³ of treated effluent/water generated from the CWA development. The use of chicken manure was considered in alternative 3, however this has been removed in the preferred alternative. Other waste sources can at a later stage be included in the bio-digester. The second alternative is to use PV systems (with a combined capacity of 1000 kW) combined with battery storage to provide electricity to the CWA development. It is intended that municipal electricity supply will be used as a backup source of power in the vent of plant failure or maintenance to the primary plant. It is currently proposed that the bio-digester plant and PV system is utilised in unison to provide electricity to the CWA development. A wind power turbine generator plant was also considered in alternative 3, however this was removed in the preferred alternative due to spatial and design constraints. Non-renewable and renewable secondary backup power supply is also being investigated.

Lighting and security services will also be installed for the airport boundary, aprons, parking areas, airport entrances, etc. These are explained in more detail below.

- Boundary Lighting including Entrance and Parking Areas:
  - LED luminaires will be fitted on 6 m high concrete poles at 30 m centres around the entire site. The designed lighting level will be 30-lux; and
  - A series of 30 kVA mini-substations will be provided around the site, allowing for site-wide distribution at 11 000 V and 400 V three phase power supplies for local street lighting connections.
- Apron Lighting:
  - EWO R-System R4 floodlights will be fitted on 28 m masts with integrated pulley system (to raise/lower mast-top flood lighting mounting) with a high-mast vehicle barrier around each mast light pole. The designed lighting level for the apron aircraft parking will be 30-lux; and
  - A mini-substation will be provided for the apron lighting system, allowing for connection to the site-wide distribution at 11 000 V, and 400 V three phase power supplies for local mast lighting connections.
- Airfield Side: Boundary & Apron Security Services:
  - A hybrid daylight/thermal imaging camera system will be installed for the security envelope, allowing for automatic intruder alert monitoring.
  - Outdoor rated horn speakers and fixed lighting/CCTV camera masts will be installed allowing for Security Control voice instructions to Security Staff and Intruders. The CCTV cameras will be mounted on concrete poles (for image stability) and connected to the monitoring/image storage headend using a dedicated fibre-optic cable network. The field cameras will be powered using the Boundary Lighting Electrical Network, and intruders monitored between the illuminated boundary fencing and the airfield runways using the thermal imaging. The CCTV will be linked to the Boundary Electric Fence

Monitoring System, such that Security Control Room Operators automatically have TV Monitoring of the affected security breach;
- An electric Fence and associated monitoring system will be provided by the Security Fence Installer Specialist; and
- Security services will be installed at the vehicle entry/exit control to the Cape Winelands Airport Road entrances.

Traffic services:

Existing access to the properties is via the Lichtenberg Road (R312). Various options are being considered for future access to the CWA development, taking into consideration the surrounding proposed developments of Greenville Garden City to the south, and Bella Riva to the west. Various access opportunities to the road network system are available for the site west of the runway. These include the existing Melish Road (OP 6/8) connection onto Lichtenberg Road, the future Class 3 Lucullus Road extension and the future Class 3 Melish Road extension through Bella Riva. Site access for any development east of the runway could potentially be from Lichtenberg Road (R312) or via Koelenhof Road (R304) over private property.

Internal roads will be designed to accommodate pedestrian and bicycle traffic. Preliminary designs of the internal roads are provided in Figure 6.

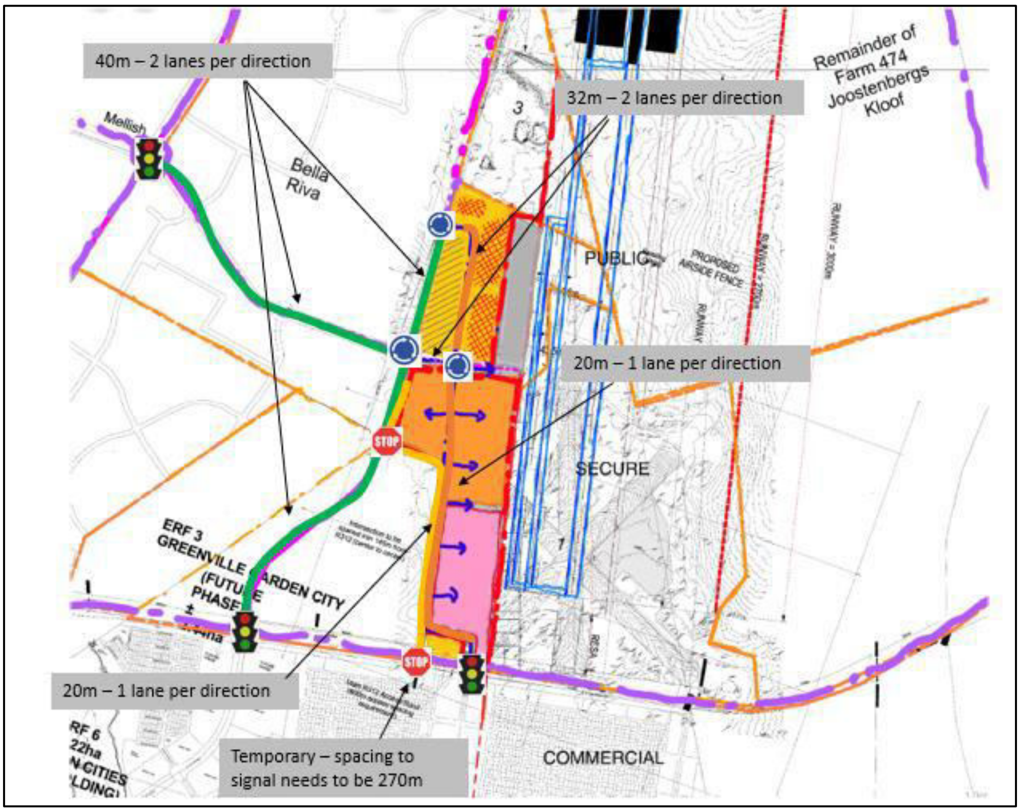

Figure 6: Preliminary internal road design.

1.2 Study Objectives

The proposed activities may intercept the subsurface flows in the vadose zone feeding the occurring watercourses as well as affect vadose zone recharge mechanisms. Thus, it was deemed necessary to investigate the recharge mechanism of the watercourse within and in close proximity to the study area to ensure that development planning takes cognisance of the hydropedologically important areas and

hence enable informed decision making, construction design and support the principles of sustainable development. Recommendations considering mitigation were then considered and presented.
The objective of this study was to:

- Define the identified soil types and map them according to their hydropedological characteristics;
- Investigate the hydropedological drivers of the watercourses;
- Present a conceptual hydropedological model to assist in understanding water movement in the landscape;
- Determine the risk of the proposed activities on the watercourses;
- Quantify the hydropedological losses;
- Determine a suitable scientific buffer to minimise impact on wetland and avoid a change of PES/EIS class and functionality; and
- Present mitigation measures.

Figure 7: A general overview of the landscape setting where the proposed development is to be developed.

1.3 Assumptions and Limitations

- The focus of this study was to define the dominant hillslope processes and therefore the transects focused on the dominant processes, but some "micro-processes" may occur which have not described;
- This assessment was confined to the study area as depicted in Figure 1, however the neighbouring and adjacent areas within the greater development area were investigated and considered so as to indicate the destination and fate of water in the landscape.
- Sampling by definition means that not all areas are assessed, and therefore some aspects of soil and hydropedological characteristics may have been overlooked in this assessment. However, it is the opinion of the professional study team that this assessment was carried out with sufficient sampling and in sufficient detail to enable the proponent, the Environmental

Assessment Practitioner (EAP) and the regulating authorities to make an informed decision regarding the proposed activity; and
- The effects climate change dynamics were not considered as part this assessment; however, it is acknowledged that this might exacerbate the anticipated impact associated with a reduction in water inputs and the resultant hydrological function of the remaining wetlands beyond the extent of the proposed development.

2. ASSESSMENT METHODOLOGY

A hydropedological survey and sampling activities were conducted in March 2024 to assess the hydropedological characteristics of the landscape associated with soils within the study area. This date was deemed acceptable since seasonality has no bearing on the hydropedological characteristics. A soil sampling exercise was undertaken at selected representative points, considering the various soil types, to deduce the wetland recharge mechanisms and identify the anticipated hydropedological impact of the proposed development on the wetland resources that will be affected by the proposed development. soil observations were made by means of a TLB and additional soil subsurface observations by means of a soil hand auger.

Identification of the representative hillslope/s

Prior to the site visit a desk-based exercise was undertaken which included the following:
- Identification of land types (Land Type Survey Staff, 1972 – 2006) within the study area; and
- Identification of dominant hillslopes (from crest to stream) of the study area using terrain analysis.

Conceptualize hillslope hydropedological responses

- Transect soil survey was conducted on each of the identified hillslope (Le Roux et al., 2011);
- Soil observations were made at regular intervals, not exceeding 100 m, on the transect;
- Analysis of soil was made by means of a hand augur as well as analysis of exposed profile areas which depict the diagnostic horizon sequence; and
- Soil observations were made until the layer of refusal.

Field assessment data included description of physical soil properties including the following parameters to characterise the various recharge mechanisms of the investigated wetlands:
- Diagnostic soil horizon sequence;
- Landscape position in relation to the investigated wetlands (recorded on GPS); and
- Depth to saturation (water table), if encountered.

Conceptual hillslope hydropedological response

The occurrence, sequence, and coverage of the different hydropedological groups on a transect was used to describe the hydrological behaviour of the hillslope (van Tol *et al*., 2013). This includes a graphical representation of the dominant and sub-dominant flowpaths at hillslope scale prior to development (as presented in Section 5.3). This will include:

- Overland flow;
- Subsurface lateral flow;
- Bedrock flow;
- Return flow; and
- Storage mechanisms.

Step 3: Quantification of hydraulic properties and flowrates

- Identify the representative soil forms and horizons from the transect survey.

- Collect selected verification samples for textural analysis, bulk density and conductivity at a SANAS accredited analytical laboratory.
- Relate the measurements to the conceptualised hydropedological response model to provide a quantitative description of flowrates and storage.

Step 4: Quantification of hydropedological fluxes

- Identify the potential impacts of the proposed development on the unsaturated flow processes and wetlands.
- Recommend suitable mitigation and management measures to alleviate the identified impacts on the wetland hydropedological drivers.
- Based on the outcome of the hydropedological assessment and taking into consideration the results of the geohydrological assessment, a scientifically determined buffer will be generated around the affected wetlands.
- Compile a specialist report on the conceptual hydropedological regime of the investigated wetlands based on the identified soil types under current conditions.

Table 1: Average permeability for different soil textures in cm/hour Food and Agriculture Organization (FAO), 1980.

Soil Texture	Permeability (cm/hour)
Sand	5
Sandy loam	2.5
Loam	1.3
Clay loam	0.8
Silty clay	0.25
Clay	0.05

Table 2: Soil permeability classes for agriculture and conservation (Food and Agriculture Organization (FAO), 1980.

Soil permeability classes	Permeability rates*	
	cm/hour	cm/day
Very slow	Less than 0.13	Less than 3
Slow	0.13 - 0.3	3 - 12
Moderately slow	0.5 - 2.0	12 - 48
Moderate	2.0 - 6.3	48 - 151
Moderately rapid	6.3 - 12.7	151 - 305
Rapid	12.7 - 25	305 - 600
Very rapid	> 25	> 600

****Saturated samples under a constant water head of 1.27 cm***

Table 3: DWS range of hydraulic conductivities in different soil types (DWS Groundwater Dictionary, 2011).

Soil Type	Saturated Hydraulic Conductivity, K_s (cm/s)
Gravel	$3x10^{-2}$ – 3
Coarse Sand	$9x10^{-5}$ – $6x10^{-1}$
Medium Sand	$9x10^{-5}$ – $5x10^{-2}$
Fine Sand	$2x10^{-5}$ – $2x10^{-2}$
Loamy Sand	$4.1x10^{-3}$

Soil Type	Saturated Hydraulic Conductivity, K_s (cm/s)
Sandy Loam	1.2×10^{-3}
Loam	2.9×10^{-4}
Silt, Loess	$1 \times 10^{-7} – 2 \times 10^{-3}$
Silt Loam	1.2×10^{-4}
Till	$1 \times 10^{-10} – 2 \times 10^{-4}$
Clay	$1 \times 10^{-9} – 4.7 \times 10^{-7}$
Sandy Clay Loam	3.6×10^{-4}
Silty Clay Loam	1.9×10^{-5}
Clay Loam	7.2×10^{-5}
Sandy Clay	3.3×10^{-5}
Silty Clay	5.6×10^{-6}
Unweathered marine clay	$8 \times 10^{-11} – 2 \times 10^{-7}$

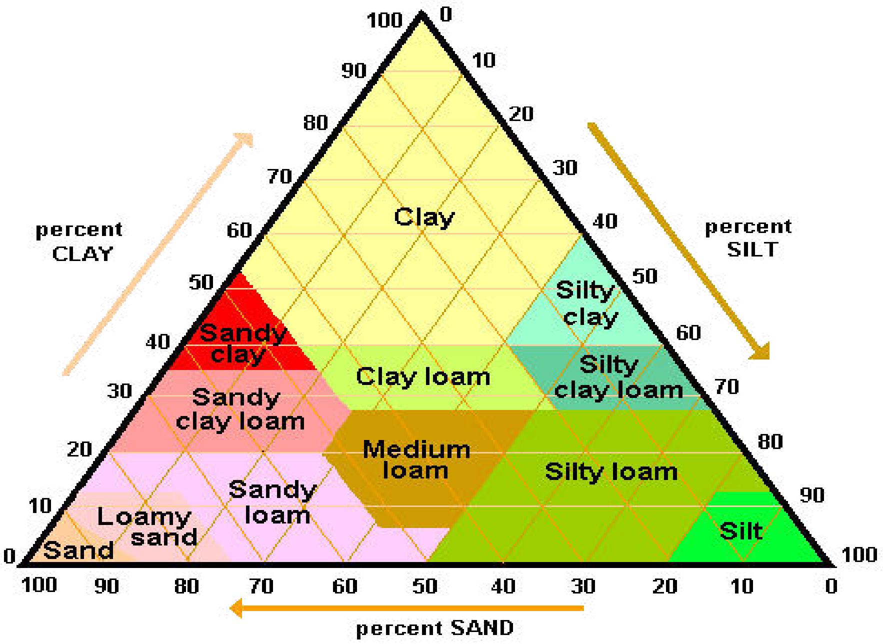

Figure 8: Soil texture classification chart (Food and Agriculture Organization (FAO), 1980).

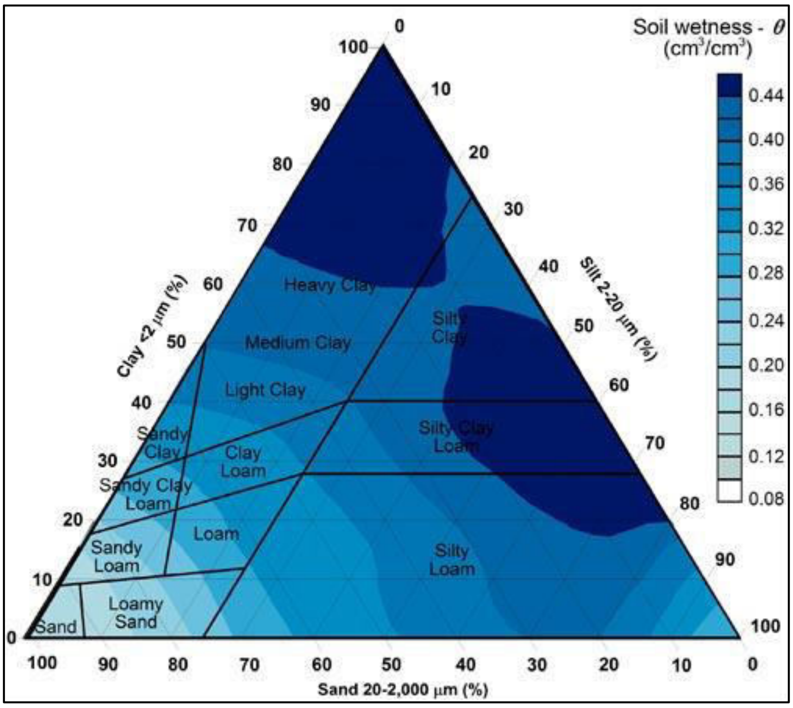

Figure 9: A diagram depicting soil wetness based on soil textural class.

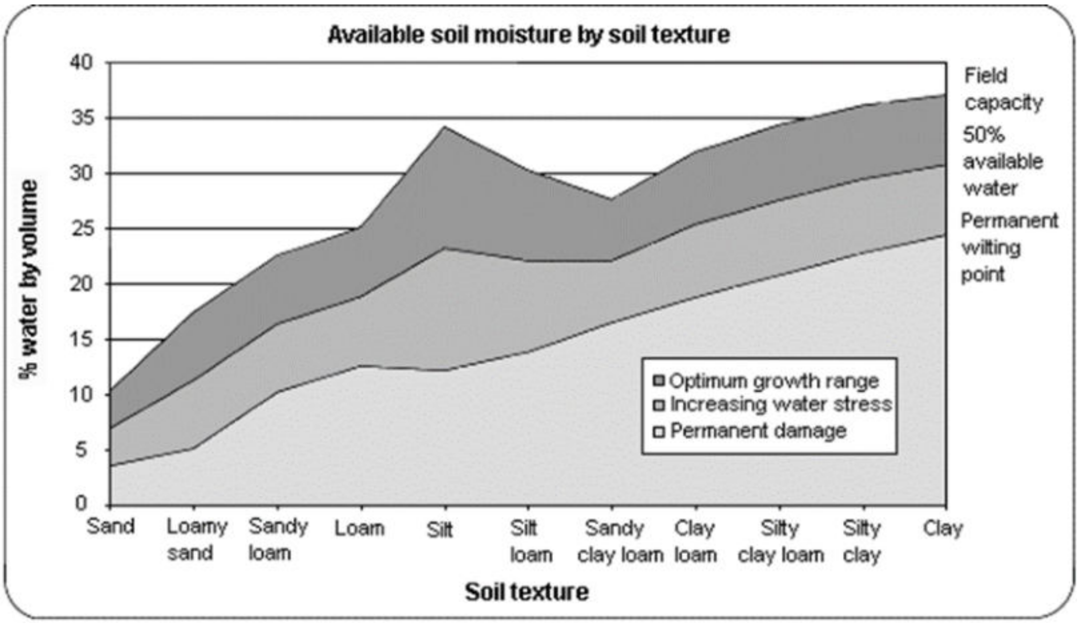

Figure 10: A diagram depicting the percentage volume of water in the soil-by-soil texture.

Table 4 presents impact categories for describing the impact significance of the proposed development on the wetlands and associated hydropedological drivers.

Table 4: Impact categories for describing the impact significance of the proposed development on the wetlands and associated hydropedological drivers.

Severity	SSI Reduction	Change Class	Description
No Impact	0 – 2.5 %	No change.	Hydropedological process are predicted to be unmodified and the functionality of the wetland will remain unchanged.
Low	2.5 – 5 %	No Significant change.	Small effect on the hydropedological process are predicted, however the functionality of the wetland remains unchanged and no change in resource class is expected.
Low to Moderate	5 – 10 %	Limited change with a change in PES category possible.	A slight change in hydropedological processes is predicted and a small change in the in the wetland may have taken place but is change to the PES, EIS or wetland functionality and ecoservice provision is limited with no more than one PES class predicted.
Moderate	10 – 15 %	Significant change with a change in PES Category definite and possibly a change of more than one category.	A moderate change in the hydropedological processes is predicted to occur. The change in PES may exceed one category but no change in EIS takes place. No loss of important ecoservices is predicted to occur.
High	15 – 22.5 %	Very significant change with a change in PES of more than two categories.	Modifications have reached a very significant level and the hydropedological processes are predicted to be largely modified with a large change in the PES, EIS of the wetland feature as well as a significant loss in ecoservice provision.
Very High	22.5 -60%	Serious to Critical change with a change in PES of more than three categories or a permanent complete loss of wetland resource.	Modifications have reached a serious level and the hydropedological processes have been seriously modified with an almost complete loss of wetland integrity, functionality and service provision.

2.1 Conceptual Hydropedological Response Approach

Transects were defined within the area earmarked for development. For each transect the dominant soil forms were identified and at strategic locations, undisturbed soil core samples were taken to be subjected to particle size analysis and hydraulic properties. A Tractor Loader Backhoe (TLB) was used for profiled excavation to classify and describe the soils and to ensure that the variation within the soil distribution patterns were captured. The profile descriptions and soil classification were undertaken according to the Soil Classification Working Group (2018) and the soil morphological properties were then related to a specific hydrological behaviour as presented in the new Department of Water and Sanitation (DWS) guidelines (2020) (van Tol *et al.*, 2010).

Figure 11: Establishment of soil test pits using the Tractor Loader Backhoe (TLB).

3. MODELLING APPROACH

Hydropedological information collected on site and in laboratory conditions (e.g., dominant soils, hydraulic properties and chemical data) is crucial in hydrological modelling to quantify the dominant hydrological processes as well as the impact of the proposed developments on them. In this study only the impact of the proposed development on hydrological processes was considered.

The hydrological model SWAT+ (v 1.2.3) was used for the modelling with QSWAT+ (v. 1.2.2) to set up the watershed. SWAT+ is a revised version and an effective and comprehensive tool for simulating streamflow and pollutant transport across a wide range of spatial and temporal scales, environmental conditions, land management practices, and land use and climate change scenarios (Arnold and Fohrer, 2005).

Hydraulic processes the major driving force behind any process in SWAT (Neitsch *et al*., 2011). Components of the water balance such as precipitation (rainfall), surface runoff, infiltration, evapotranspiration, soil water and channel processes (Figure 12) are key components of the hydraulic process definition. The water balance equation used by SWAT+ is as follows:

$$SWt = SWo \sum_{i=0}^{t} (\mathrm{Rday} - \mathrm{Qsurf} - \mathrm{Ea} - \mathrm{Wseep} - \mathrm{Qgw})$$

Where:

SWt–final soil water content;

$SW0$–initial soil water content;

$Rday$–precipitation;

$Qsurf$–surface runoff;

Ea–evapotranspiration;

$wseep$–the amount of percolation flow exiting the soil profile at the bottom;

Qgw–groundwater flow enters the channel (return flow);

Units –mm H_2O; and

t–is the time span to apply the equation.

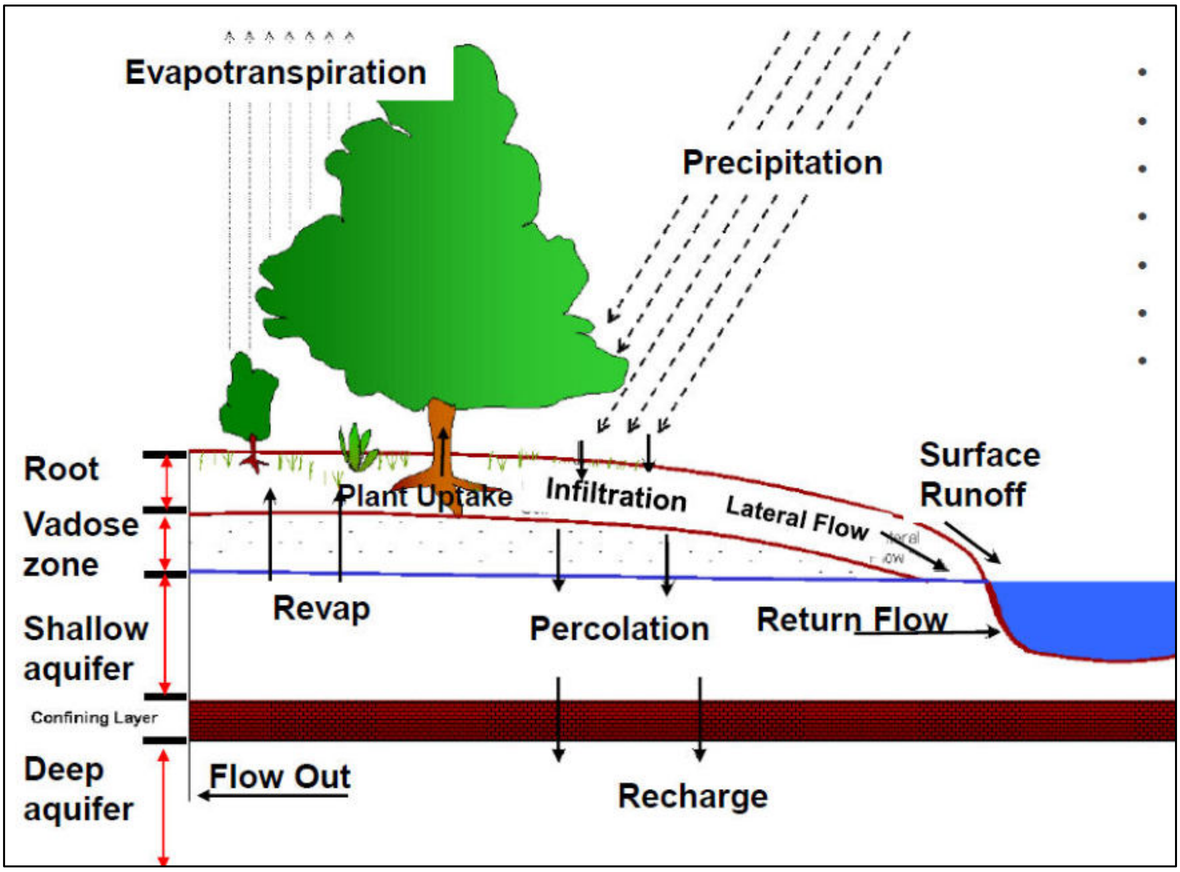

Figure 12: schematic representation of the water balance equation (adapted from Neitsch et al., 2011).

Table 5: SWAT+ Input Data Used for the CWA development Watershed Model Setup.

Data	Scale	Source
Topography	30 m	The Shuttle Radar Topography Mission (SRTM)
Soil	30 m	In-situ and Land Type Data (Sorter Database).
Landuse/Land Cover	30 m	South African National Land-Cover Database (2013 – 2014).
Climate	1 station	Climate Forecast System Reanalysis (CFSR, 1979 – 2014).

The catchment area was determined from a 30m DEM and subdivided into 28 sub-basin, with 329 Landscape Units, See Figure 13 below. The hillslope (HRU scale) is the smallest hydrological unit where hydrological processes can be assessed holistically and therefore serves as an important building block for the understanding and the simulation of hydrological processes for all 1872 HRUs and the model simulates the water balance for each of the HRU. The current land use was obtained from the South African National Land-Cover Database (2013 – 2014) with predefined parameters for each of the uses.

To simulate the impact of the development, the area under the development footprint was assigned a "Built-up" class in relation to the proposed activities and may include runways and major infrastructure development sites, in the post development modelling scenario.

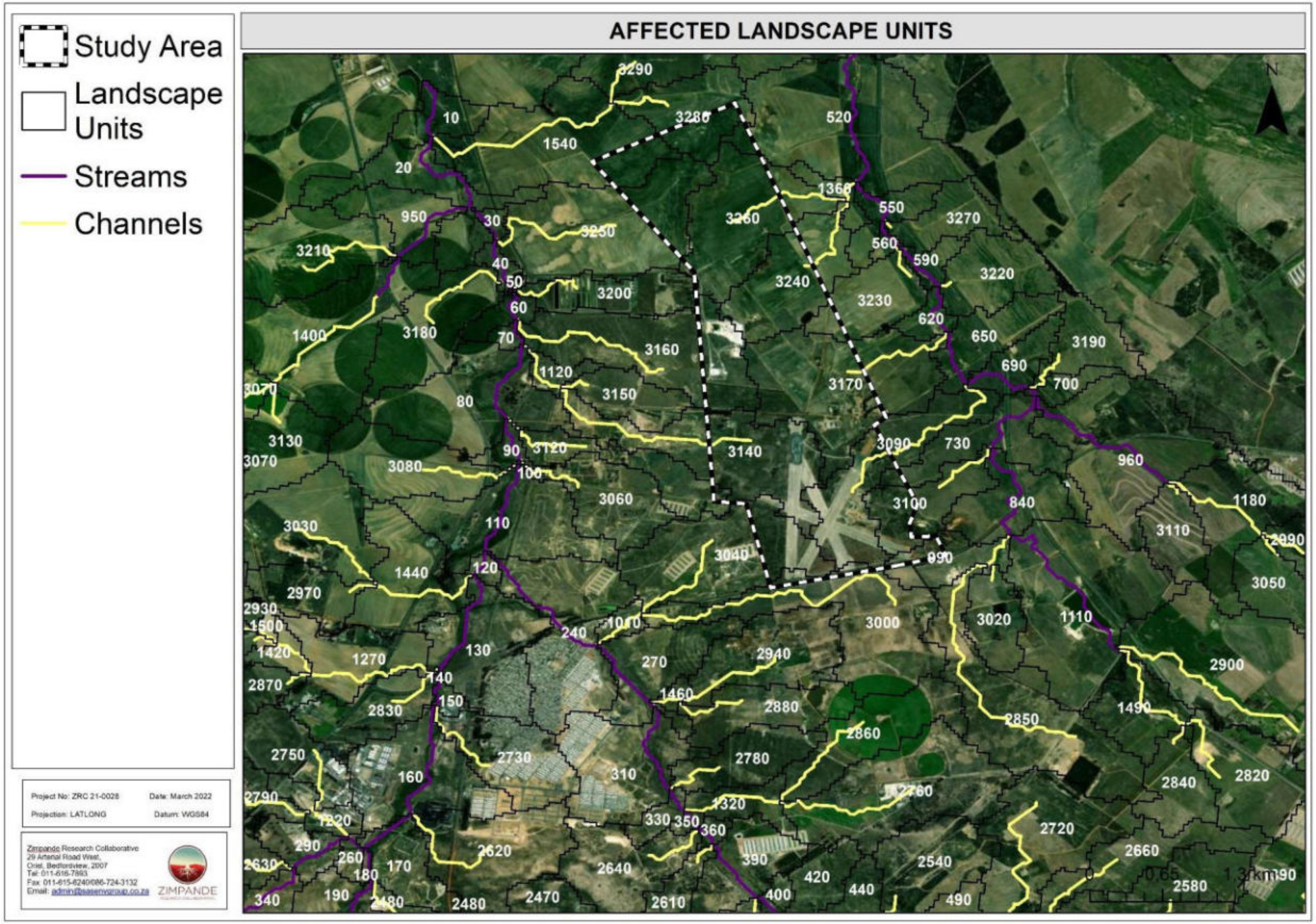

Figure 13: Affected landscape units associated with the catchment area.

The soils identified from the soil survey were reclassified and regrouped into hydropedological classes namely according to Van Tol & Le Roux, 2019; Responsive (shallow), Interflow (Deep), Stagnating, and Responsive (saturated). The soils were further extrapolated to cover the areas outside the study area using the Land Type soil information and thus enabling the modelling to take place at a lager catchment scale (Basin scale). Soil physical parameters such as bulk density, particle size distribution affecting the water content and the hydraulic conductivity were determined under laboratory conditions. The hydraulic properties of the dominant horizons used as inputs into the SWAT+ model are presented in Table 6 below.

Table 6: Selected hydraulic properties of representative horizons.

Hydropedological class	Depths	Db	Clay	Silt	Sand	AWC	Ks
STNG	300	1,41	13.15	6.57	81.02	0.019	143.75
	600	1.34	49.89	18.66	31.87	0.0078	0.004
	-	-	-	-	-	-	-
RESS	300	1.17	11.34	7.76	81.12	0.017	160.24
	-	-	-	-	-	-	-
INTD	300	1.17	11.34	7.76	81.12	0.017	160.24
	500	1.73	16.90	7.07	76.40	0.094	0.012
	800	1.53	8.04	2.15	90.09	1.09	79.64
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
RESW	300	1.19	12.38	4.99	83.16	0.03	0.55
	-	-	-	-	-	-	-
Ca2	800	1.24	28.32	12.76	59.18	0.08	22.86
Fa21	800	1.18	31.57	19.18	49.56	0.12	38.71
Db89	500	1.60	40.0	30.0	30.0	0.35	11.0

***RESS = Responsive (Shallow); RESW = Responsive (Saturated); STNG (Stagnating); RECS = Recharge (Shallow); INTS = Interflow (Shallow); INTD = Interflow (Deep)**

A 20-year simulation period was selected (1st January 2000 – 31st December 2018) based on the latest climatic data available. Climatic data for this period was obtained from the Climate Forecast System Reanalysis (CFSR, 1979 – 2014) project done by the National Centers for Environmental Prediction (NCEP) (Saha *et al*., 2010). WeatherGen in SWAT+ Editor used daily precipitation, temperature (minimum and maximum, wind speed, solar radiation and relative humidity from selected stations to generate daily climatic variables for the simulations. Only years with full data ranges were selected, leaving an 18-year evaluation period. Results are reported only as yearly averages for the affected HRUS, LSUs and the basin, before, and after the proposed development.

4. HYDROPEDOLOGICAL BEHAVIOUR OF SOIL TYPES

4.1 Application of Hydropedological Surveys

According to Van Tol *et al.,* 2017, one of the most important contributions of hydropedology is the holistic understanding of the hydrological functioning of landscapes (catchments or hillslopes) as well as being able to conceptualise (visualise) these hydrological processes spatially.

Soil physical and hydraulic properties (such as textural class, hydraulic conductivity and porosity) have an influence on numerous processes such as runoff, infiltration, groundwater recharge and general water movement in soils. Whereas soil morphological properties do not have any direct impact on hydrological processes but serve as indicators of dominant flow paths, flow directions and storage mechanisms in the form of mottling and the presence and/or absence of signs of hydromorphy. The correct mapping and interpretation of these soil morphological properties thus allows for the correct conceptualisation of hydropedological processes spatially. Consequently, the captured hydropedological information allows for effective water resource management, as required by the National Water Act. Figure 14 below depicts some of the applications of hydropedological surveys.

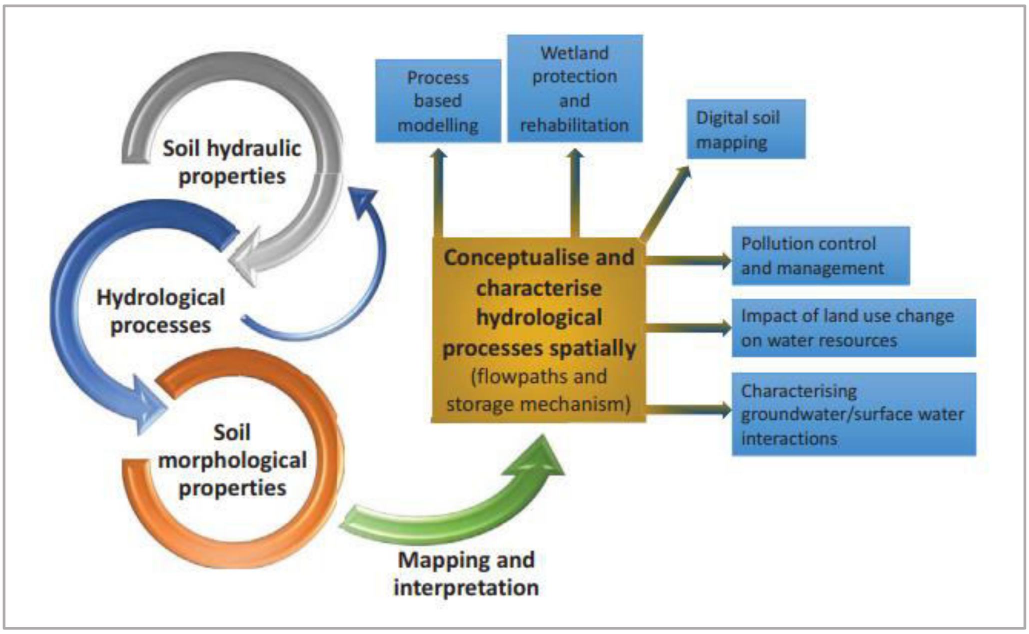

Figure 14: Hydropedology and some of the applications of hydropedological surveys (Van Tol *et al.*, 2017).

4.2 *Behavior of Hydrogeological Soil Types*

Hydropedological behaviour of different soils can vary significantly, depending on the soil drainage patterns. The discussion below is largely based on the concept presented in Figure 15 and 16, and Table 8 below.

Responsive shallow soils ‘respond’ quickly to rain events and typically generate overland flow. These soils can be shallow and overlie relatively impermeable bedrock, with limited storage capacity which is quickly exceeded following a rain event.

High chroma red soils are typically deep, well drained soils, and vertical flow is the dominant hydrological pathway. These soils are referred to as recharge soils, as they are likely to recharge groundwater, or lower lying positions in the regolith, via the fractured bedrock. Therefore, these soils may be important in terms of recharge over significant distances (several kilometers) and over long periods (years to centuries). These soils are likely to contribute to surface freshwater systems three (3) stream orders down in the landscape.

Lighter coloured soils or leached soils are usually associated with lateral movement of water which leaches soil minerals from the soil through the process of eluviation. Lateral flow occurs due to differences in the conductivity of soil horizons or due to the presence of an impermeable subsurface layer. These soils are termed interflow soils. Lateral flow occurs at the A/B horizon interface and/or bedrock interfaces due to the reduced permeability, which therefore prevents vertical movement.

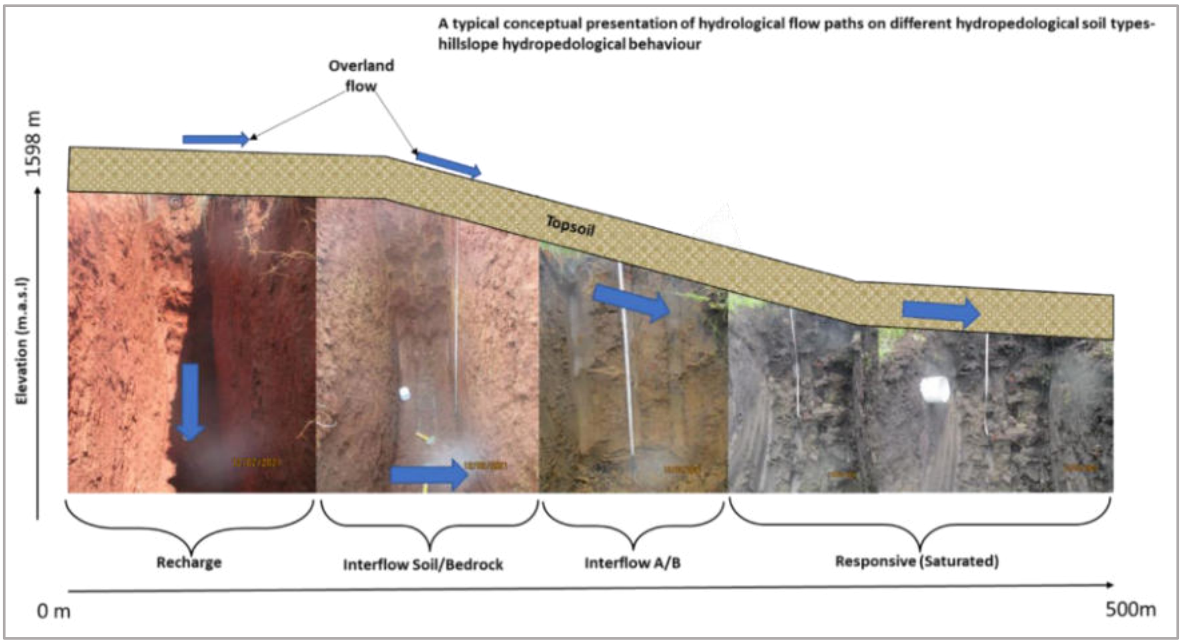

Figure 15: A typical conceptual presentation of hydrological flow paths on different hydropedological soil types.

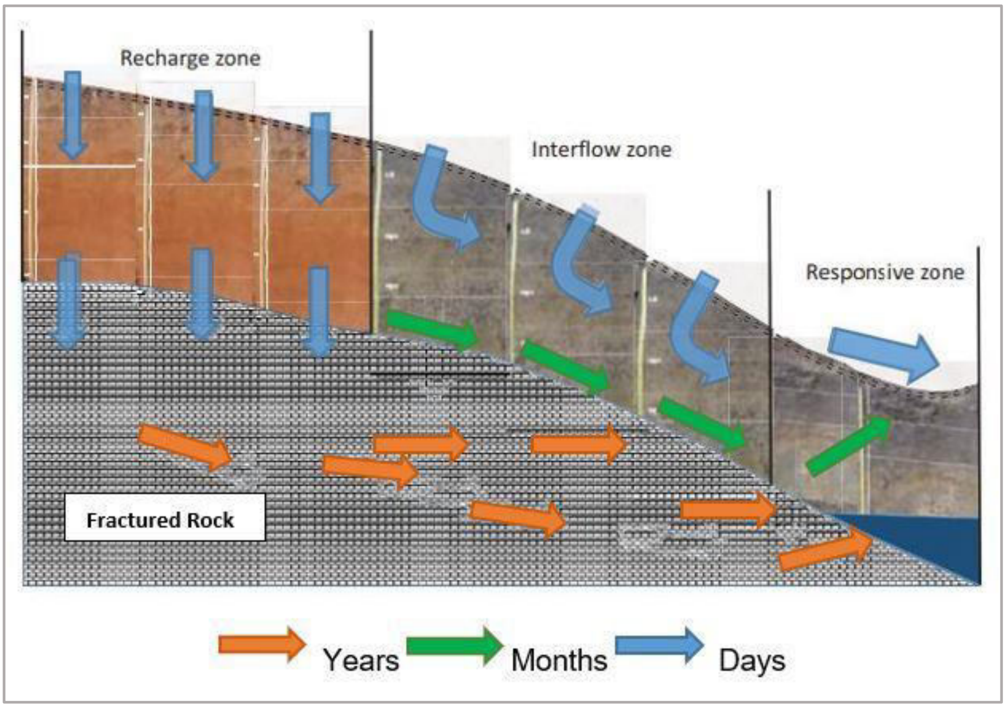

Figure 16: A typical conceptual presentation of hydrological flow paths on different hydropedological soil types, underlined by a fractured rock material.

Table 7 below presents the hydropedological soil groupings as studied by Le Roux *et al.* (2015).

Table 7: Hydropedological soil types of the studied hillslopes (Le Roux, *et al.,* 2015).

Hydrological Soil Types	Description	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep, freely drained soils with significant contribution to ground water regime.	
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates accumulation of water in the topsoil. Duration of drainable water depends on the rate of evapotranspiration, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	
Interflow (Soil/Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build-up of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	
Responsive (Saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	

The flow paths from the crest of a slope to the valley bottom is assessed and classified. According to Le Roux, *et al.* (2015), the classification largely takes into account the flow drivers during a peak rainfall event and the associated flow paths of water through the soil. The hillslope classes are:

- Class 1 – Interflow (Soil/Bedrock Interface);
- Class 2 – Shallow responsive;
- Class 3 – Recharge to groundwater (Not connected);
- Class 4 – Recharge to watercourse;
- Class 5 – Recharge to midslope; and
- Class 6 – Quick interflow (A/B horizon).

5. DESKTOP ASSESSMENT RESULTS

This section aims to provide some background information in terms of the climatic conditions as well as the soils associated with the study area. Table 8 below presents the summary results from the desktop exercise.

Table 8: Summary of the climatic and soil conditions associated with the study area.

Parameters	Description	Significance
Mean Annual precipitation (MAP)	The entire study area experiences a Mean Annual Precipitation (MAP) between 401-600mm.	The area can therefore be described as relatively water stressed, however hydropedological process are likely to occur.
Mean Annual Evaporation (MAE)	The entire study area has an evaporation rate ranging between 1801 – 2000mm.	The high evaporation rate combined with the low rainfall means that the soil will not receive adequate soil moisture to facilitate the hillslope processes since most the water will likely be lost through evapotranspiration.
Geology	The study area is comprised of the Malmesbury, Kango, Gariep.	This geological formation associated with the study area tends to be resistant to weathering and typically yields shallow soils or deeper soils with fine grade lithic composition.

Parameters	Description	Significance
Landform	According to the SOTER database, the entire study is classified to have a plain landform setting.	The terrain units present within these landforms include the foot slopes as well as valley bottoms. Hydropedological processes may be slow (if any).
SOTER Soils	The entire study area is characterised by Albic Arenosols	These soils tend to be deep, with a bleached surface soils with a bleached character which may extend downward to a depth of 100 cm from surface. Due to the sandy and high permeability, water is more likely to flow vertically through and out of the profile.
Land type Classes	The entire study area is underlain by the Db41 land type class.	The Db land type is dominated by soils of duplex character with non-red B horizons. The distinct differences in hydraulic conductivity between the sandy topsoil and the higher clay subsoil will accommodate more distinct lateral flows with its associated redox morphology in the form of bleaching and removal of colloidal matter.
Soil Clay Content (%)	The clay content for all the soils within the study area is less than 15%	This means that more percolation of water will be encouraged and up to the soil/bedrock interface.
Soil Depth (mm)1	The soils within the study area have a depth of 450-750 mm	This means that the hydropedological process will likely be shallow.
Soil Water Retaining Characteristics	The soil water retaining characteristics are present wit the risk of waterlogging	Water storage during the drier periods may not be possible and thus the soils have low potential to facilitate the hydropedological processes.

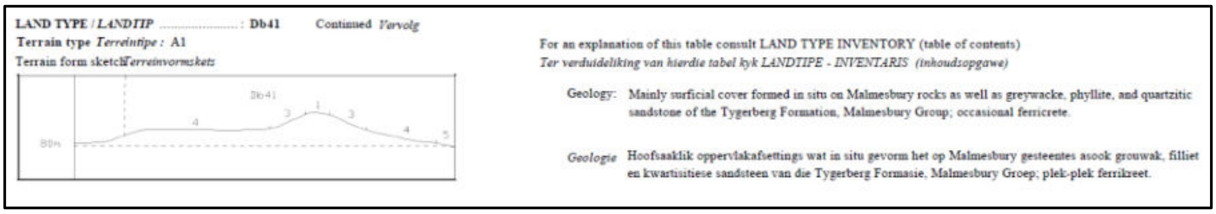

Figure 17: Land type description associated with the Db41 land type.

6. ECOLOGICAL SIGNIFICANCE

The proposed development area is associated with watercourse systems which traverse the study area and are in proximity to the proposed activities, thus it is deemed important to understand the status of the affected wetland in terms of their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) to ensure that the necessary protection is afforded.

According to FEN (2024), numerous wetlands (seep and channelled valley bottom (CVB) wetlands) are located within the study area and northern and eastern extent of the investigation area, although not all wetlands will be impacted by the proposed CWA development. However, the freshwater assessment by FEN (2024) quantitatively assessed a representative set of the wetlands that will be directly impacted by the proposed CWA development, whereas wetlands that may be indirectly impacted by the proposed CWA development are discussed qualitatively. The following freshwater systems were identified by the freshwater study:

- A seep wetland (seep wetland 1) was identified within the central portion of the study area. This seep wetland is indirectly linked, via an agricultural drain, to a channelled valley bottom (CVB) wetland located to the east and outside of the study and investigation areas;

- Three CVB wetlands were identified east of the study area. The larger CVB wetland (referred to as CVB wetland 1) is associated with the unnamed tributary of the Klapmuts River was identified running parallel with the eastern portion of the study area;
- Two smaller CVB wetlands (CVB wetlands 2 and 3) linked to CVB wetland 1 were identified and do not encroach into the study area. However, based on historical imagery these wetland features possibly extended further west into the study area;
- CVB wetland 4 was identified north of the study area. These wetlands are located downgradient of the study area and are considered likely, although indirectly, to be impacted by the proposed development;
- A seep wetland (seep wetland 2) was identified approximately 310 m east of the study area and is directly linked to the CVB wetland 1. This wetland is located downgradient of the study area and are considered likely, although indirectly, to be impacted by the proposed development;
- No freshwater ecosystem indicators were identified within the central western portion of the study area;
- A quarry associated with historical open-pit clay mining activities is located within the central portion of the study area; and
- An artificial impoundment, connected to the CVB wetland 1 via a stormwater channel and agricultural drain, was identified along the eastern boundary of the study area.

Majority of the study area has been subject to heavy transformation through historical clay mining, on-going agricultural practices, excavation and infilling activities. Thus, limiting or reducing the hydrological functioning and linkage of historic freshwater systems within the study area to the valley bottom wetlands identified outside the study area (i.e., Mosselbank River and the unnamed tributary of the Klapmuts River). Hydrological, geomorphological and vegetation modifications have occurred within the identified freshwater systems, in varying degrees. The PES of the identified CVB and Seep wetland systems were found to be in seriously modified and a largely modified state respectively. Refer to Figure 18. Table 9 below summaries the PES/EIS results of the identified HGM units with the study and investigation areas.

Table 9: Summary of the overall scores per watercourse, as well as the calculated REC. (FEN, 2024).

Resource	Present Ecological State (PES) Category	Ecological function and service provision	Ecological Importance and Sensitivity (EIS)	Recommended Ecological Class (REC)
CVB wetlands 2 and 3	Category E (Seriously modified)	Very Low	Low	D
Seep wetland 1 and 2	Category D (Largely modified)			

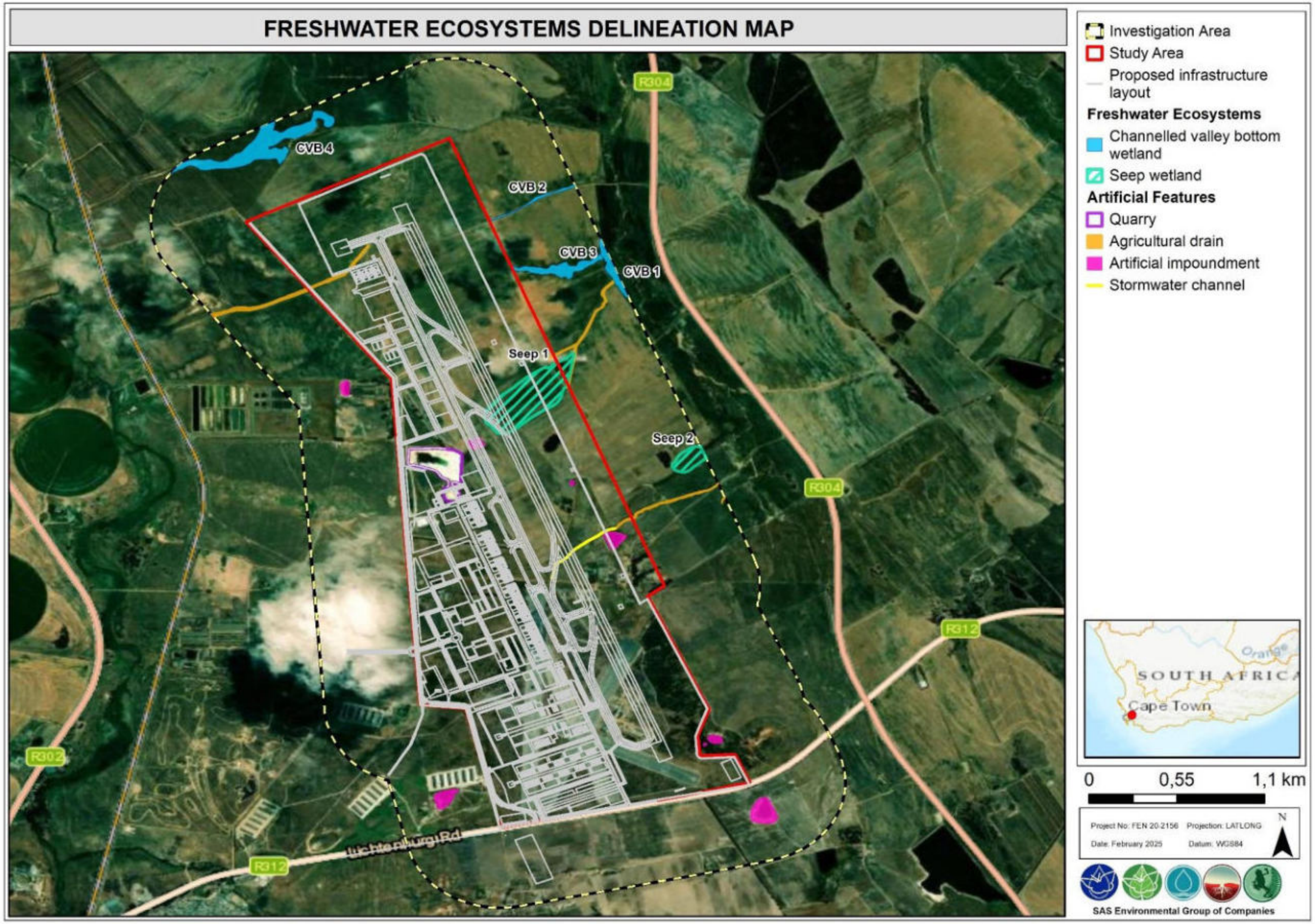

Figure 18: Map illustrating the watercourses delineated associated with proposed airport project (courtsey of FEN, 2024).

7. RESULTS AND DISCUSSION

7.1 Morphological and Hydraulic Properties of Wetland and Hydropedologically Important Soils Associated with the Study area:

The study area is largely dominated by secondary accumulations of powdery gypsum and cemented horizons containing silica as the cementing agent. These soils typically occur under arid to extremely arid conditions with a high evaporative demand and are generally associated with calcareous soils. Deep drainage of water is typically restricted or limited in these soils, although infiltration occurs readily in the sandy surface horizons. Therefore, the hydrological flow path in these soils is upwards driven by evapotranspiration and have a very slow recharge rate.

Seasonal flowpath of lateral flow or bedrock flow is typically absent and reduction or redox expression in soil morphology is less common. The soils simply do not saturate long enough to generate anaerobic conditions. There are, however, morphological indicators of flowpaths of water in the soils of these drier climates. These are typically in the form of precipitates, such as lime ($CaCO_3$), which form extremely slowly and are often perceived as relict but can be good indicators of hydrological flowpaths. This is because $CaCO_3$ easily dissolves in water and will flow with the water until the water is extracted by roots where the $CaCO_3$ will precipitate. The occurrence of these precipitates is therefore an indication that the water did flow there. The solubility of calcareous, gypsum and salt compounds increase, in the order listed. The presence of lime accumulations in shallower depth indicates a stronger evapotranspiration demand and vice versa. The Gypsum precipitates typically occur lower down the flowpath than calcareous precipitates, as gypsum is more soluble.

The soils associated with the seep wetlands included the soils characterised by uniform matrix colours resulting from a loss of colloidal matter, silicate clay and humus. These conditions typically result from the underlaying horizon restricting infiltration of water and thus facilitating the build-up and storage of water and release of water in a predominantly lateral direction. Deep interflow soils characterised by flow along the soil-rock interface were also observed as such the lithic material below the topsoil horizon was characterised by redoximorphic features.

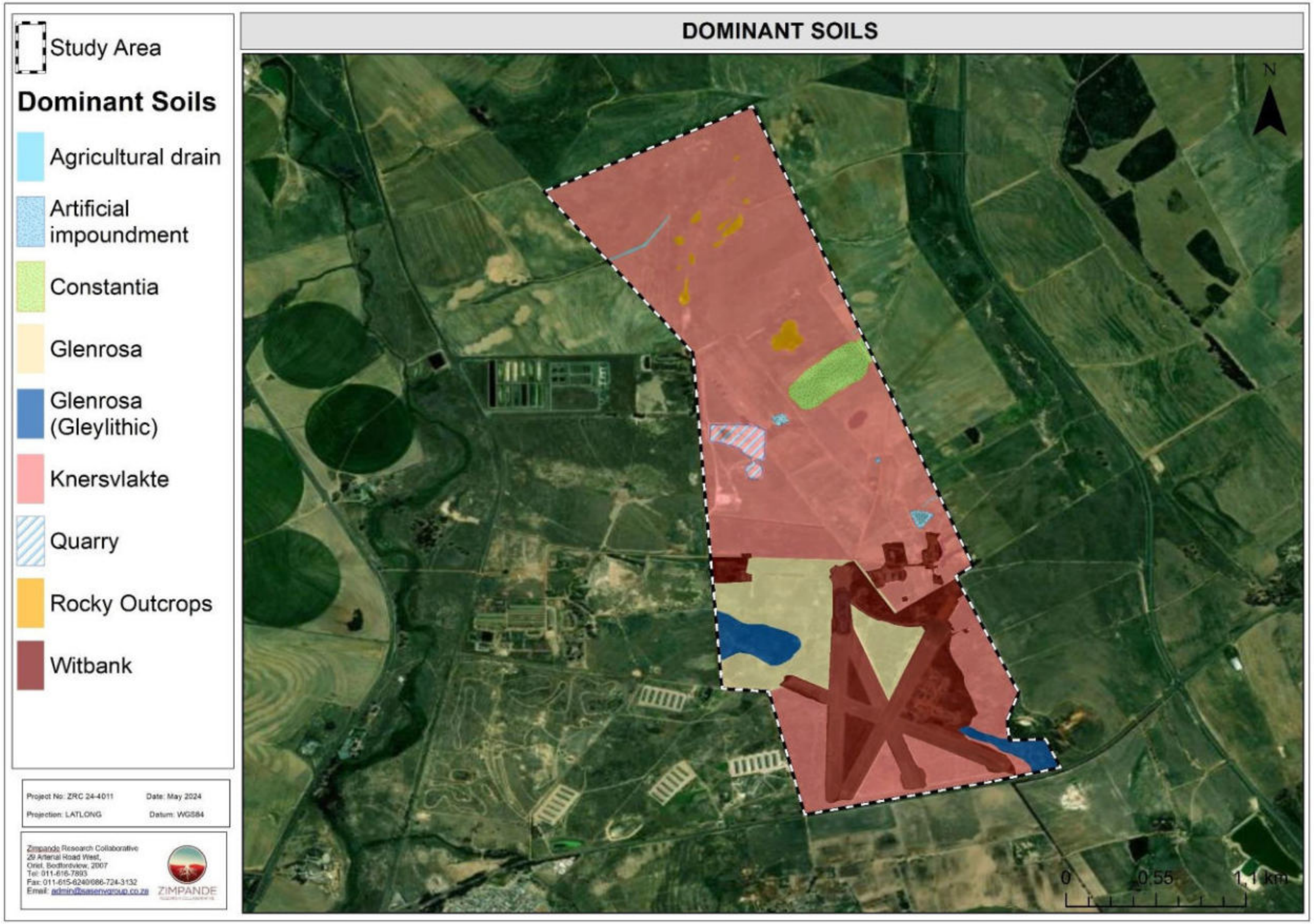

Figure 19: Map depicting spatial distribution of soils within the study area.

7.2 Recharge of the Wetlands

Typically, there are four primary wetland recharge mechanisms, and these include:

- Precipitation (rainfall);
- Surface flow (runoff);
- Subsurface flow (interflow) through the vadose zone of the surrounding soils; and
- Groundwater discharge.

The identified soils within the study area have been grouped according to their hydropedological responses and are discussed below to understand their contribution to wetland recharge.

7.2.1 Stagnating/Recharge (Slow) Soils

From the texture and porosity it is evident that these soils and landscapes exhibit rapid drainage and percolation of water in the topsoil due to the sandy nature. However the presence of cemented layers of the Dorbank and Gypsic horizons leads to stagnation and shallow water tables in these landscapes but without a clear redox morphology. Slow vertical movement is the dominant flowpath and ET excess water seldom reaches the bottom of the soil profile and the contribution to transpiration (upward flux) is generally the dominant flowpath. However, if these soils occur in inclined slopes, they may lead to event driven lateral flowpath as these soils may get saturated fairly quickly. Figure 20 depicts the Knersvlakte soil formation associated with the stagnating hydropedological soil type.

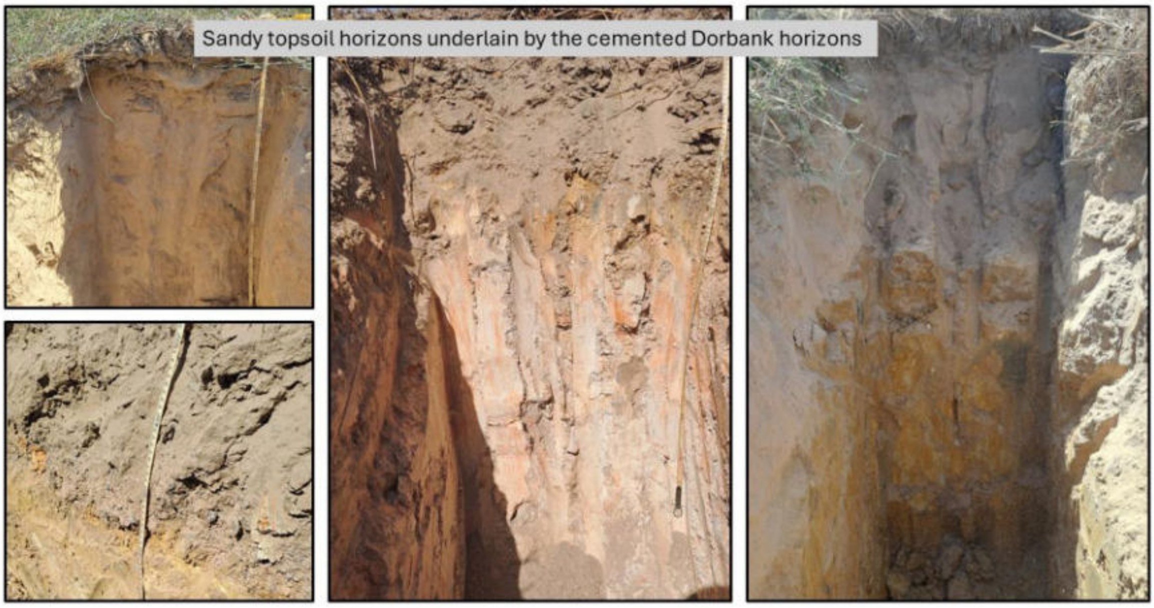

Figure 20: View of the stagnating soils with slow recharge mechanisms characterised by cemented horizons.

7.2.2 Responsive (Shallow)

These soils are characterised by limited depth and as a consequence small storage capacity and in some instances no capacity to infiltrate as a result of impervious surfaces as a result of the already existing runway. These soils respond quickly to rain events in a sense that, when a significant amount of rainfall is received, the storage capacity of the soil is exceeded and therefore overland flow is generated. Figure 21 depicts the Glenrosa soil type associated with the responsive shallow hydropedological soil type.

Figure 21: View of the Glenrosa soil form.

7.2.3 Interflow (Soil/Bedrock) Soils

These soils are characterised by hydromorphic properties particularly mottling (red, yellow, and grey colors) which signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction. The horizons are indicative that the underlying bedrock is slowly permeable and periodic saturation in the rainy season is likely, which may lead to lateral flow at the soil bedrock interface. The drainage may be restricted by a shallow impermeable rock layer (Le Roux, *et al.,* 2015). The interflow (Soil/Bedrock) soils within the study area comprised of Gleylithic Glenrosa soil form (Figure 23).

Figure 22: Glenrosa of the Gleylithic family depicting signs of water stagnation below the lithic horizon.

7.2.4 Responsive saturated (Artificial impoundments)

The saturated features which were identified were not natural and as result of historical open-pit clay mining activities (quarry) and intentional impoundment of water and connected to the valley bottom wetlands via a drainage channel. See Figure 24 below.

Figure 23: Artificial impoundments identified within the study area.

7.2.5 Interflow Soils (Occurring outside the study area adjacent to watercourse)

The subsurface lateral flow is the dominant flow in these soils. The subsurface flow can either occur at the A/B horizon interface where there is differences in the hydraulic conductivity, which results in the temporal build-up of water above the B horizon and thus in such cases an albic horizon forms. The Contantia soil form is characterised by an albic horizon overlying a yellow-brown apedal horizon and both overlain by an orthic horizon. In such cases where an albic horizon overlies a freely drained horizon, some form of vertical infiltration can still be expected (See Figure 24 below).

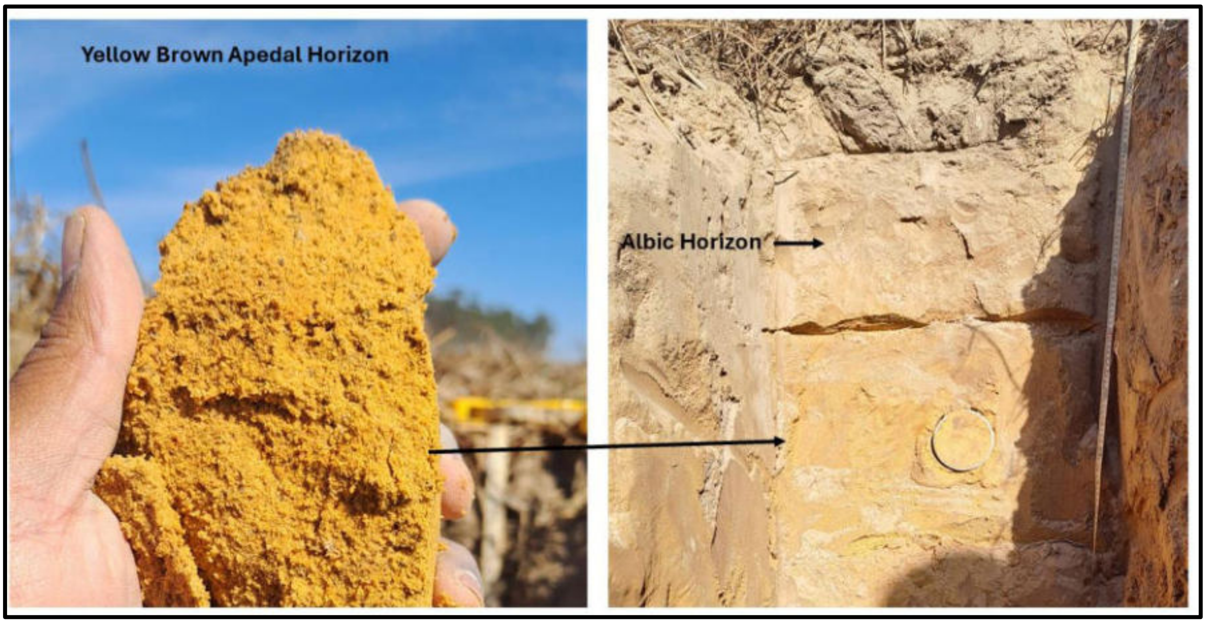

Figure 24: View of the identified Constantia soil form.

Table 10 and 11 below present the hydropedological classification as well as the description of the recharge mechanisms.

Table 10: Hydrological grouping of soils occurring within the study area according to Van Tol and Le Roux (2016).

Stagnating	Recharge (Shallow)	Interflow (A/B)	Interflow (Soil/Bedrock)	Responsive (Saturated)
Knersvlakte	Witbank (airport runway)	Constantia	Glenrosa (Gleylithic)	Quarry
	Glenrosa			Agricultural drains

Table 11: List of soil forms within the study area and their contribution to wetland recharge.

Recharge Mechanism	Soil Forms	Diagnostic Horizons	Description
Responsive (Shallow)	**Glenrosa (Gs)**	- A: Orthic - B: Lithic	These soils have a quick response time during intense rainfall events attributed to their shallow nature.
Interflow (Soil/Bedrock)	**Glenrosa Gleylithic (Gs)**	- A: Orthic - B: Lithic	The horizons are indicative that the underlying bedrock is slowly permeable and periodic saturation in the rainy season is likely, which may lead to lateral flow at the soil bedrock interface. The drainage may be restricted by a shallow impermeable rock layer.
Responsive (Saturated)	**Artificial saturated features**	Anthropogenic Influenced	Man made water features.
Stagnating	**Knersvlakte**	- A: Orthic - B: Dorbank	These horizons are characterised by secondary accumulations of powdery gypsum and cemented horizons containing silica as the cementing agent. Deep drainage of water is typically restricted or limited in these soils, although infiltration occurs readily in the sandy surface horizons. Therefore, the hydrological flow path in these soils is upwards driven by evapotranspiration and have a very slow recharge rate.

Figures 25 and 26 below depicts the hydropedological soil types derived from the soil forms associated with the study area.

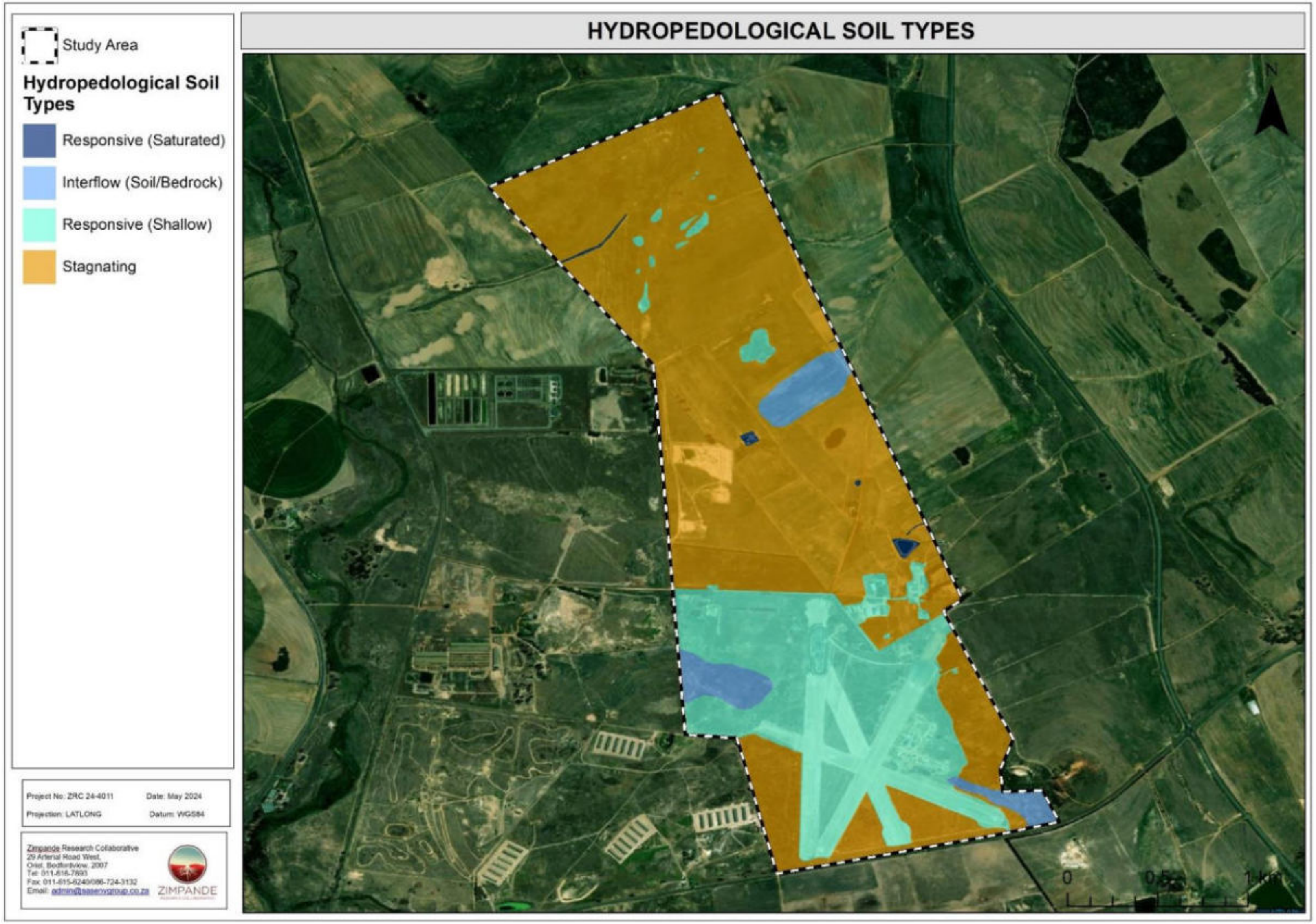

Figure 25: Map depicting hydrological soil types associated with the study area.

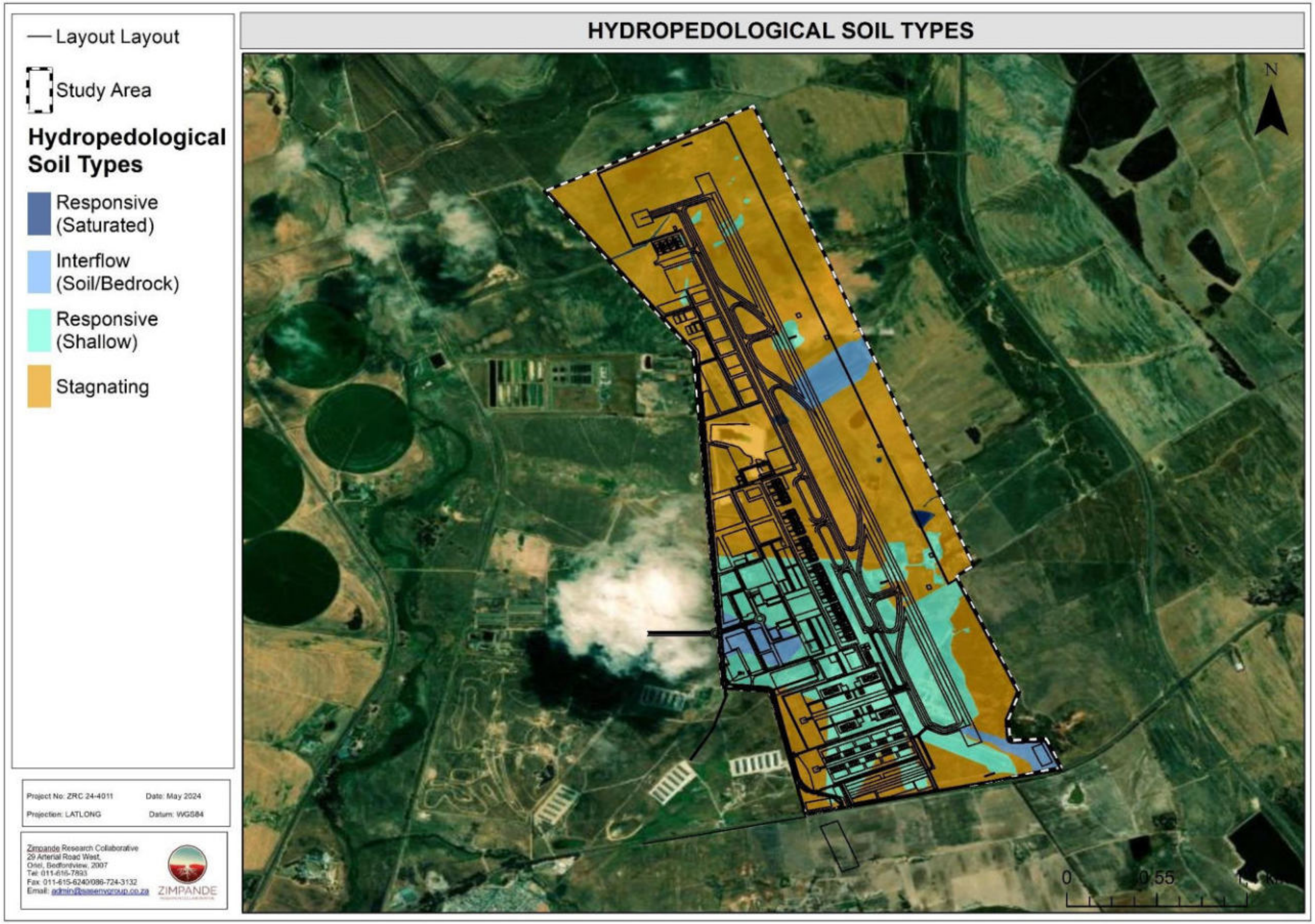

Figure 26: Hydrological soil types associated with the study area overlain by the proposed layout outline.

7.3 Hydropedological Conceptual Models and Implications

This section presents the hydropedological impacts that can be anticipated resulting from the proposed discard dump project. Conceptual cross sections will be presented to indicate the hydropedological flow paths and how the proposed project will likely interrupt the movement of water in the landscape and affect recharge mechanisms (Figure 27).

Conceptual models depicting the dominant flowpaths were constructed and were the basis for discussing the potential impact of the development on the hydropedological response. The hydrological processes are discussed in relation to the arrows indicating flowpaths. Figure 29 below depicts the elevation profiles associated with transects.

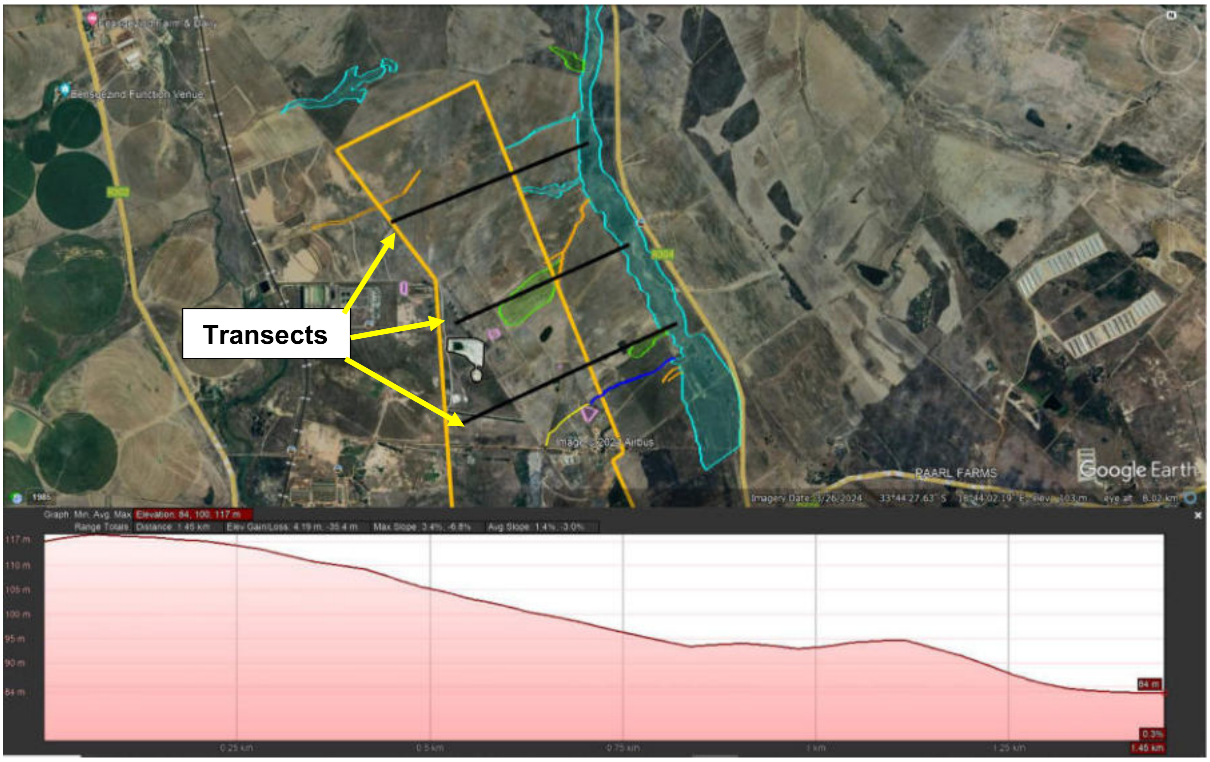

Figure 27: Location of the investigated three transects (black lines) and elevation profile.

The identified transects are largely characterised by free draining sandy topsoil horizons underlain by cemented horizons due to silica enrichment. The cemented dorbank horizon is generally massive, with high clay content and has a hard to extremely hard consistence when dry and stays extremely firm even in a moist state. Thus, these soils tend to obstruct the vertical infiltration of water and reducing the hydraulic conductivity. With the sandy topsoil, this indicated a lower water holding capacity. In a flat terrain slow vertical infiltration of water can be expected, however ET excess water seldom reaches the bottom of the soil profile and the contribution to transpiration (upward flux) is generally the dominant flowpath. In sloping areas of the landscape, event-driven lateral flow processes can take place.

The potential impacts from the proposed CWA development will likely pertain to the impacts experienced once the land is excavated during the construction of foundations for the proposed development. Following the completion of the construction activities the sealed and impervious surfaces may invariably cause changes to the hydrological flow regimes associated with the study area and may result in accelerated erosion and sedimentation of the lower lying areas if not properly attenuated. The infiltration of water will thus be limited as a result of sealed surfaces and therefore water may need to be channelised into stormwater structures and released to the downstream watercourse or lower lying positions in the landscapes.

The CWA footprint will cause an impact of the wetland recharge mechanisms since there is encroachment on the interflow soils which may lead to notable impact in terms of subsurface process and change in PES/EIS and functionality. The downgradient streams are ephemeral (see Figure 28 below) and likely recharged by overland flow over a short period of time and direct precipitation and thus the contribution of the interflow soils to downgradient watercourse may be limited.

Figure 28: Ephemeral watercourse east of the study area, likely recharged by overland flow during rain events associated with the unnamed tributary of the Klapmuts River.

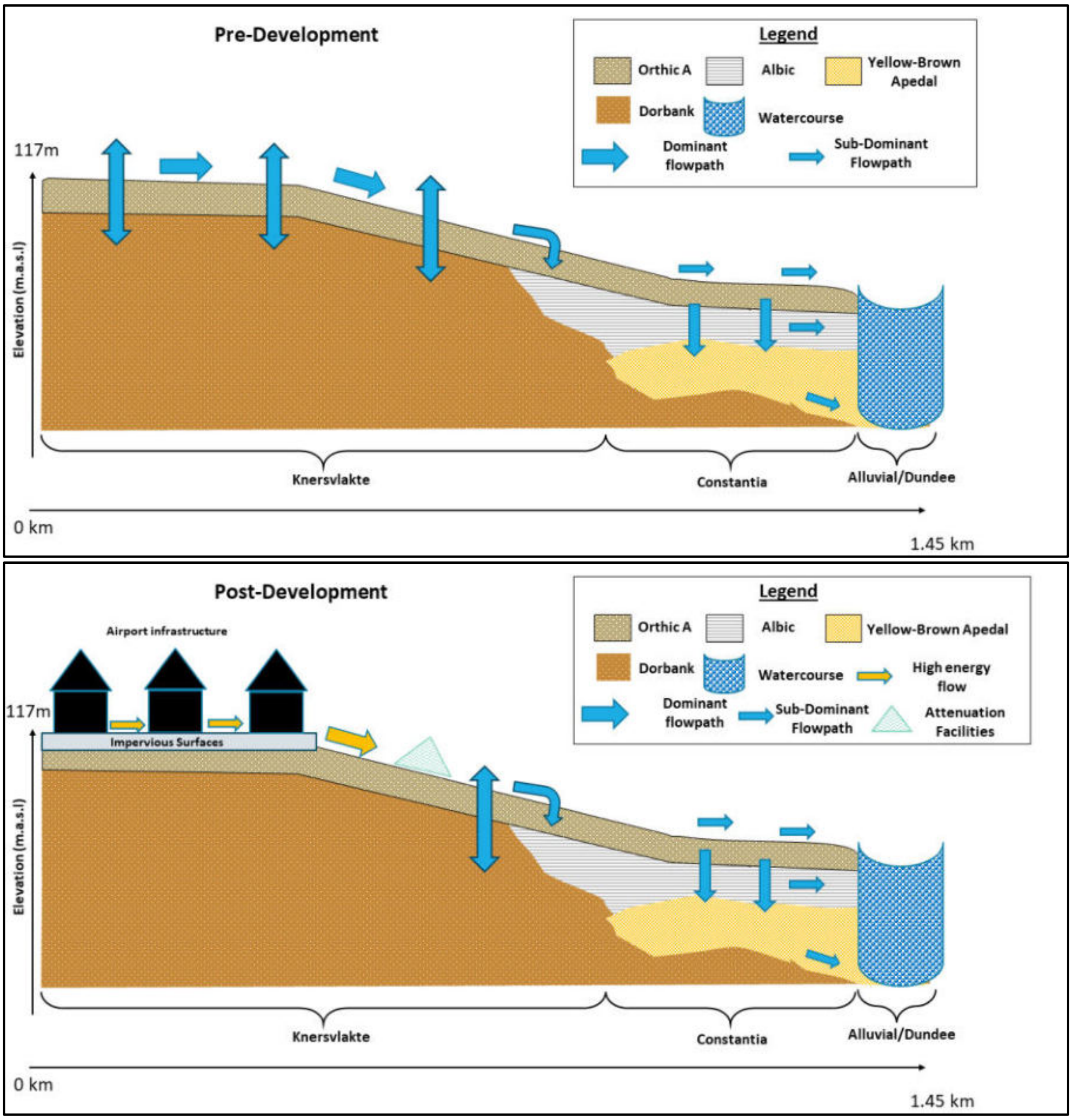

Figure 29: Conceptual hydrological response model of hillslopes in Transects for the pre and post development scenarios.

7.4 Quantification of Hydropedological Fluxes

A modelling exercise using the SWAT+(v 1.2.3) model was undertaken in effort to quantify the losses with specific mention of the lateral flow which can be anticipated because of the proposed development. The quantification of losses was undertaken at three different scales namely the basin scale, landscape unit scale and hydrological response unit scale, and these are discussed below.

Basin Scale

The quantified hydropedological fluxes at the basin scale indicate an increase in both the streamflow and surface runoff by 10.55% and 10.99% respectively while they both account for less than 15% of the water balance. The increases are not anticipated to cause an unacceptable change in the pattern, timing and flow of water in the landscape which can impact on instream functionality, and considering the limited contribution to the water balance, this risk is considered limited.

The model simulations indicate a decrease in the lateral flow and the percolation components by 2.21% and 5.62% respectively, while they both account for less than 1% of the water balance. This can be attributed to flowpath discontinuities and sealed surfaces as a result of the proposed CWA development.

The most significant loss of water at this scale is through evapotranspiration which accounts for over 79.3% of the water balance as modelled. The model also indicates that rainfall in the basin is lost through evapotranspiration processes and little water from the defined basin is exported to the greater catchment. The data thus indicates that rainfall in the area is important in driving the wetland response in the landscape at this scale. The profile water at scale increases by 7.88% and slight change in hydropedological processes is predicted and a small change in the in the wetland may have taken place but is change to the PES, EIS or wetland functionality and ecoservice provision is limited with no more than one PES class change predicted. Refer to Table 12 below.

Table 12: Summary of the water balance pre- and post-development at Basin scale.

	Before	% of WB	After	% of WB	Change	Weighted Loss	Anticipated PES/EIS Change
Rainfall	623,2843		623,2842				Limited with no more than one PES class change predicted.
Streamflow	79,9027	12,8196	88,2567	14,1599	10,4551	1,4804	
Surface runoff	76,6931	12,3047	85,1181	13,6564	10,9853	1,5002	
Lateral flow	3,2097	0,5150	3,1386	0,5036	-2,2148	-0,0112	
Percolation	6,2647	1,0051	5,9124	0,9486	-5,6230	-0,0533	
ET	504,1576	80,8873	494,5141	79,3401	-1,9128	-1,5176	
eCanopy	5,7670	7,2176	5,7557	6,5215	-0,1968	-0,0128	
Transpiration	44,0300	7,0642	43,9645	7,0537	-0,1488	-0,0105	
Evaporation	454,3605	72,8978	444,7939	71,3629	-2,1055	-1,5025	
ET0	1576,6309		1611,1848				
Profile available water	1,1765		1,0837		-7,8899		
Topsoil available water	9,8895		9,4766		-4,1748		

Land Segment Scale (LSU)

The LSU scale which is equivalent to the hillslope scale depicted an increase in both streamflow and surface runoff by 6.17% and 6.52% respectively for both components while accounting for 13% of the water balance. This can be attributed to the impervious surfaces emanating from the proposed development and runways which will be redirecting water through stormwater channels.

The model simulates a decrease in the lateral flow and percolation components by approximately 2.8% and 3.7% respectively, while they both account for less than 1 percent of the water balance. This can be attributed to the lack of interflow soils identified within the study area.

The most significant loss of water at this scale is through evapotranspiration which accounts for 78.53% of the water balance as modelled. The model also indicates that rainfall in the hillslope is consumed by evapotranspiration processes and little water from the impacted land scape units is exported to the greater catchment. The data thus indicates that rainfall in the area is important in driving the wetland response in the landscape at this scale. The profile water at scale decreases by approximately 6.5%, however slight change in hydropedological processes is predicted and a small change in the in the wetland may have taken place but is change to the PES, EIS or wetland functionality within the catchment area and ecoservice provision is limited with no more than one PES class change predicted. Refer to Table 13.

Table 13: Summary of the water balance pre- and post-development at LSU scale.

	Before	% of WB	After	% of WB	Change	Weighted Loss	Anticipated PES/EIS Change
Rainfall	623,2850		623,2838				Limited with no more than one PES class change predicted.
Streamflow	81,2817	13,0409	86,3035	13,8466	6,1783	0,8555	
Surface runoff	78,3146	12,5648	83,4218	13,3842	6,5213	0,8728	
Lateral flow	2,9670	0,4760	2,8817	0,4623	-2,8767	-0,0133	
Percolation	5,8488	0,9384	5,6287	0,9031	-3,7628	-0,0340	
ET	497,4307	79,8079	489,4732	78,5314	-1,5997	-1,2563	
eCanopy	5,2834	6,5001	5,3189	6,1630	0,6719	0,0414	
Transpiration	37,9979	6,0964	38,2837	6,1423	0,7523	0,0462	
Evaporation	454,1495	72,8639	445,8706	71,5357	-1,8229	-1,3041	
ET0	1576,6309		1611,1848				
Profile available water	1,1293		1,0550		-6,5771		
Topsoil available water	9,5294		9,2791		-2,6265		

Hydrological Responsive Unit (HRU) Scale

At the HRU scale, the site clearing activities and establishment of surface infrastructure will result in a decrease in the evapotranspiration component and an increase in direct evaporation from bare soil. The evapotranspiration component is regarded as the dominant water outflow mechanism since it accounts for approximately 78.71% of the overall water balance. This is thus supported by the type of soils identified within the study area which are largely associated with a high evapotranspiration demand. This is evident through the soils which are characterised by the presence of calcium carbonates, gypsum, cementation and lime in some instances.

The streamflow and surface runoff components depict an increase of 13.62% and 14.26% respectively in the post development scenario as a result of impervious surfaces from the proposed development and also soils with a low storage capacity which in the favourable conditions (intense rainfall and inclined slopes) will likely result in overland flow due to the low hydraulic conductivity of these soils. It is however notable that the pattern flow and timing of water movement in the landscape will be changed and as far as possible this impact must be managed with the Stormwater Management Plan ensuring that natural recharge and discharge processes are recreated, as far as possible.

The model predicts that the lateral flow component will remain fairly constant at this scale given the limited loss of approximately 0.4%, and with the percolation component decreasing by 4.35%. The profile available water slightly increases from initial conditions and thus the model predicts an increase in moisture as a result of the proposed development and this should be taken into consideration during the design and planning phase of the proposed development, especially with an increase in surface runoff as well. Overall, the hydropedological processes are predicted to remain largely unmodified in the post development scenario, and the functionality of the wetlands identified within the catchment area will likely remain unchanged, provided that stormwater is appropriately managed. Refer to Table 14.

Table 14: Summary of the water balance pre- and post-development at HRU scale.

	Before	% of WB	After	% of WB	Change	Weighted Loss	Anticipated PES/EIS Change
Rainfall	623,2841		623,2841				No Change anticipated.
Streamflow	67,3854	10,8113	76,5647	12,2841	13,6220	1,6733	
Surface runoff	64,2743	10,3122	73,4410	11,7829	14,2618	1,6805	

	Before	% of WB	After	% of WB	Change	Weighted Loss	Anticipated PES/EIS Change
Lateral flow	3,1111	0,4991	3,1237	0,5012	0,4049	0,0020	
Percolation	5,6349	0,9041	5,3896	0,8647	-4,3519	-0,0376	
ET	502,2760	80,5854	477,0062	76,5311	-5,0311	-3,8503	
eCanopy	5,9388	8,8132	6,5827	8,5975	10,8422	0,9322	
Transpiration	35,6774	5,7241	42,8946	6,8820	20,2289	1,3922	
Evaporation	460,6597	73,9085	427,5289	68,5929	-7,1920	-4,9332	
ET0	1576,6309		1576,6309				
Profile available water	1,2272		1,2425		1,2470		
Topsoil available water	9,1629		8,9367		-2,4678		

7.6 Scientific Buffer Determination

A scientifically derived buffer was developed to ensure that appropriate consideration of the hydropedological drivers in the study area is given in support of the principles of Integrated Environmental Management (IEM) and sustainable development. A buffer zone can be defined as a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another. As a result, the bigger the buffer the greater the results thereof. This is to allow a large enough area to allow for subsurface or surface flow of water to provide a steady but slow recharge to the groundwater or the downslope watercourse.

Based on the above, the buffer was developed to minimise impact in line with the mitigation hierarchy. The approach to the development of the scientific buffer considered the following;

- The hydropedologically important soils;
- Anticipated losses of lateral flows based on the SWAT+ Model;
- Edge effect of the proposed development; and
- The catchment area of the impact wetland.

Based on the CWA design practicality and consideration of the mitigation hierarchy, total avoidance of the potential impact on the interflow soils (Constantia) associated with the Seep 1 wetland according to the FEN Freshwater report (2024) as well as the buffer will not be possible. Given the geometric requirements of the airport and associated runway complex, avoidance of the scientific buffer is not practical. Thus, an offset investigation should be undertaken to identify suitable target wetland areas to be rehabilitated to compensate for the wetland habitat and functionality loss as a result of the proposed CWA development, which may counteract the negative impact associated with the loss of the interflow/seep wetland area.

Although the hydropedological losses are anticipated to be low, mitigation measures and recommendations have been compiled and these include but not limited to:

- All development footprint areas should remain within the demarcated areas as far as possible and disturbance of soil profiles to be limited to what is essential with a compact footprint;
- Subsurface lateral flow of water through the landscape (under seep wetlands and interflow soils) has to be taken into account and buildings/structures should accommodate waterproofing and water management structures to divert laterally seeping water away from foundations into the gardens or storm water structures.

- Increased surface sealing as a result of the proposed development will result in decreased infiltration as bulk of the stormwater from sealed or paved surfaces are generally discharged in stormwater systems. The exception to this is where runoff is localised and directed to unsealed surfaces or adjacent watercourses in an attenuated manner;
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed development;
- Only the designated access routes are to be used to reduce any unnecessary compaction;
- Water from clean water diversion structures should be discharged back into the adjacent wetland features in an attenuated manner; and
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed project.

The proposed project can be considered for authorisation from a hydropedological perspective as it is not anticipated to cause an unacceptable impact of the wetland recharge mechanisms based on the type of soils identified as well as the quantification of hydropedological losses. The PES/EIS and functionality will likely remain unchanged once mitigations have been implemented.

This document should be used as a guideline to manage water in the landscape surrounding the CWA operation by guiding the positioning, extent, design, management and rehabilitation of the disturbed areas.

8 CONCLUSIONS AND RECOMMENDATIONS

The Zimpande Research Collaborative (ZRC) was to undertake a hydropedology assessment as part of the Water Use License Authorisation (WULA) and Environmental Impact Assessment (EIA) processes for the proposed Cape Winelands Airport (CWA) development, located outside Fisantekraal, in the Western Cape Province. The development boundary for the proposed airport will henceforth be referred to as the "study area".

development may intercept the subsurface flows in the vadose zone feeding the occurring watercourses as well as affect vadose zone recharge mechanisms. Thus, it was deemed necessary to investigate the recharge mechanism of the watercourse within and in close proximity to the study area to ensure that development planning takes cognisance of the hydropedologically important areas and hence enable informed decision making, construction design and support the principles of sustainable development. Recommendations considering mitigation were then considered and presented.

The modelling exercise using the SWAT+(v 1.2.3) model was undertaken in effort to quantify the losses with specific mention of the lateral flow which can be anticipated as a result of the proposed development. The modelling exercise was undertaken at three (3) different scales namely, the Basin scale, the Landscape Unit scale as well as the Hydrological Response Unit scale (HRU). Detailed results of losses are presented in Section 7.4.

At the HRU scale, the site clearing activities and establishment of surface infrastructure will result in a decrease in the evapotranspiration component and an increase in direct evaporation from bare soil. The evapotranspiration component is regarded as the dominant water outflow mechanism since it accounts for approximately 78.71% of the overall water balance. This is thus supported by the type of soils identified within the study area which are largely associated with a high evapotranspiration demand. This is evident through the soils which are characterised by the presence of calcium carbonates, gypsum, cementation and lime in some instances.

The streamflow and surface runoff components depict an increase of 13.62% and 14.26% respectively in the post development scenario as a result of impervious surfaces from the proposed development and also soils with a low storage capacity which in the favourable conditions (intense rainfall and inclined slopes) will likely result in overland flow due to the low hydraulic conductivity of these soils.

The model predicts that the lateral flow component will remain fairly constant at this scale and with the percolation component decreasing by 4.35%. The profile available water slightly increases from initial conditions and thus the model predicts an increase in moisture as a result of the proposed development and this should be taken into consideration during the design and planning phase of the proposed development, especially with an increase in surface runoff as well. Hydropedological process are predicted to be unmodified and the functionality of the wetland will likely remain unchanged.

Table A: Summary of the water balance pre- and post-development at HRU scale.

	Before	% of WB	After	% of WB	Change	Weighted Loss	Anticipated PES/EIS Change
Rainfall	623,2841		623,2841				No Change anticipated.
Streamflow	67,3854	10,8113	76,5647	12,2841	13,6220	1,6733	
Surface runoff	64,2743	10,3122	73,4410	11,7829	14,2618	1,6805	
Lateral flow	3,1111	0,4991	3,1237	0,5012	0,4049	0,0020	
Percolation	5,6349	0,9041	5,3896	0,8647	-4,3519	-0,0376	
ET	502,2760	80,5854	477,0062	76,5311	-5,0311	-3,8503	
eCanopy	5,9388	8,8132	6,5827	8,5975	10,8422	0,9322	

	Before	% of WB	After	% of WB	Change	Weighted Loss	Anticipated PES/EIS Change
Transpiration	35,6774	5,7241	42,8946	6,8820	20,2289	1,3922	
Evaporation	460,6597	73,9085	427,5289	68,5929	-7,1920	-4,9332	
ET0	1576,6309		1576,6309				
Profile available water	1,2272		1,2425		1,2470		
Topsoil available water	9,1629		8,9367		-2,4678		

A buffer zone can be defined as a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another. As a result, the bigger the buffer the greater the results thereof. This is to allow a large enough area to allow for subsurface or surface flow of water to provide a steady but slow recharge to the groundwater or the downslope watercourse. A scientifically derived buffer was developed to ensure that appropriate consideration of the hydropedological drivers in the study area is given in support of the principles of Integrated Environmental Management (IEM) and sustainable development. The buffer was developed to minimise impact in line with the mitigation hierarchy.

The approach to the development of the scientific buffer considered the following;

- The hydropedologically important soils;
- Anticipated losses of lateral flows based on the SWAT+ Model;
- Edge effect of the proposed development; and
- The catchment area of the impact wetland.

Based on the above, the buffer was developed to minimise impact in line with the mitigation hierarchy. The approach to the development of the scientific buffer considered the following;

- The hydropedologically important soils;
- Anticipated losses of lateral flows based on the SWAT+ Model;
- Edge effect of the proposed development; and
- The catchment area of the impact wetland.

Based on the CWA design practicality and consideration of the mitigation hierarchy, total avoidance of the potential impact on the interflow soils (Constantia) associated with the Seep 1 wetland according to the FEN Freshwater report (2024) as well as the buffer will not be possible. Given the geometric requirements of the airport and associated runway complex, avoidance of the scientific buffer is not practical. Thus, an offset investigation should be undertaken to identify suitable target wetland areas to be rehabilitated to compensate for the wetland habitat and functionality loss as a result of the proposed CWA development, which may counteract the negative impact associated with the loss of the interflow/seep wetland area.

Although the hydropedological losses are anticipated to be minimal, mitigation measures and recommendations have been compiled and these include but not limited to:

- All development footprint areas should remain within the demarcated areas as far as possible and disturbance of soil profiles to be limited to what is essential with a compact footprint;
- Subsurface lateral flow of water through the landscape (under seep wetlands and interflow soils) has to be taken into account and buildings/structures should accommodate waterproofing and water management structures to divert laterally seeping water away from foundations into the gardens or storm water structures.
- Increased surface sealing as a result of the proposed development will result in decreased infiltration as bulk of the stormwater from sealed or paved surfaces are generally discharged in

stormwater systems. The exception to this is where runoff is localised and directed to unsealed surfaces or adjacent watercourses in an attenuated manner;

- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed development;
- Only the designated access routes are to be used to reduce any unnecessary compaction;
- Water from clean water diversion structures should be discharged back into the adjacent wetland features in an attenuated manner; and
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed project.

The proposed project can be considered for authorisation from a hydropedological perspective as it is not anticipated to cause an unacceptable impact of the wetland recharge mechanisms based on the type of soils identified as well as the quantification of hydropedological losses. The PES/EIS and functionality will likely remain unchanged once mitigations have been implemented.

This document should be used as a guideline to manage water in the landscape surrounding the CWA operation by guiding the positioning, extent, design, management and rehabilitation of the disturbed areas.

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APPENDIX A: DETAILS, EXPERTISE AND CURRICULUM VITAE OF SPECIALISTS

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

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

Tshiamo Setsipane MSc (Agric.) (Soil Science) (University of Free State)

Braveman Mzila BSc (Hons) Environmental Hydrology (University of KwaZulu-Natal)

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

Company of Specialist:	Zimpande Research Collaborative		
Name / Contact person:	Stephen van Staden		
Postal address:	29 Arterial Road West, Oriel, Bedfordview		
Postal code:	2007	Cell:	083 415 2356
Telephone:	011 616 7893	Fax:	011 615 6240/ 086 724 3132
E-mail:	stephen@FENenvgroup.co.za		
Qualifications	MSc (Environmental Management) (University of Johannesburg) BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)		
Registration / Associations	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP) Accredited River Health practitioner by the South African River Health Program (RHP) Member of the South African Soil Surveyors Association (FENSO) Member of the Gauteng Wetland Forum		

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

I, Stephen van Staden, declare that -

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

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Signature of the Specialist

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

I, Braveman Mzila, declare that -

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

Signature of the Specialist

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

I, Tshiamo Setsipane, declare that -

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

Signature of the Specialist

FEN ENVIRONMENTAL GROUP OF COMPANIES –

SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Group CEO, Water Resource discipline lead, Managing member, Ecologist, Aquatic Ecologist
Joined FEN Environmental Group of Companies	2003 (year of establishment)

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)
Accredited River Health practitioner by the South African River Health Program (RHP)
Member of the South African Soil Surveyors Association (FENSO) Member of the Gauteng Wetland Forum
Member of the Gauteng Wetland Forum;
Member of International Association of Impact Assessors (IAIA) South Africa;
Member of the Land Rehabilitation Society of South Africa (LaRSSA)

EDUCATION

Qualifications

MSc Environmental Management (University of Johannesburg)	2003
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2001
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	2000
Tools for wetland assessment short course Rhodes University	2016
Legal liability training course (Legricon Pty Ltd)	2018
Hazard identification and risk assessment training course (Legricon Pty Ltd)	2013

Short Courses

Certificate – Department of Environmental Science in Legal context of Environmental Management, Compliance and Enforcement (UNISA)	2009
Introduction to Project Management - Online course by the University of Adelaide	2016
Integrated Water Resource Management, the National Water Act, and Water Use Authorisations, focusing on WULAs and IWWMPs	2017

AREAS OF WORK EXPERIENCE

South Africa – All Provinces
Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe Zambia
Eastern Africa – Tanzania Mauritius
West Africa – Ghana, Liberia, Angola, Guinea Bissau, Nigeria, Sierra Leona
Central Africa – Democratic Republic of the Congo

KEY SPECIALIST DISCIPLINES

Biodiversity Assessments

- Floral Assessments
- Biodiversity Actions Plan (BAP)
- Biodiversity Management Plan (BMP)
- Alien and Invasive Control Plan (AICP)
- Ecological Scan
- Terrestrial Monitoring
- Protected Tree and Floral Marking and Reporting
- Biodiversity Offset Plan

Freshwater Assessments

- Desktop Freshwater Delineation
- Freshwater Verification Assessment
- Freshwater (wetland / riparian) Delineation and Assessment
- Freshwater Eco Service and Status Determination
- Rehabilitation Assessment / Planning
- Maintenance and Management Plans
- Plant species and Landscape Plan
- Freshwater Offset Plan
- Hydropedological Assessment
- Pit Closure Analysis

Aquatic Ecological Assessment and Water Quality Studies

- Habitat Assessment Indices (IHAS, HRC, IHIA & RHAM)
- Aquatic Macro-Invertebrates (FENS5 & MIRAI)
- Fish Assemblage Integrity Index (FRAI)
- Fish Health Assessments
- Riparian Vegetation Integrity (VEGRAI)
- Toxicological Analysis
- Water quality Monitoring
- Screening Test
- Riverine Rehabilitation Plans

Soil and Land Capability Assessment

- Soil and Land Capability Assessment
- Soil Monitoring
- Soil Mapping

Visual Impact Assessment

- Visual Baseline and Impact Assessments
- Visual Impact Peer Review Assessments
- View Shed Analyses
- Visual Modelling

Legislative Requirements, Processes and Assessments

- Water Use Applications (Water Use Licence Applications / General Authorisations)
- Environmental and Water Use Audits
- Freshwater Resource Management and Monitoring as part of EMPR and WUL conditions

FEN ENVIRONMENTAL GROUP OF COMPANIES (SEGC) – SPECIALIST CONSULTANT INFORMATION CURRICULUM VITAE OF TSHIAMO SETSIPANE

PERSONAL DETAILS

Position in Company	Soil Scientist/ Hydropedologist
Joined FEN Environmental Group of Companies	2020

MEMBERSHIP IN PROFESSIONAL SOCIETIES

South African Council for Natural Scientist Professions (SACNASP)

EDUCATION

Qualifications

M.Sc. (Agric) Soil Science (*Cum Laude*)	(University of the Free State)	2019
BSc. (Agric) Honours Soil Science	(University of the Free State)	2014
BSc. (Agric) Soil Science & Agrometeorology	(University of the Free State)	2013

COUNTRIES OF WORK EXPERIENCE

South Africa – Kwa-Zulu Natal, Mpumalanga and Free State

KEY SPECIALIST DISCIPLINES

Hydropedological Assessments:

- Soil Survey
- Soil Delineation
- Hydrological hillslope classification
- Hydropedological loss Quantification
- Hydropedological impact assessment
- Scientific buffer determination

Soil, Land use, Land Capability and Agricultural Potential Studies

- Soil Desktop assessment
- Soil classification
- Agricultural potential
- Agricultural Impact Assessments

FEN ENVIRONMENTAL GROUP OF COMPANIES –

SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF BRAVEMAN MZILA

PERSONAL DETAILS

Position in Company	Wetland Ecologist and Soil Scientist
Joined FEN Environmental Group of Companies	2017

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Member of the South African Soil Science Society (FENSO)

Member of the Gauteng Wetland Forum (GWF)

EDUCATION

Qualifications

BSc (Hons) Environmental Hydrology (University of Kwazulu-Natal)	2013
BSc Hydrology and Soil Science (University of Kwazulu-Natal)	2012

COUNTRIES OF WORK EXPERIENCE

South Africa – Gauteng, Mpumalanga, Free State, North West, Limpopo, Northern Cape, Eastern Cape, KwaZulu-Natal

KEY SPECIALIST DISCIPLINES

Hydropedological Assessments:

- Soil Survey
- Soil Delineation
- Hydrological hillslope classification
- Hydropedological loss Quantification
- Hydropedological impact assessment
- Scientific buffer determination

Soil, Land use, Land Capability and Agricultural Potential Studies

- Soil Desktop assessment
- Soil classification
- Agricultural potential
- Agricultural Impact Assessments