



**HYDROPEDOLOGICAL STUDIES AS PART OF THE ENVIROMENTAL
AUTHORISATION APPLICATION PROCESS FOR THE DEVELOPMENT OF
STORM WATER SERVICES FOR THE HIGH-DENSITY RESIDENTIAL
DEVELOPMENT IN ACACIA VILLAS, BLUE HILLS MIDRAND WITHIN THE CITY
OF JOHANNESBURG MUNICIPALITY, GAUTENG PROVINCE, SOUTH AFRICA.**

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Title: **Hydropedological studies as part of the environmental authorisation application process for the development of storm water services for the high-density residential development in Acacia Villas, Blue Hills Midrand within the City of Johannesburg Municipality, Gauteng Province, South Africa.**

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Location: Acacia Villas Luxury Residential Rentals, Gauteng Province

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LIST OF ACRONYMS

°C	Degrees Celsius
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
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
HGM	Hydrogeomorphic
m	Meter
MAP	Mean Annual Precipitation
MPRDA	Minerals and Petroleum Resources Development Act, Act 28 of 2002
NEMA	National Environmental Management Act
NWA	National Water Act
PSD	Particle Size Distribution
SACNASP	South African Council for Natural Scientific Professions
SAS	Scientific Aquatic Services
subWMA	Sub-Water Management Area
WMA	Water Management Areas
WULA	Water Use Licence Application

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 conditions, 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
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.
Vadose zone	The unsaturated zone between the ground surface and the water table (groundwater level) within a soil profile
Watercourse:	n 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

GUIDE DOCUMENTS

No	requirements	Section in report
2.1	Assessment must be undertaken by a suitably qualified SACNASP registered specialist	Appendix A
2.2	Description of the preferred development site , including the following aspects	Section 1.1
2.2.1	a. Aquatic ecosystem type b. Presence of aquatic species and composition of aquatic species communities, their habitat, distribution and movement patterns	Section 4
2.2.2	Threat status, according to the national web based environmental screening tool of the species and ecosystems, including listed ecosystems as well as locally important habitat types identified	Section 4
2.2.3	National and Provincial priority status of the aquatic ecosystem (i.e. is this a wetland or river Freshwater Ecosystem Priority Area (FEPA), a FEPA sub- catchment, a Strategic Water Source Area (SWSA), a priority estuary, whether or not they are free-flowing rivers, wetland clusters, etc., a CBA or an ESA; including for all a description of the criteria for their given status	Section 4
2.2.4	A description of the Ecological Importance and Sensitivity of the aquatic ecosystem including: a. The description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); b. The historic ecological condition (reference) as well as Present Ecological State (PES) of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel, flow regime (surface and groundwater	Section 4
2.3	Identify any alternative development footprints within the preferred development site which would be of a “low” sensitivity as identified by the national web based environmental screening tool and verified through the Initial Site Sensitivity Verification	Section 5.3
2.4	Assessment of impacts - a detailed assessment of the potential impact(s) of the proposed development on the following very high sensitivity areas/ features:	Section 5.3
2.4.1	Is the development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Section 5.3

2.4.2	is the development consistent with maintaining the Resource Quality Objectives for the aquatic ecosystems present?	Section 5 and 6
2.4.3	How will the development impact on fixed and dynamic ecological processes that operate within or across the site, including: a. Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); b. Change in the sediment regime (e.g. sand movement, meandering river mouth/estuary, changing flooding or sedimentation patterns) of the aquatic ecosystem and its sub-catchment; c. The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). d. Assessment of the risks associated with water use/s and related activities.	Section 5
2.4.4	How will the development impact on the functionality of the aquatic feature including: a. Base flows (e.g. too little/too much water in terms of characteristics and requirements of system); b. Quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over abstraction or instream or off-stream impoundment of a wetland or river); c. Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an Unchannelled valley-bottom wetland to a channelled valley-bottom wetland); d. Quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); and e. Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).	Section 5
2.4.5	How will the development impact on the functionality of the aquatic feature including: a. water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river)	Section 5

	b. Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an Unchannelled valley-bottom wetland to a channelled valley-bottom wetland). c. Quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); d. Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); e. The loss or degradation of all or part of any unique or important features (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.) associated with or within the aquatic ecosystem.	
2.4.6	How will the development impact on key ecosystem regulating and supporting services especially Flood attenuation; Streamflow regulation; Sediment trapping; Phosphate assimilation; Nitrate assimilation; Toxicant assimilation; Erosion control; and Carbon storage	Section 4 and 5
2.4.7	How will the development impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	Section 4 and 5
2.4.8	A motivation must be provided if there were development footprints identified as per paragraph 2.3 above that were identified as having a “low” biodiversity sensitivity and were not considered appropriate.	Section 5 and 6
3.	The report must contain as a minimum the following information:	
3.1	Contact details and curriculum vitae of the specialist including SACNASP registration number and field of expertise and their curriculum vitae;	Appendix A
3.2	A signed statement of independence by the specialist;	Appendix A
3.3	The duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 2
3.4	The methodology used to undertake the impact assessment and site inspection, including equipment and modelling used, where relevant;	Section 2
3.5	A description of the assumptions made and any uncertainties or gaps in knowledge or data as well as a statement of the timing and intensity of site inspection observations;	Section 1.3
3.6	Areas not suitable for development, to be avoided during construction and operation (where relevant);	Section 5.3

3.7	Additional environmental impacts expected from the proposed development based on those already evident on the site and a discussion on the cumulative impacts;	Section 5.3.3
3.8	A suitable construction and operational buffer for the aquatic ecosystem, using the accepted protocol;	Section 5.3.2
3.9	Impact management actions and impact management outcomes proposed by the specialist for inclusion in the EMPr	Section 5.3.3
3.10	A motivation where the development footprint identified as per 2.3 were not considered stating reasons why these were not being not being considered; and	none
3.11	A reasoned opinion, based on the finding of the specialist assessment, regarding the acceptability or not, of the development and if the development should receive approval, and any conditions to which the statement is subjected.	Section 6
3.12	A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.	Section 6
3.13	Proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr).	Section 7: Table 5.
3.14	A motivation must be provided if there were development footprints identified as per paragraph 2.3 for reporting in terms of Section 24(5)(a) and (h) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) that were identified as having a “low” aquatic biodiversity and sensitivity and that were not considered appropriate	None.
3.15	A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not	Section 6
3.16	Any conditions to which this statement is subjected.	Section 6

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1 INTRODUCTION

Ariys Consulting (Pty) Ltd was appointed by Selahle Consultancy and Projects (Pty) Ltd to conduct a hydropedological assessment as part of the Environmental Authorisation (EA) process for the High density residential development and its proposed storm-water services located in Blue Hills, Midrand (Acacia Villas) approximately 5km of Midrand CBD within the City of Johannesburg Municipality, Gauteng Province. The footprint area under which the proposed expansion activities are to occur will henceforth be referred to as the “investigation area” (See Figure 1 and Figure 2). The assessment area encompasses the actual footprint area of the proposed developments.

1.1 Project Description

Selahle Consultancy and Projects (Pty) Ltd appointed Ariys Consulting (Pty) Ltd to conduct Hydropedological studies for the proposed storm-water development on a new high density residential development with an aim to see if the wetland function is active or in active. From the previous studies which was conducted a specialist rated the wetland function to be low, GDARD want hydropedological results in order to make decisive conclusion on this matter. The site Environmental Authorization is already granted but with conditions. Some of the conditions includes the clearly delineate the wetlands, provide storm-water services to prevent the degradation of the stream and the valley bottom, the hydropedology studies also have to provide substantial evidence to support or deny the recommendations made by the wetland specialist on the functioning of the seep.

New proposed storm water development is on a High-density residential building consist of high-density building units, Guard room and parking lot for residence and visitors. Present Ecological Settings shows that the main part of the development has already been completed and only the storm-water systems to control water flow and erosion of the natural surface or carrying over of waste materials to both the valley bottom and the unnamed stream.

Far southwestern side and the far southeastern side portion shows that the investigation area is occupied by environmental features of ecological importance. This includes the wetland from the southeastern of the investigation area which does increase in size moving south west wards, and Perennial stream which flows from SSW of the study area towards SSE where it exit the study area.

The presence of these two Ecological features does command the developer to perform all necessary ecological preservative studies which will lead to the protection of fauna and Flora and also make sure that this future development does not impact negatively on the Present Ecological Settings Rather improve them in order to uphold the principles of sustainable development.

Up to date all studies which support the development of this high density residential development have been conducted, but an environmental encroachments was noticed by GDARD officials which lead them to request an additional Hydropedological studies in which its main function is to check the interaction between the soils, plants and water flows within the environment and through the environment like from surface to underground water bodies then recharge of perennial streams.

The investigation area is about 5.1ha in size and the investigation is only limited to the boundaries of the investigation area this is because of the geographical location of the study area. The study area is surrounded by developments from all sides. The geographical coordinates of the study are 25°57'31.16"S, 28°5'24.01"E. below is figure 1 showing the study area and the surrounding environment.



Figure 1:Locality map depicting the assessment area and the associated investigation area in relation to the surrounding areas, depicted on digital satellite imagery.

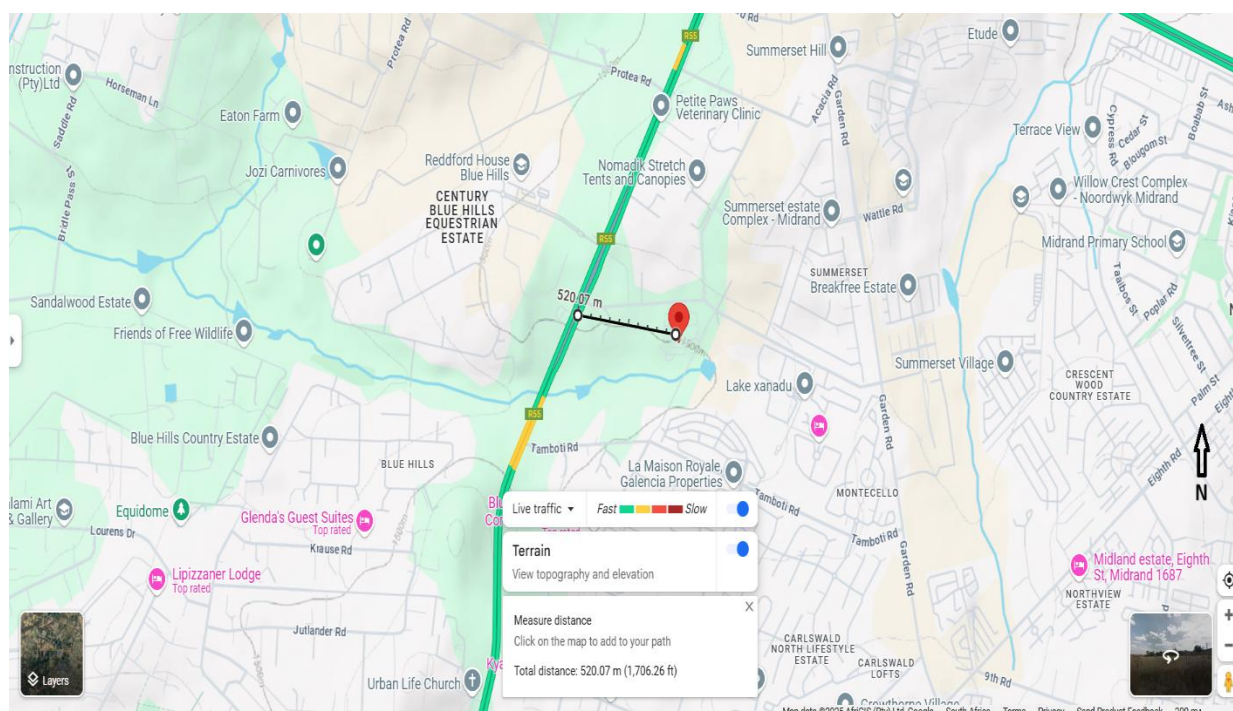


Figure 2: Locality map depicting the assessment area and the associated investigation area in relation to the surrounding areas, depicted on digital 1:200 topographic map.



Figure 3: Locality of existing and planned infrastructure in relation to the surrounds, depicted on digital satellite imagery.

1.2 Objectives

The purpose of this investigation was to investigate the hydrogeological properties of the soils associated with the watercourses which are distributed across the landscape associated with the proposed developments. These watercourses which exist as cryptic wetlands (valley bottom), preferential flow paths, Perennial stream as well as episodic drainage lines are more likely to be impacted by the proposed developments.

This is due to the bulk earthworks the proposed development will entail and thus may intercept and redirect both surface and subsurface flows (if any) in the vadose zone contributing to the recharge of the watercourses as well as affect vadose zone recharge mechanisms. Consequently, it was deemed necessary to investigate the recharge mechanisms of the watercourses within the investigation area to ensure that development planning takes cognizance of any potentially hydrogeologically important areas and hence enable informed decision making and to guide construction design in support of sustainable development and Integrated Environmental Management. In this case most of the construction where already

completed with most surfaces already paved only storm-water services were left installed. Recommendations on mitigation were then considered and presented.

1.3 Assumptions and Limitations

The following assumptions and limitations are applicable to this report

- Hydropedological science and research is rapidly evolving and there are currently no standard methods to assess and/or model the recharge capacity of soils, as a result, the findings of this assessment are therefore a mix of qualitative and quantitative results and based on the specialist's training, opinion and experience with the hydropedological properties of the identified soil types topographic conditions and wetland characteristics;
- The hydropedological assessment is confined to the investigation area as illustrated in Figures 1 and 2 and does not include the neighbouring and surrounding properties outside of the investigation area. This study however considers adjacent watercourse and the recharge mechanisms on a desktop level;
- Inaccuracies may exist in the delineation of the catchment scientific buffers of the cryptic wetlands associated with the project footprint due to the inaccuracies in the contours (acquired from Global Mapper) used during the delineation process;
- The effects climate change dynamics were not considered as part this assessment; however, it is acknowledged that this might exacerbate the anticipated impacts associated with a reduction in water inputs and the resultant hydrological function of the remaining wetlands beyond the extent of the proposed development.

1.4 Legislative Requirements and Provincial Guidelines

The following legislative requirements and relevant provincial guidelines were taken into consideration during the assessment:

- Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998);
- The Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996);
- The National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA);
- The National Water Act, 1998 (Act No. 36 of 1998) (NWA);
- The National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEMWA).

2 ASSESSMENT METHODOLOGY OF THE INVESTIGATION AREA

A hydropedological survey was conducted in 19 November 2024 to assess the hydropedological characteristics of the landscape and associated soils within the investigation area. A soil classification exercise was undertaken at selected representative points, considering the various soil types, in order to deduce the wetland recharge mechanisms and identify the anticipated hydropedological impacts of the proposed development on the wetland resources that will be affected by the proposed development. Subsurface soil observations were made by means of a standard hand auger and investigation methods.

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 auger as well as analysis of exposed profile areas which depict the diagnostic horizon sequence; and
- Soils observations were made until the layer of refusal.

Field assessment data included description of physical soil properties including the following parameters, in order to characterize 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 behavior of the hillslope (van Tol et al., 2013). This includes a graphical representation of the dominant and sub-dominant flow-paths 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 conceptualized hydropedological response model to provide a quantitative description of flowrates and storage.

Step 4: Quantification of hydropedological fluxes

- Quantify the hydropedological fluxes using SWAT+ Model (Bieger et al., 2017; van Tol et al., 2020a).
- Identify the potential impacts of the proposed high-density development and storm-water services 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)

	Permeability rates*	Permeability rates*
Soil permeability classes	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	> 60

*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, Ks (cm/s)
Gravel	$3 \times 10^{-2} - 3$
Coarse Sand	$9 \times 10^{-5} - 6 \times 10^{-1}$
Medium Sand	$9 \times 10^{-5} - 5 \times 10^{-2}$
Fine Sand	$2 \times 10^{-5} - 2 \times 10^{-2}$
Loamy Sand	4.1×10^{-3}
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	$8 \times 10^{-11} - 2 \times 10^{-7}$

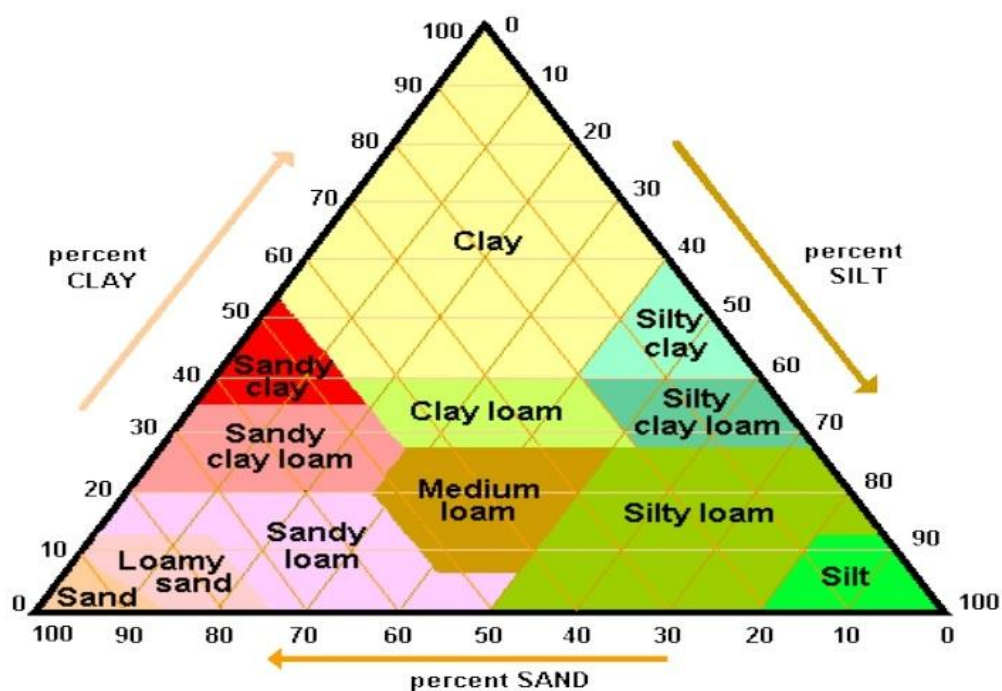


Figure 4: Soil texture classification chart (Food and Agriculture Organization (FAO), 1980)

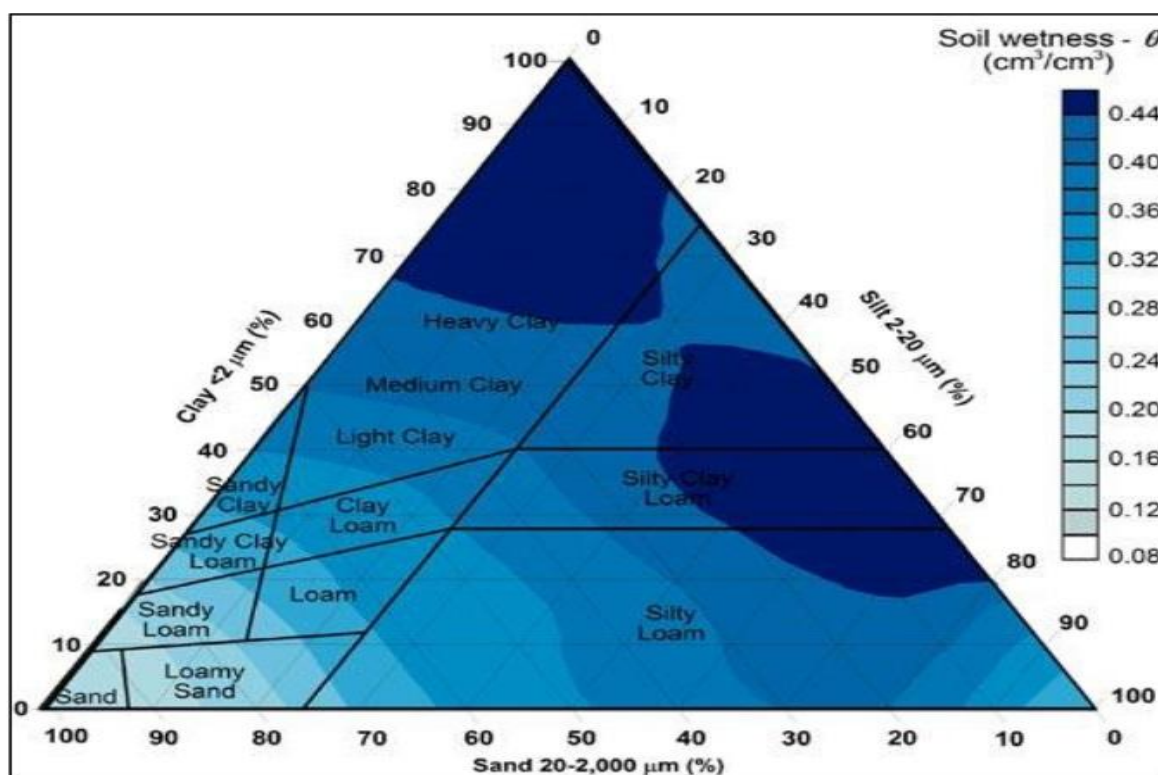


Figure 5: A diagram depicting soil wetness based on soil textural class.

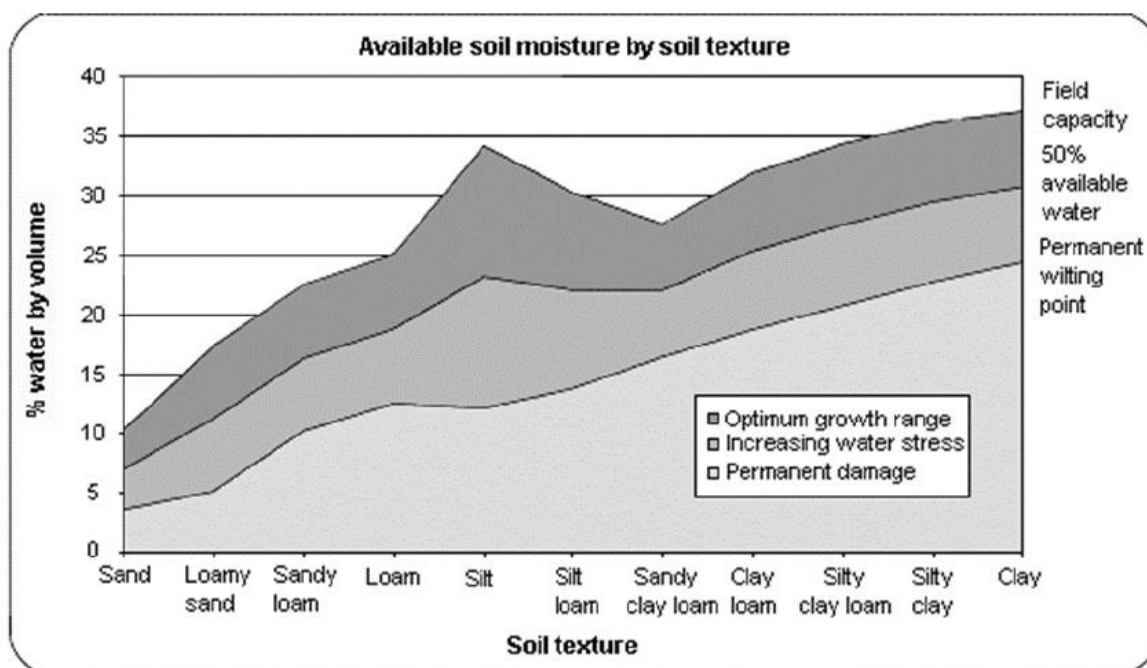


Figure 6: A diagram depicting the percentage volume of water in the soil by soil texture.

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.

3 HYDROPEDOLOGICAL BEHAVIOUR OF SOIL TYPES

Hydropedological behavior of different soils can vary significantly, depending on the soil drainage patterns. The discussion below is largely based on the concept presented in Figure 8 and Table 5 below.

Stagnating soils

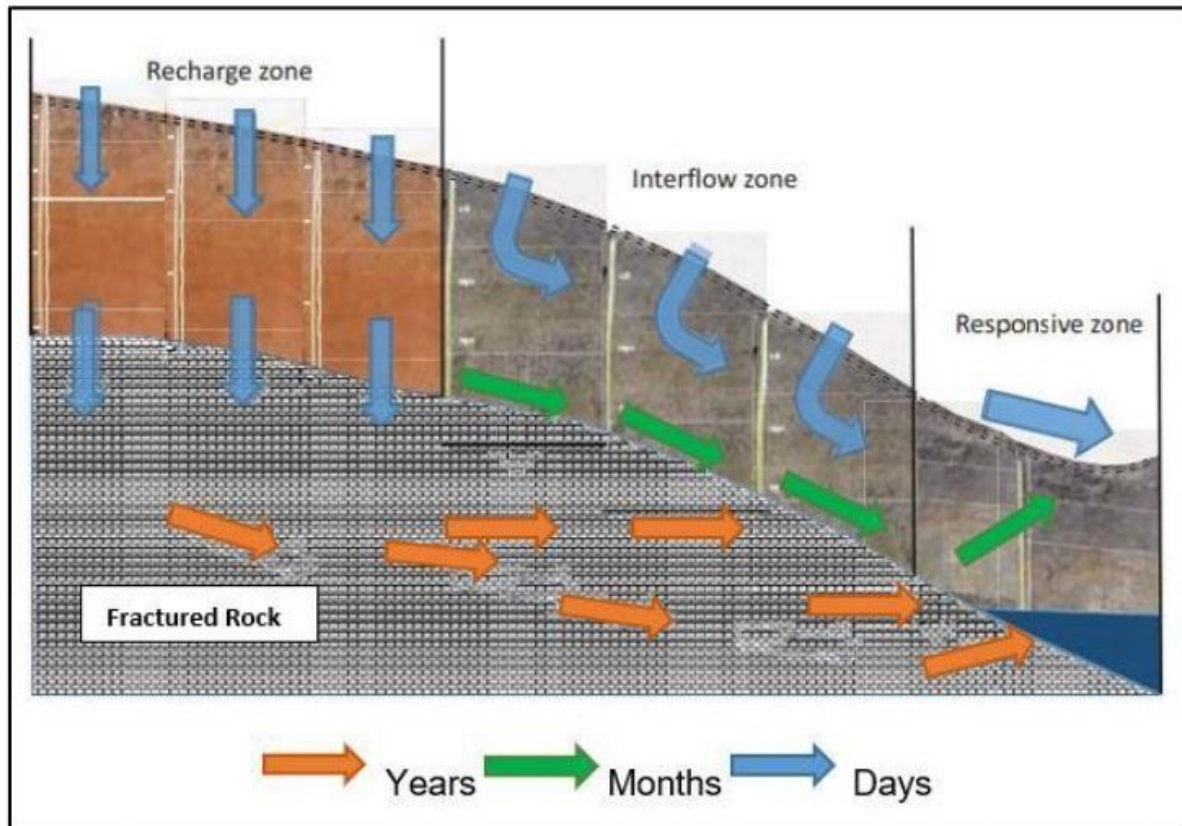
Hydropedological soil types classified as “stagnating” dominate the investigation area. These soils are termed stagnating due to the occurrence of evidence of silification of surface soils layers in the landscape which forces water to be stagnate and prevent water to penetrate freely to the bottom soils. In these types of soils silica rich with evidence of claying has accumulated to a point that it is hardened and restricts water movement. The soils are colluvium but very hard surface due to high rates of evapotranspiration demand. Although infiltration occurs readily in the topsoil, the dominant hydrological flow path in the soil is upward, driven by evapotranspiration.

Rechargable soils

Recharge shallow soils also dominate in the landscape.

Just few centimeters 50cm in average and less in depth below the thin layer topsoil, there is a rechargeable layer of moist, grey orange to black, loose, sandy, fine to medium gravel soil. This was formed by the disintegration of the hoist rock and the top layer. This layer does have some HGM properties as Mottle was observed which show that water did remain stagnates for a period of time. Claying on this layer was not that dominate, and this is a sign of interflow between this layer and other layers of soil, refusal was experienced in this layer as the end of this layer is a less disintegrated hoist rock hardpan ferricrete layer. Seasonal perched water table is expected to form in rainy seasons in this zone. This implies that water flows through and out of the profile into the underlying rock material recharging the underlying aquifers. These soils can either be shallow on fractured rock with a limited contribution to evapotranspiration or deep freely drained soils that can contribute significantly to evapotranspiration.

Figure 7 presents a conceptual diagram of the recharge mechanism of different soil types within the landscape and their influence on freshwater resources.



*stagnating soils are not included in the diagram they are not considered hydrogeologically important

Figure 7: A typical conceptual presentation of hydrological flow paths on different hydrogeological soil types- hillslope hydrogeological behavior.

Table 5: Hydrological 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 (Wet)	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.	
Stagnating	In these soils outflow of water is limited or restricted. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant however no wetland response is observed. These include soils with carbonate accumulations in the subsoil, accumulation and cementation by silica and precipitation of iron as concretions and layer. The dominant hydrological flow path in the soil is upward, driven by evapotranspiration	

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).

4 ECOLOGICAL SIGNIFICANCE

The proposed development area is associated with valley bottom cryptic wetland and hill slope seepage; thus, it was deemed important to understand the status of the affected wetland in terms of their Present Ecological State and Ecological Importance and Sensitivity to ensure that the necessary protection is afforded. The results presented below focus on the features that will be directly and indirectly impacted by the proposed expansion project which is now the installation of storm-water services.

The aquatic studies conducted by Eco-Santle(Pty) Ltd (2024) identified a channel of valley bottom and hill slope seepage wetland environments based on distinct topographic features, specifically relating to endorheic (inward draining) depressions. In addition, preferential flow paths and anthropogenically-derived channels were identified. The extent of modification on these above-mentioned systems will vary, depending on the nature of the proposed activity and proximity to affected wetlands. The full summary of the wetland delineation findings is presented in Table 6 below. Protection of these features where feasible is deemed important, in line with the National Water Act No. 36 of 1998 and National Environmental Management Act No. 107 of 1998.

The watercourses identified within the investigation area were grouped according to their locality (See Figure 9, 10,11 and 12) as follows:

- **Perennial stream** - single stream is identified flowing towards South west located at the far eastern side of the investigation area , the stream was assessed and it was found that it was heavily affected by environmental alteration currently, evidence of eutrophication was seen and the riverbed where heavily eroded.
- **Valley bottom cryptic wetland** - this wetland cover small portion of the investigation area and is located on the far southern portion of the investigative area, it shrinks from north towards south west in alignment with the stream flow. This area is not really going to be directly affected by the services structures which are going to be constructed towards the south eastern portion of the investigation area, protected species where identified outside the buffer zone.
- **Denudation hills** - this features dominate the north portion of the study area and this is a region where hill slope seepage is taking place, the seepage output was found to be flowing towards the stream in a southwards direction, this zone is already heavily altered with the foundation of the structures already been dug in this zone and most of the development had already been completed on site only storm water services are left to be installed.

- **Water runoff course** - natural and manmade runoff flow courses where noticed spreading throughout the study area with most of them already paved and well channeled, the remaining courses needs to be channelled in order to protect them from erosion and reduce the erosive activities on site. This courses where suggested to be used as main paths during the construction phase of the project in order to limit environmental alterations.

Table 6: Summary of results of the field assessment of the identified wetland features associated with the project footprint

Watercourse Grouping	PES Category	EIS Category
CW 1	B (1.08)	High
Hillslope seepage	B (1.57)	High
Run-off course	C	Moderate
Perennial stream	D/E	High



Figure 8: The location of the delineated watercourses within the investigation area with emphasis on coverage of hillslope seepage and bottom valley wetland (courtesy of Eco-Sentle consultant).

5 RESULTS AND DISCUSSION

5.1 Morphological and Hydraulic Properties of Wetland and Hydropedologically Important Soils Associated with the Investigation area:

Table 7: summary of hydropedological soils and their water movement which are found withing the investigation area

Soil type	thickness	Soil water class	Soil class	Movement of water	Driving force	
Colluvium	0.0-0.5m	Rechargeable soils (infiltration)	Transported		gravity	Water moves through pore spaces, when filtrated some form runoff
Ferreginized horizon	0.5-1.2	Pearched aquifer(stagnate)	Chemical leaching			Water moves through open spaces, the dominant movement is lateral, water is stagnate
Residual granite	1.2-	Perculative soils(rechargeable)	Residual soils		gravity	Water moves through open spaces
Completely weathered Granite	-	Deep percolation (interflow movement)	Pedogenic soils		gravity	Water moves through open fractures from the parent rock
Host rock granite with minor fractures	-	Aquitard	Bedrock			Water moves lateral through major fractures until they recharge the streams.

5.1.1 Physical Characteristics

The structure of the soils associated with the investigation area are sandy with loose and single grained structure. A ferrecrete layer is present at shallow depth within most part of the landscape and is deemed to have a moderate impermeability with a moderate to good water holding capability. The Cryptic wetlands however do not hold water long enough to create soil morphological properties indicative of prolonged saturation as the evaporative demand is greater than the water residence time within these features. Infiltration rates on the shallow soils underlined by the permeable fractured bedrock is anticipated to be very high due to large cracks present in the bedrock and thereby recharging the regional aquifers.



Figure 9: shows the cross profile of all soil layers associated with the investigation area.

5.1.2 Discussion of soils within the investigation area

High porosity together with small pore size and low connectivity in the upper transported soil horizons result in water retained by adhesion with excess water gradually draining under gravity. The underlying ferricrete is less porous but with larger pores and better connectivity, resulting in cohesion between water molecules and subsequently drainage under gravity.

However, as the saprolite underlying the ferricrete is once again porous but with much smaller pores and more clogging due to clay minerals such as kaolinite and mica, adhesion retains moisture with interflow in the overlying ferricrete being easier than percolation into the saprolite. This results in surface infiltration, interflow in the perched water table in the ferricrete, and limited deeper percolation in ferruginized portions (Fig. 14).

Transported soil horizons (notably upper colluvium) are pinholed with porosity in the order of 0.22. Ferricrete has larger pore sizes with average porosity in the order of 0.15 and is underlain by residual granite with porosity of 0.22. Vertical near-saturated hydraulic conductivities (which represent infiltrating water derived from precipitation on land surface) for these materials vary between 7×10^{-5} m/s on the upper to midslope to 1.8×10^{-4} on the midslope to lower slope.

Ferricrete underlies colluvium on the upper-midslope and the mid-lower slope and is distinctly absent just below the midslope and on the upper reaches of the slope. Yellow, orange and red discolouration of residual soil and weathered rock is much more pronounced than the discolouration in the colluvial materials, suggesting that leaching may occur in the upper horizons followed by precipitation in the deeper horizons. As visual evidence of seepage and distinct large, connected pores are present in the ferricrete, it is expected that water infiltrating will enrich in mobile ions. Thereafter, enriched water will move as interflow within the ferricrete or alternatively may be sourced from interflow further upslope or from the bedrock below. The ferricrete is therefore expected to form upward, hence the distinct absence of some significant identifiers (such as soil mottling and wetness) in the upper horizons.

The residual granite underlying the ferricrete (or the colluvium, where absent) is once again more porous, stained with goethite and possibly resulted from the weathered bedrock (porosity 0.15 and lower) serving as a local aquitard. Fractures within the lesser weathered granite may serve as flow paths, although the same structures in the completely weathered granite appears to be more clogged with goethite and kaolinite.

Kaolinite forms from the weathering of the feldspars and may be sources from bedrock further upslope. This clay mineral, albeit not expansive, aids in clogging of porosity and may play an important role in the formation of the perched water table.

The flow in the ferricrete results as the larger pores promote cohesion between water molecules rather than adhesion to mineral surfaces. The direction and degree of interconnectivity govern the flow rate and direction. Vertical percolation will result where the ferricrete pinches out or where the void space is directly connected to that of the deeper horizons, although imbibition into smaller pores in the residuum may be less pronounced given the large void spaces within the ferricrete. The importance of pore size (scale of porosity) as opposed to volumetric porosity is accentuated in this process where the path of least resistance is the larger pores in the ferricrete, resulting in interflow rather than deeper percolation.

The weathered bedrock forms a fractured vadose zone. The ferricrete forms due to alternating reducing and oxidizing conditions, the latter supplying opportunity for precipitation of goethite. The system – which mimics a temporary wetland – is not related to the permanent groundwater table, therefore making classification of the site as a wetland (s.s.; sensu stricto or in the strict sense as defined in the National Water Act, DWA 1998) impossible. However, its behaviour as such in a region where groundwater is not shallow results in ecosystems flourishing in this area following long and intense rainfall events.

In areas where groundwater is generally deep and where rainfall is erratic, intense and concentrated within short periods, perched water tables form, which may result in waterlogged conditions supporting wetland vegetation. As the groundwater or surface water itself does not form the system, classification as a wetland is presently not possible and these sensitive systems are being zoned for development. This adversely impacts biodiversity, water quality and influences the development as water later affects foundations and underground services.



Figure 10: Shows position of test holes in the investigation area.

Table 8: Gives the summary of all test holes, their locations and the layers they intersected for each auguring

Hole ID	Trail Hole Location	X-Coordinate(°)	Y-coordinates(°)	Elevation(m)	General Discription of the intersected layers	Layers Diagram	Intersected Layers	End of Hole
MTH1	Dunadation Hill	28°05'25,5"E	25°57'32,9"S	1433	colluvium Slightly Moist ,Brown ,Soft , Shattered ,Silty sand with ferricrete nodules and concretions.was incountered in all test pits from surface to avarage depth of 0,8 meters		L1,L2	1,0m
MTH2	Wetland	28°05'24,6"E	25°57'34,0"S		Nodular Ferricrete Slightly moist becoming moist , grey mottled orange and black , loose ,Sandy ,Fine and Medium Gravel consisting of hard ,round ,intact ,nodular ferricrete and medium Ferricrete concetration was encountered in most of the test points from a avarage depth of 0.4m upto an avarage depth of 1.2 meters .the backhou refused on hardpan ferricrete at an avarage depth of 1.2m.		L1,L2,L3	0,9m
MTH3	Wetland	28°05'22,7"E	25°57'34,2"S	1414	resedual granite very moist , brown and yellowsh brown , Medium Dense, Intact , Clayey Silghtly Sand with stained yellowish brown , Ferricrete Gravels, this layer was avaraging from 0,8m to end of hole , for this study it was not intersected becuese of the Auger refusal but it was exposed by the TLB during geotechnical investings		L1,L2	1,3m
MTH4	Wetland	28°5'20"E	25°57'33"S	1410m			L2	0,7m
MTH5	Denudation Hill	28°05'21,1"E	25°57'32,4"S	1437m			L1,L2,L3	1m

Figure 11 below presents the dominant soil forms associated with the proposed development as identified during the hydrogeological assessment.



Figure 11: Map depicting spatial distribution of soils within the investigation area.

5.2 Recharge of the Cryptic 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. This section seeks to address the behavioural patterns of the different soil types from a hydrogeological point of view, and the other recharge mechanisms will be highlighted in Section 5.3.1 of this report.

The identified soils within the investigation area have been grouped into hydrogeological soil types and are discussed below in order to understand their contribution to wetland recharge. The subsections below present the hydrogeological soil types which were identified within the investigation area during the site assessment.

5.2.1 Recharge (Shallow) soils

These soils are characterized by the absence of any morphological indication of saturation. In this instance these soils are mostly shallow underlined by a fractured bedrock. These soils are characterized weak structured and mostly sandy textured properties which allows for rapid infiltration of water. Below the soil material the presence of lithic material in the form of fractured rock still allows for percolation of water and thus the dominant hydrological pathway for these soils is vertical through and out the profile into the underlying aquifers. Therefore, these soils are referred to as recharge soils, as they are likely to recharge groundwater, or lower lying positions in the regolith via bedrock. Figure 14 below depicts typical ground water recharge soils identified within the investigation area.



Figure 12: An example groundwater recharge soils of associated with the investigation area.

5.2.2 Stagnating Soils

The soils in the investigation area can be classified as shallow stagnating for soil forms such as the ferricrete which was formed by leaching of iron. The ferricrete soil form is characterized by the presence of a hard plinthic horizon underlying the Orthic A horizon. Whereas the soil form is characterised by the presence of a soft iron rich and material with signs of wetness underlying the Orthic A horizon. In both these soils outflow of water is limited or restricted due to the underlying impeding layer. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant. (van Tol et al., 2011).



Figure 13: An example of saturated soils associated with investigation area.

5.3 Hydropedological and Recharge Implications

The recharge mechanism of the soils associated with the watercourses and their respective catchment areas are characterized by stagnating soils which are associated with high evapotranspiration demand areas. The subsurface flow contribution to the wetlands associated with the investigation area need to be considered. The shallow soils associated with the study area has resulted in streamflow channels associated with overland flow during rainfall events. These channels have the potential to recharge the wetlands in the investigation area. The wetland features are typically due to depressions in the landscape in the form of endorheic systems and perched shallow aquifers because of the low permeability of ferric rich soils underlying the topsoil.

This section presents the hydropedological impacts that can be anticipated resulting from the high-density residential area project and the additional stormwater services which are proposed to be installed and considers the outcomes of the geohydrological studies in relation to the type of aquifers present and the groundwater levels. This section will also present an appropriate scientific buffer which is derived from taking into consideration the wetland ecology component as well as the significant wetland drivers to ensure that all wetland features are afforded protection in line with the applicable legislation.

Hydropedological losses is foreseen for these wetlands as interflow (sub-surface flows recharging the wetlands) soils where noticed during the investigation soils within the catchment of these systems. Direct impact is foreseen for the wetlands overlain by the proposed developments, thus the recommendation of the wetland demarcation from the Aquatic studies report compiled by Eco-Santle consultant (2024) should strongly be considered. Additionally, other components in the water balance, with specific mention of recharge by surface water runoff may be impacted particularly in areas where the surface infrastructure is located within the catchment area and separation of clean and dirty water areas takes place.

The results of the impacts based on the current layout can be summarized as follows:

CW1 - is located far South west of the investigation area and reduces in sizes moving south east wads of the stream , there is no building structure which has deemed to have encroach any scientific buffer as all structures where noticed to be outside the 1:50 years flood line even the proposed storm water services shows that they will be outside the scientific buffer lines, protected species where noticed by the Aquatic studies specialist.

Hill slope seepage – most of the development is located at this region, redirection of seepage water flow to be implemented. This water will enter the attenuation pond before entering the wetland.

Stream riverbed - PES of the stream riverbed shows that the conditions are already altered Although the stream was located outside the boundaries of the investigation area and gabions needs to be installed some portions of the stream riverbed to prevent erosion.

From a hydropedological perspective, if the cryptic wetlands and their applicable scientific buffers as defined in this report are avoided (as far as practicable) the proposed development is deemed acceptable. Avoidance of wetlands and applicable scientific buffers will ensure that the Present Ecological State (PES), wetland functionality as well as impact on the Ecoservices the wetland provides remain unchanged during all phases of development. It is therefore imperative that the recommendation presented in this document as well on the Aquatic studies report (Eco-Santle, 2024), and the scientific buffer are implemented.

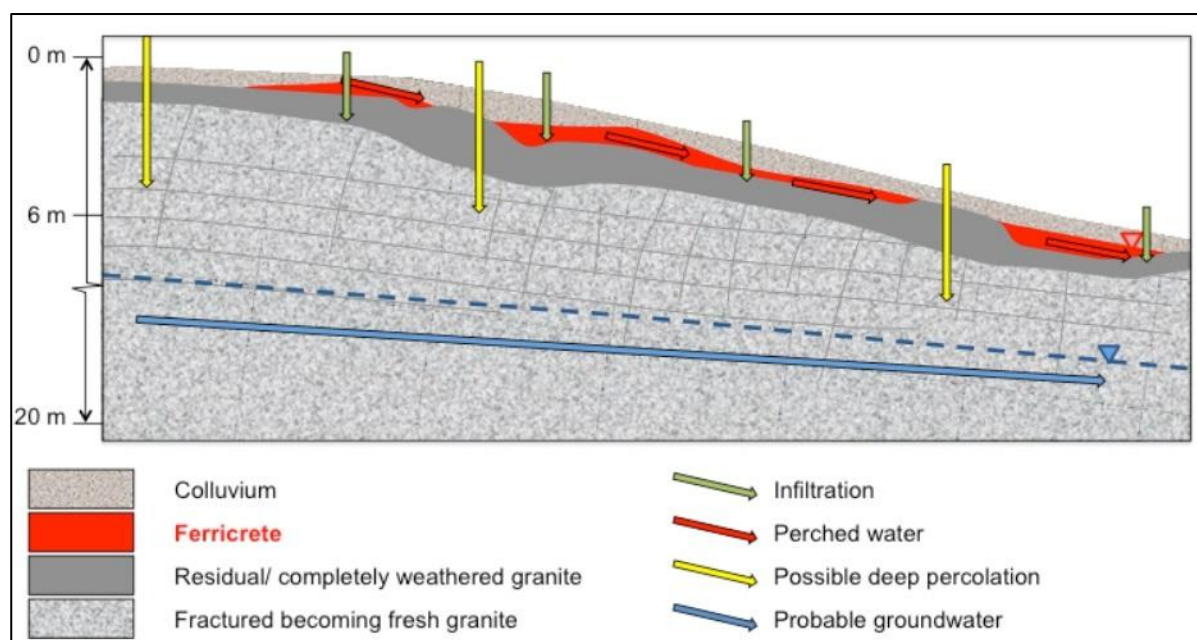


Figure 14: Conceptual hydrological flow paths of the wetlands associated with the investigation area.

The outflow in the soils associated with the Cryptic wetlands is limited or restricted. The A and/or B horizons are permeable morphological indicators suggest that recharge and interflow are average. These include soils with and ferric texture in the subsoil, accumulation and cementation as concretions and layers. percolation to deep areas occurs where this ferricrete is not present and through fractures of the bedrock which have form a residual soil. Were the bedrock becoming solid the water starts to form a permanent water table below.

5.3.1 Geohydrological Study Consideration

It should be noted that the groundwater information presented in this document was adopted from the hydrogeological report (2024).

Aquifers

The geohydrological regime in the area is made up of two main aquifer systems namely:

The upper, unconfined to semi - confined aquifer which occurs in Ferri-ginized residual Granite. Spring formations are a common occurrence especially in the lower lying topography due to the shallow water table.

The deeper weathered and fractured Gneiss water table is associated with fractures, fissures, joints and other discontinuities within the consolidated bedrock and associated intrusive of the Transvaal super group.

According to Hydrogeological report effective recharge to the aquifer can be as high as 10% of rainfall and higher at certain areas. The major contributor to the recharge of the aquifer is through the rock cracks and fissures and the weathered zones in the granite or through sandy soils in depression areas.

Groundwater levels

According to the ground water studies (2024) the static groundwater levels vary from zero meters (springs flowing out at surface), generally in the topographically lower lying areas, to a maximum of approximately 35m meters below surface to the north-east of Midrand. Based on observation during the site visit, most of the wetlands were dry without freestanding water. The groundwater component is not anticipated to provide a significant contribution although the perched shallow aquifer may contribute (to a degree) during the rainy season. Overall, the watercourses will therefore negligibly be impacted by the abstraction activities that will occur as part of the high-density development project.

5.3.2 Buffer Determination Using Hydropedological Principles

A scientifically derived buffer was developed to ensure that appropriate consideration of the hydropedological drivers in the investigation area is given in support of the principles of Integrated Environmental Management (IEM) and sustainable development. Refer to Figure 19 and Figure 20. The buffer was developed to indicate the required setback to appropriately negate the impact of high-density development on the recharge mechanisms of cryptic wetlands pan to minimize impact in line with the mitigation hierarchy, significant impact would occur if slight encroachment on the buffer was to occur due to recorded endangered species within the scientific buffer zone.

Due to the nature of the area where the development is developed consideration of hydropedologically important soils, of which dominates the wetland zone the scientific buffer was developed taking into consideration the catchment area of the wetlands to ensure that all runoff occurring under normal circumstances reaches the wetlands.

The high density development footprints indicate that several watercourses and the bottom valley cryptic wetland were impacted as a result; the significance of impacts varies depending on the nature of the activity and extent thereof, most activities were rated high risk by Santle Consultant but following the mitigations measures reported by Eco-Santle consultant on Aquatic report all risk will be of low significance none are deemed to have 'high' risk significance and most can be feasibly mitigated (Eco-Santle, 2024). The footprint of the high-density residential development has already been developed and thus total avoidance of the cryptic wetlands within the footprint may not be feasible.

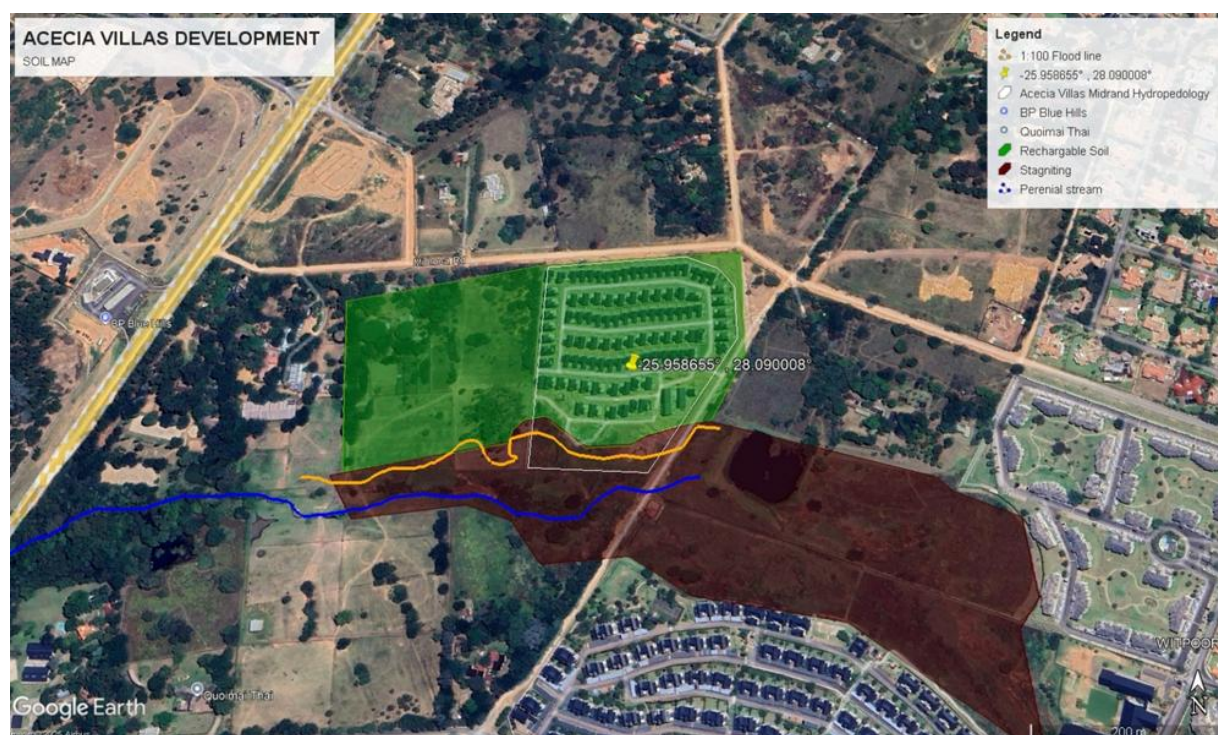


Figure 15: Applicable scientific buffer applicable to the wetlands for best practice in line with the mitigation hierarchy.

6 CONCLUSIONS AND RECOMMENDATIONS

The investigation area is characterized by soils with recharge, saturating and stagnating properties. The recharge shallow soils depict signs of prolonged saturation, but it was periodical, with the dominant flow direction being vertical through and out of the profile. On these types of soils, glaying wetland features were identified. On the other hand, soils with stagnating properties were dominated by cryptic wetlands and seasonal depressions features. This can be attributed to the low permeability of the hardpan ferric granite and solid rock underlying the topsoil. These features occur on mostly on depressional areas and thus allow for wetland temporary zones, meaning they are saturated for short periods in a year due to the high evapotranspiration demand of the investigation area and easy saturation in most parts of the wetland. Although, saturated for short periods these wetland features are still considered to be of Ecological Importance and should be afforded the necessary protection.

The Hydrogeological report indicated that the static groundwater levels vary from zero meters (springs flowing out at surface) typically in the lower lying areas, to a maximum of approximately 35 meters below surface to the north-east of Midrand (Ariys Consulting, 2024). During the site visit it was observed that majority of the wetland features, and seasonal depressions were dry without freestanding water, however some did depict some form of wetness indicator (expansive cracks on soils that contain clay). The groundwater component is not anticipated to have a significant contribution (if any) to the wetlands associated with the investigation area. The watercourses will therefore not be impacted by the development activities that will occur as part of the high-density residential area project and the proposed storm-water services.

Hydropedological losses is foreseen for these wetlands as interflow (sub-surface flows recharging the wetlands) soils were present within the catchment of these systems. Even though this is the case, direct impact is foreseen for the wetlands overlain by the proposed developments, thus the recommendation of the Aquatic Studies by Eco-Santle Consultants (2024) should strongly be considered. Additionally, other components in the water balance, with specific mention of recharge by surface water runoff may be impacted particularly in areas where the surface infrastructure is located within the catchment area and separation of clean and dirty water areas takes place.

The footprint area is not largely dominated by cryptic wetlands, thus total avoidance of direct impact on the watercourses will be practical. The construction activities should aim to avoid developing within the scientific buffers where feasible. Alternatively, the high-density residential development should aim to minimize the disturbance within the scientific buffers as far as practically possible. Key recommendations presented below and those presented in the Aquatic studies compiled by Eco-Santle Consultants (2024) should strongly be considered, particularly during the finalization stage of the footprint layout. This will ensure that the Present Ecological State (PES), wetland functionality as well as impact on the Ecoservices the wetland provides remain unchanged during all phases of development.

Recommendations have been developed in the points below to mitigate impacts on the receiving environment:

- Structures are already on site, and they were built outside the river and valley bottom buffer zones.
- The stormwater structures are meant to control the continuous degradation of the valley bottom wetland and unnamed river stream, so the construction of this services is supported.
- Most part of the valley bottom shows signs of a Cryptic wetland which is normally recharged seasonally and spend most of the time being dry.
- There is evidence of evapotranspiration taking place at a higher rate since stagnate soil layer is not fully developed and most soils within the wetland are rechargeable soils.
- Although the present ecological setting does show that the wetland is in dilapidated state due to the environmental non compliances subjected to it by the surrounding building structures, it can be pointed out that correct implementation of this project will benefit the wetland and help it to rejuvenises and take a positive function into the ecosystem again.
- Although some wetlands will be directly impacted, all development footprint areas to remain outside of the wetlands and associated scientific buffer as far as practically possible;
- Contractor laydown areas, and material storage facilities to remain outside of the cryptic bottom valley wetlands, as well as the applicable scientific buffer;
- The watercourses must be protected against erosion arising from the stormwater runoff from the associated infrastructural areas. In this regard, runoff should be attenuated before discharging into the wetland, thus recharging the wetlands in an ecologically appropriate manner.
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the wetlands adjacent to the proposed project;

- All surface development footprint areas should remain as small as possible and disturbance of soil profiles to be limited to what is absolutely essential;
- Following the completion of the construction phase, areas of disturbance, particularly adjacent to the watercourse should be monitored at least once after an erosive rainfall until the natural vegetation has well established.

If the above mitigatory measures are implemented, with careful construction practices, the PES class of the wetlands is unlikely to occur, and the development is deemed acceptable from a hydrogeological and water balance perspective.

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- Van Tol, J.J., Le Roux, P.A.L. & Hensley, M .2011. Soil Indicators of Hillslope Hydrology, Principles, Application and Assessment in Soil Science, Dr. Burcu E. Ozkaraova Gungor (Ed.), ISBN: 978-953-307-740-6, InTech, Available from: <http://www.intechopen.com/books/principles-application-and-assessment-in-soil-science/soil-indicators-of-hillslope-hydrology>
- Van Tol, J.J., Le Roux, P.A.L. & Hensley, M. 2013. Pedological criteria for estimating the importance of subsurface lateral flow in E horizons in South African soils. Water SA (39):1.
- Van Tol, J.J., Le Roux, P.A.L., Lorentz, S.A., Hensley, M. 2013. Hydropedological classification of South African hillslopes. Vadose Zone Journal.

APPENDIX A: DETAILS, EXPERTISE AND CURRICULUM VITAE OF SPECIALISTS

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

Thahala Moses (Earth sciences in Mining and Environmental Geology (university of Venda)

Siboza M.Douglas BSc Geology (University of Johannesburg)

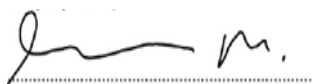
(ii) The expertise of that specialist to compile a specialist report including a curriculum vitae.

Company of Specialist	Domo Consulting (Pty)Ltd
Name Or Contact Person	Thahala Moses
Postal code	Plot 98,leeuwkuil,polokwane,0699
Telephone	0818441527
Email	mosesthahala@gmail.com
Qualifications	BSc Earth Science in Mining & Environmental Geology (Hons), Certificate in Advance Mine Evaluation, Certificate in Mine Sampling
Registration /association	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNSP)
Operational area	South Africa (Nationwide)
Speciality	Geological Sciences, Environmental Management, Geotechnical Investigation, Geohydrology
Experience	11 years

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

I, Thahala Moses, 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

Company of Specialist	Domo Consulting (Pty)Ltd
Name or Contact Person	Siboza M Douglas
Postal Code	Plot 98, Leeuwkuil, Polokwane,0699
Telephone	0825330198
Email	dsiboza@gmail.com
Qualifications	BSc Economic Geology, introduction to groundwater Division of Geological Society of South Africa, MRM Survey Actuals, MRM Evaluation, Data warehouse Introductory Training and Sable Data Course, Advanced Statistics.
Registration /Association	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNSP) (400078/04)/Geology Society of South Africa (GSSA)
Operational Area	South Africa (Nationwide)
Speciality	Geological Sciences, Environmental Management, Geotechnical Investigation, Geohydrology
Experience	38 years

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

I, sibozza M Douglas , 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

APPENDIX B: LABORATORY RESULTS

TEST REPORT**S24/0811**

For

ARIYS CONSULTING
58 KGOROTO STREET
LOTUS GARDENS EXT 2
PRETORIA
0008
95 CROSSBERG CENTRAL, DIAGONAL STREET,
GRAND CENTRAL, MIDRAND
1685

Date

2024-12-06

Attention

FHATANI MAKHUVHA

Your Reference

MIDRAND HYDROPEYROLOGICAL STUDIES

Sample(s)	Test(s) Conducted	Date requested	Test Method(s) used	Sampling method & Date	Test(s) done at	Test(s) dates
S24/0811/2	• Falling Head Permeability	2024-11-20	• *ASTM D2434	Sampling by client	PRETORIA	2024-11-25
S24/0811/6	• Falling Head Permeability	2024-11-20	• *ASTM D2434			2024-12-06

Note: **** Decision rule not be applied to the Colto Classification, please enquire if required.
 *** Non-standard aggregate sizes used in test. Generally smaller aggregates will produce lower values and the larger sizes higher values.
 ** Used tap water to wash and not distilled water.
 * Not SANAS Accredited:
 Results marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this laboratory / certification body / inspection body.
 Sample and sampling environmental conditions will only be noted if it is abnormal, not according to test method specification or can have an influence on the final result.
 The test results are only applicable to the samples tested.



I accept this document
Miss EB Lefoka
Technical Signatory (Geolab)

The results relate only to the items tested.
Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
Refer to the Scope of Accreditation for details regarding the technical signatories.
This test report shall not be reproduced except in full, without written approval of the laboratory.

Falling Head Permeability

Project:	MIDRAND
Client:	ARIYS CONSULTING
Geolab Job Nr:	S24-0811
Date:	2024/12/04
Test Method:	ASTM D2434:1974

		Remoulded to:								
Sample Number:	Depth: m	Dry Density: kg/m³	w %	H1 cm	H2 cm	Time h m s			Permeability cm/s	
MTH01	-	1665	13,7	60	20	5	0	53	5,17E-06	
MTH04	0,4-0,7	1523	15,9	60	15	0	2	19	8,66E-04	



Geotechnical Laboratory
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E Geolab@soillab.co.za
Geolab
www.soillab.co.za

TEST REPORT**S24/0811**

For

ARIYS CONSULTING
58 KGOROTO STREET
LOTUS GARDENS EXT 2
PRETORIA
0008
95 CROSSBERG CENTRAL, DIAGONAL STREET,
GRAND CENTRAL, MIDRAND
1685

Date

2025-02-10

Attention

FHATANI MAKHUVHA

Your Reference

MIDRAND HYDROPETROLOGICAL STUDIES

Sample(s)	Test(s) Conducted	Date requested	Test Method(s) used	Sampling method & Date	Test(s) done at	Test(s) dates
S24/0811/1	- Moisture Content of Sample as Received - Road Ind Sieve Anal to 0075mm Aberg Lim	2024-11-20	- SANS 3001 GR20 - SANS 3001 GR1, GR10	Sampling by client	PRETORIA	2024-11-25 2025-02-10
S24/0811/3	- Moisture Content of Sample as Received - Road Ind Sieve Anal to 0075mm Aberg Lim	2024-11-20	- SANS 3001 GR20 - SANS 3001 GR1, GR10			
S24/0811/4	- Moisture Content of Sample as Received - Road Ind Sieve Anal to 0075mm Aberg Lim	2024-11-20	- SANS 3001 GR20 - SANS 3001 GR1, GR10			
S24/0811/5	- Moisture Content of Sample as Received - Road Ind Sieve Anal to 0075mm Aberg Lim	2024-11-20	- SANS 3001 GR20 - SANS 3001 GR1, GR10			
S24/0811/7	- Moisture Content of Sample as Received - Road Ind Sieve Anal to 0075mm Aberg Lim	2024-11-20	- SANS 3001 GR20 - SANS 3001 GR1, GR10			

Note: **** Decision rule not be applied to the Colto Classification, please enquire if required.
 *** Non-standard aggregate sizes used in test. Generally smaller aggregates will produce lower values and the larger sizes higher values.
 ** Used tap water to wash and not distilled water.
 * Not SANAS Accredited:
 Results marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this laboratory / certification body / inspection body.
 Sample and sampling environmental conditions will only be noted if it is abnormal, not according to test method specification or can have an influence on the final result.
 The test results are only applicable to the samples tested.

I accept this document
Ms M Choeu
Technical Signatory (Soils)

The results relate only to the items tested.
Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
Refer to the Scope of Accreditation for details regarding the technical signatories.
This test report shall not be reproduced except in full, without written approval of the laboratory.



(PTY) LTD
Registration Number
1971/000112/07



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Fax: (+27) (12) 481 3941 / 3812
Email: info@soillab.co.za

Engineering Materials Laboratory

VKE CENTRE, 230 Albertus Street
La Montagne, Pretoria, 0184
PO Box 72928, Lynnwood Ridge,
South Africa, 0040

Project Description

Client:	ARIYS CONSULTING	Soillab Job No.:	S24-0811
Job Description:	MIDRAND HYDROPETROLOGICAL STUDIES	Contract Number:	
Date:	2025/01/06	Reference Number:	

Sample Description

Soillab Sample No.:	S24-0811-01	S24-0811-02	S24-0811-03	S24-0811-04
Sample Description:	MTH01	MTH02	MTH03	MTH04
Sample Depth:	-	-	-	-
Material Description:	DARK GREY	DARK GREY	LIGHT GREY	LIGHT GREY

Screen Analysis (% Passing) - SANS 3001-GR1

75,00 mm	100	100	100	100
63,00 mm	100	100	100	100
50,00 mm	100	100	100	100
37,50 mm	100	100	100	100
28,00 mm	100	100	100	100
20,00 mm	100	100	100	100
14,00 mm	100	100	100	100
5,00 mm	100	100	99	100
2,000 mm	99	99	94	97
0,425 mm	62	60	23	61
0,075 mm	42	26	4	38

Soil-mortar percentages - SANS 3001-PR5

Coarse Sand	2.000-0.425mm	38	39	75	37
Coarse Fine Sand	0.425-0.250mm	11	19	14	13
Medium Fine Sand	0.250-0.150mm	5	10	5	6
Fine Fine Sand	0.150-0.075mm	4	6	2	4
Silt and clay	<0.075mm	42	26	4	39

Constants

Grading Modulus	SANS 3001-PR5	0.97	1.15	1.79	1.05
Liquid Limit		42			27
Plasticity Index	SANS 3001-GR10	19	SP	NP	8
Linear Shrinkage		8.0	1.0	0.0	4.0

MOD AASHTO - SANS 3001-GR30

Max Dry Density (kg/m ³)				
Optimum Moisture Content (%)				

CBR - SANS 3001-GR40

MOULD A				
Moulding Moisture Content (%)				
Dry Density (kg/m ³)				
Relative Compaction				
CBR (%)				
% Swell				
MOULD B				
Dry Density (kg/m ³)				
Relative Compaction				
CBR (%)				
% Swell				
MOULD C				
Dry Density (kg/m ³)				
Relative Compaction				
CBR (%)				
% Swell				
CBR (%)				
100% Mod AASHTO				
98% Mod AASHTO				
97% Mod AASHTO				
95% Mod AASHTO				
93% Mod AASHTO				
90% Mod AASHTO				
COLTO Classification:				



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Registration Number
1971/000112/07



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Fax: (+27) (12) 481 3941 / 3812
Email: info@soillab.co.za
PO Box 72928, Lynnwood Ridge,
South Africa, 0040

Project Description

Client:	ARIYS CONSULTING	Soillab Job No.:	S24-0811
Job Description:	MIDRAND HYDROPETROLOGICAL STUDIES	Contract Number:	
Date:	2025/01/06	Reference Number:	

Sample Description

Soillab Sample No.:	S24-0811-05			
Sample Description:	MTH05			
Sample Depth:	-			
Material Description:	DARK GREY			

Screen Analysis (% Passing) - SANS 3001-GR1

75,00 mm	100			
63,00 mm	100			
50,00 mm	100			
37,50 mm	100			
28,00 mm	100			
20,00 mm	100			
14,00 mm	100			
5,00 mm	100			
2,000 mm	100			
0,425 mm	66			
0,075 mm	39			

Soil-mortar percentages - SANS 3001-PR5

Coarse Sand	2.000-0.425mm	34			
Coarse Fine Sand	0.425-0.250mm	15			
Medium Fine Sand	0.250-0.150mm	7			
Fine Fine Sand	0.150-0.075mm	5			
Silt and clay	<0.075mm	40			

Constants

Grading Modulus	SANS 3001-PR5	0.95			
Liquid Limit					
Plasticity Index	SANS 3001-GR10	SP			
Linear Shrinkage		1.0			

MOD AASHTO - SANS 3001-GR30

Max Dry Density (kg/m ³)				
Optimum Moisture Content (%)				

CBR - SANS 3001-GR40

MOULD A				
Moulding Moisture Content (%)				
Dry Density (kg/m ³)				
Relative Compaction				
CBR (%)				
% Swell				
MOULD B				
Dry Density (kg/m ³)				
Relative Compaction				
CBR (%)				
% Swell				
MOULD C				
Dry Density (kg/m ³)				
Relative Compaction				
CBR (%)				
% Swell				
CBR (%)				
100% Mod AASHTO				
98% Mod AASHTO				
97% Mod AASHTO				
95% Mod AASHTO				
93% Mod AASHTO				
90% Mod AASHTO				
COLTO Classification:				



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Engineering Materials Laboratory

SMEC Building, 230 Albertus Street
La Montagne, Pretoria, 0184

PO Box 72928, Lynnwood Ridge,
South Africa, 0040

Client: ARYS CONSULTING

Project: MIDRAND HYDROPETROLOGICAL

Project No.: S24-0811

Date: 2024/11/26

MOISTURE CONTENT - SANS 3001-GR20

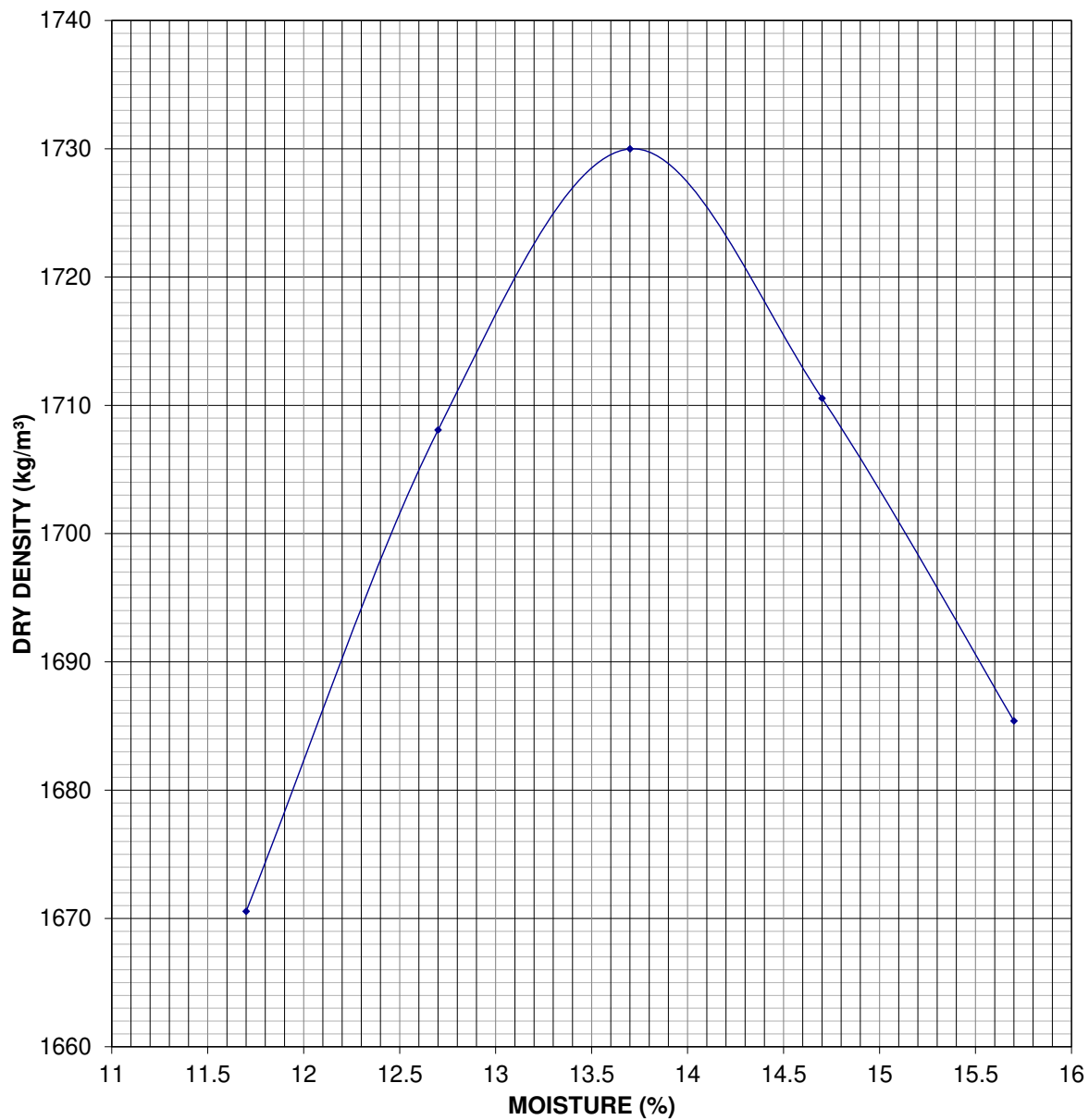
Sample No.:	Depth(m):	Position:	Moisture Content (%)
S24-0811-01	2.5 - 3.1	MTH01	10.6
S24-0811-02	3.5	MTH02	6.8
S24-0811-03	6.5	MTH03	2.3
S24-0811-04	2.8 - 3.9	MTH04	14.5
S24-0811-05	2.6 - 3.5	MTH05	5.1

Note: Items marked with a star (*) is Not Accredited

Soillab is a SANAS accredited Testing Laboratory according to the Accreditation Scope

MOISTURE/DENSITY RELATIONSHIP @ MOD AASHTO COMPACTIVE EFFORT (SANS 3001-GR30)

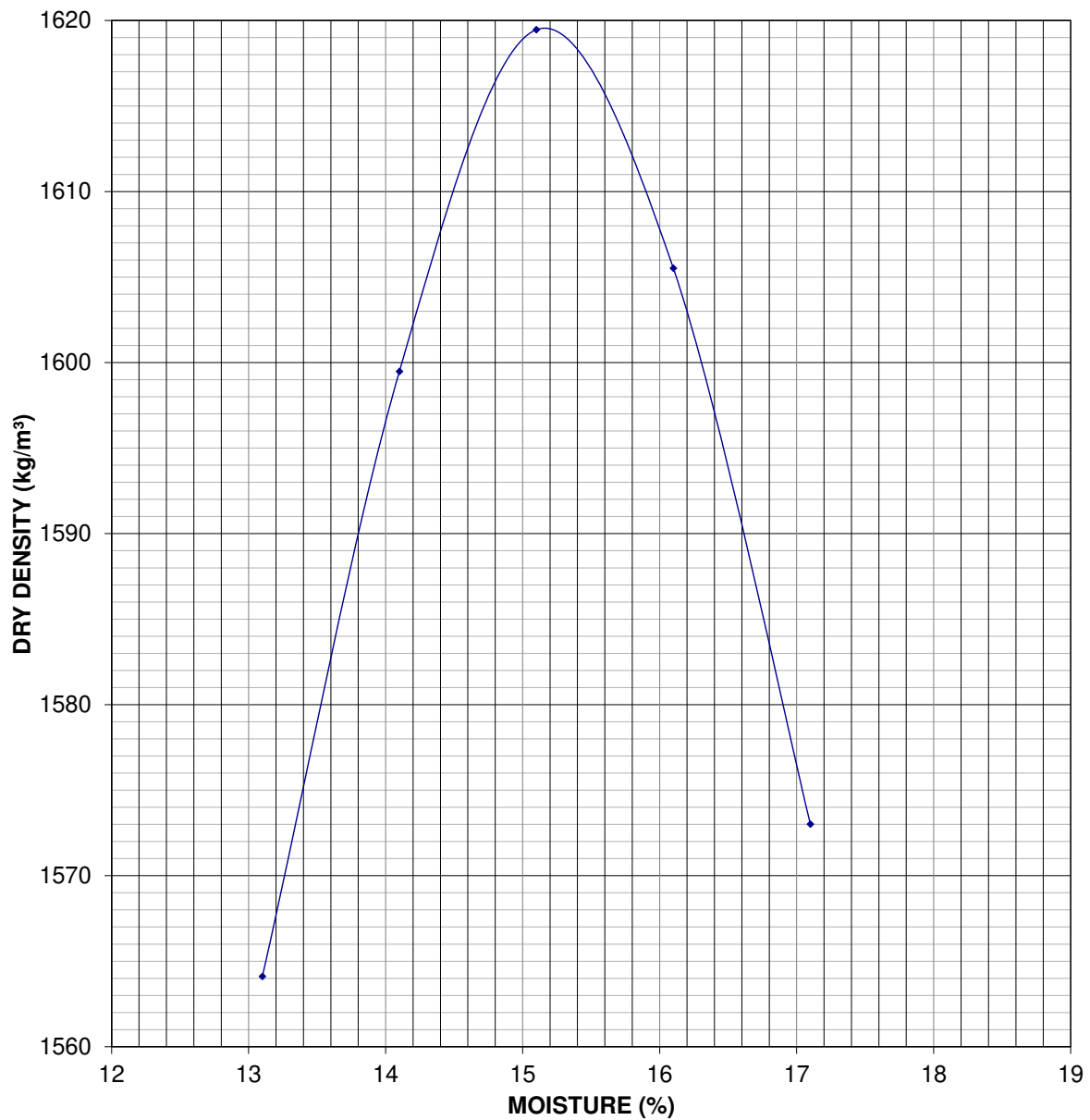
PROJECT:	MIDRAND HYDROPETROLOGICAL STUDIES
Soillab Job No.:	S24-0811-01
Description:	MTH01
Maximum Dry Density (kg/m ³):	1730
Optimum Moisture Content (%):	13.7



NOTE:

MOISTURE/DENSITY RELATIONSHIP @ MOD AASHTO COMPACTIVE EFFORT (SANS 3001-GR30)

PROJECT:	MIDRAND HYDROPETROLOGICAL STUDIES
Soillab Job No.:	S24-0811-04
Description:	MTH04 (0 - 0,2)
Maximum Dry Density (kg/m ³):	1619
Optimum Moisture Content (%):	15.9



NOTE:

INVOICE



ARIYS CONSULTING (PTY) LTD
Reg No: 2018/072435/07 | Vat No. 4940316385
PI No. 730004979

Address: Oxford Office Park,
Unit 30 First Floor, 3 Bauhinia Street,
Highveld Techno Park, 0167

Phone: +27 68 497 6579
Fax No.: +27 86 411 1718
E-mail: info@ariys.co.za

DATE: 2025-02-09
INVOICE NO AC-ENV-002
VALID UNTIL: 2025-03-11

CUSTOMER

Selahle Consultancy & Projects

Address: 546 16th Road, Constantia Park
Block 2, 1st Floor, Randjespark1682

Phone: 011 026 2560 **Cell:** 079 614 8298
Email: admin@scprojects.co.za

DESCRIPTION OF WORK

Acacia Villas Floodline

ITEM	ITEMIZED COSTS	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1.	Project Initiation and Administration				
1.1	Project setup, data management and elevation data conversions (including 3.5% for incidental office expenses such as IT, telephone, minor printing)	Sum	1	R5 500,00	R5 500,00
2	Information Review				
2.1	Review available information, Information review and catchment delineation and parameters determination	Sum	1	R6 800,00	R6 800,00
3	Site Assessments				
3.1	Site visit for site familiarisation and floodlines parameters observations, including transport	Sum	1	R10 000,00	R10 000,00
4	Floodlines				
4.1	Modelling of 1:50 and 100-year peak flows using appropriate methods for all associated sub-catchments for the streams Steady state 1-D hydraulic modelling in HEC-RAS for the stream, GIS delineation for the 100-yr floodlines and maps	Sum	1	R15 000,00	R15 000,00
5	Reporting				
5.1	Preparation of a consolidated draft report with methodology, and findings including maps. Finalisation of Report after review (Peer reviewer Included)	Sum	1	R13 500,00	R13 500,00
Thank you for your business!				SUBTOTAL	R50 800,00
				ADD 15% VAT	R7 620,00
				TOTAL QUOTE	R58 420,00

Banking Details

Account holder: ARIYS CONSULTING (PTY)LTD
Bank Name: First National Bank
Account No: 62749450079
Branch Code: 240129
Branch Name: Mall of Africa
Swift code: FIRNZAJJ

INVOICE



ARIYS CONSULTING (PTY) LTD
Reg No: 2018/072435/07 | Vat No. 4940316385
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Head Office: Unit 95 Crossberry Central,
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Phone: +27 68 497 6579
Fax No.: +27 86 411 1718
E-mail: info@ariys.co.za

DATE: 2025-02-09
INVOICE NO: AC-HG-001
VALID UNTIL: 2025-03-11

BILL TO:

Selahle Consultancy & Projects

Address: 546 16th Road, Constantia Park
Block 2, 1st Floor, Randjespark1682

Phone: 011 026 2560 Cell: 079 614 8298
Email: admin@scprojects.co.za

DESCRIPTION OF WORK

Invoice - Geohydrological and Hydropedology Study for the Acacia Villas

ITEMIZED COSTS	QTY	UNITS	UNIT PRICE	AMOUNT
Professional Fees				
Desktop Study	1	Days	R 1 100,00	R 1 100,00
Data interpretation and Analyses	1	Days	R 1 100,00	R 1 100,00
Cartography, GIS and Photologs	1	Days	R 1 100,00	R 1 100,00
Reporting	1	No.	R 10 000,00	R 10 000,00
Field Investigation				
Hydrogeologist	8	Hours	R 850,00	R 6 800,00
Field Technician	8	No.	R 550,00	R 4 400,00
Disbursement				
Hydro-census and Sampling	8	Hours	R 4 500,00	R 36 000,00
Soil Sampling	8	Hours	R 860,00	R 6 880,00
Laboratory	1	No.	R 6 487,39	R 6 487,39
Travelling	150	Km	R 9,00	R 1 350,00
	SUBTOTAL			R 75 217,39
	ADD 15 % VAT			R 11 282,61
<i>Thank you for your business!</i>	TOTAL QUOTE			R 86 500,00

Banking Details

Account holder: ARIYS CONSULTING (PTY)LTD
Bank Name: First National Bank
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Branch Code: 240129
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