2021

Proposed Organic Composting and Pelletizing / Pelleting Facility – Groundwater Assessment Report

Groundwater Abstract (Pty) Ltd

Enterprise Number: 2017/489367/07

Rietfontein
Pretoria, 0084
www.wells.*africa*

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PROPOSED ORGANIC COMPOSTING AND PELLETIZING / PELLETING FACILITY – GROUNDWATER ASSESSMENT REPORT

Astral Operations Ltd

Report compiled by:

Groundwater Abstract Pty Ltd

Lucas Smith

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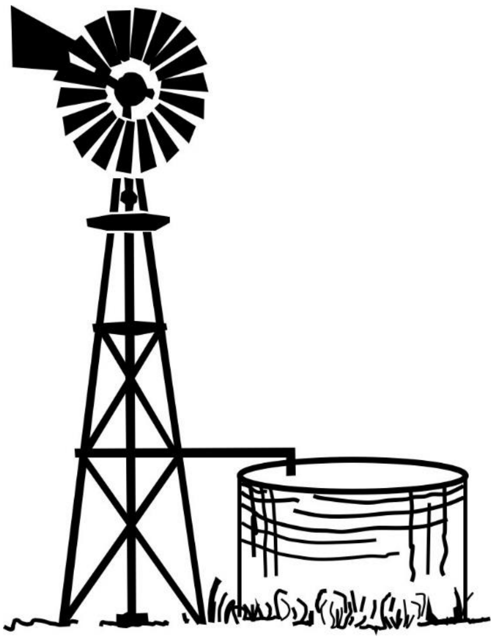
Pr. Sci. Nat.

On behalf of:

IQS Holdings



HOLDINGS

INTEGRITY QUALITY SERVICE

Declaration of Independence

I, Lucas Smith, declare that –

General declaration:

- *I act as the independent Hydrogeology practitioner 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 hydrogeological impact assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;*
- *I will comply with the Act, Regulations and all other applicable legislation;*
- *I have no, 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;*
- *I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;*
- *I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;*
- *All the particulars furnished by me in this form are true and correct;*
- *I will perform all other obligations as expected from a hydrogeological practitioner in terms of the Act and the constitutions of my affiliated professional bodies; and*
- *I realise that a false declaration is an offence in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.*

Disclosure of Vested Interest

- *I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Regulations.*

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SIGNATURE:

Executive Summary

IQS Holdings (Pty) Ltd (hereinafter IQS) was appointed by Astral Operations Limited (Ltd) as an independent Environmental Assessment Practitioner (EAP) to undertake the Environmental Impact Assessment (EIA) and Water Use Licence Application (WULA) processes, associated with the proposed organic composting and pelletizing / pelleting facility, envisaged by Astral Operations Ltd.

Groundwater Abstract (Pty) Ltd (hereinafter GWA) was appointed by IQS Holdings to assist with the groundwater assessment.

The effect of composting on water quality can be evaluated by assessing nitrate (NO_3^-), ammonium (NH_4^+), orthophosphate (PO_4^{3-}) and organic compounds (e.g., carbohydrates, lipids and proteins). The impact of composting on the water resources are influenced by the location of the heap, protection against rain, water addition during the process, the use of covers and the recovery of leaching and runoff water (Joséphine Peigné, March 2004).

Shangoni (2020) indicates that the Silverton shale of the Pretoria Group, is characterised by low hydraulic conductivities and very few primary voids. Shale naturally forms flow barriers (aquitards), rather than aquifers because water is confined within the narrow discontinuities, like jointing and fracturing and most often flows along the layering. The low hydraulic conductivities limit the spread of possible contaminants entering the saturated groundwater zone.

The aquifer system underlying the site is classified as minor, which can be defined as an aquifer system that is composed of rocks not having a high primary permeability (Shangoni, 2020). The extent of the aquifer is limited and the water quality variable, but they are important for local supply and supporting base flow for rivers.

There are no boreholes on the proposed Astral development site. Subsequently all interpretations and conclusions are based on borehole information from surrounding properties.

The groundwater level below surface varied between 1.18 m bgl (borehole AS18), and 8.56 m below surface (borehole AS08) and confirms a groundwater flow direction from southwest to northeast.

The identified boreholes in the area serve as only water supply source to most of the landowners.

Based on the SANS 241 Drinking Water Guideline, the following conclusions were drawn:

1. Health effects:
   i. E. coli – E. coli counts of 1 and 640 units per 100 ml were recorded for boreholes AS03 and AS22 respectively – no E. coli should be present. Escherichia coli is a specific indicator of faecal pollution which originates from humans or warm-blooded animals. These enterobacteria can be transmitted via the oral route and may cause diseases such as gastroenteritis.

      Borehole AS03 is an upstream control sample (approximately 2 km southwest from the proposed Astral site) and the E. coli count possibly relates to cattle movement near the borehole.

      Borehole AS22 is at Oxbow Country Estate (approximately 2 km downstream from the proposed Astral site) and the borehole is close to the main Estate complex and residential units. Oxbow Country Estate is also next to the Osspruit and in the lowest

topographical point in the Farm Boschkop study area. The very high E. coli count possibly relates to a combination of on-site impacts, plus commercial / agricultural activities upstream / to the west.

ii. Fluoride – boreholes AS14 and AS22 have a high fluoride concentration (16.2 and 1.95 mg/L respectively), compared to 1.5 mg/L allowed. Elevated fluoride concentrations are often associated with intrusive formations.

2. Operational effects:
   i. Total Coliforms – Total coliform bacteria are common in the environment (soil or vegetation) and are generally harmless. High Total Coliform counts were observed in borehole AS22; borehole at Oxbow Country Estate.
   ii. Total Hardness – high total hardness levels were measured for boreholes AS03 and AS22 and relate to elevated Calcium concentrations in the groundwater.

High bacterial counts and high fluoride concentrations are the chemicals of concern currently associated with the Farm Boschkop 543-JR project area (properties / boreholes surrounding the proposed Astral site), based on the list of parameters used for the water quality analysis during the December 2020 hydrocensus. Most salts and metals were present in concentrations below the SANS241 drinking water guideline limits.

Based on the SANS241 guideline and on the sampled borehole water results, the groundwater sampled from the 3 boreholes are not fit for human consumption, unless treated. The 3 boreholes sampled are:

- Borehole AS 3 – approximately 2 kilometres southwest from the proposed Astral site. On Festive Chicken / Astral property. Used as an upstream sample point.
- Borehole AS 14 – approximately 1.3 kilometres southeast. On property of Mr. Jannie Vermeulen. Used as a downstream sample point and next to Osspruit.
- Borehole AS 22 – approximately 2 kilometres southeast. On Oxbow Country Estate property. Used as a downstream sample point.

The groundwater sampling points were randomly selected and based on local catchment and possible groundwater flow characteristics.

<u>Impact Assessment:</u>

CONSTRUCTION PHASE

Negative groundwater quality impacts already exist in the Boschkop Farm area and have been observed in boreholes around the study area. The boreholes present alkaline pH levels and high fluoride (boreholes AS14 and AS22), and E. coli and Total Coliform counts (AS03 and AS22) were recorded for the sampled boreholes.

An increased impact is not expected in terms of the groundwater quality during the construction phase. Construction will be conducted in a relatively short period compared to the operational and post-closure phases, with the only possible risk related to site clearing and the flushing of soil and silt into the Osspruit and downstream boreholes during high rainfall episodes. Effective storm water management will however mitigate this risk. Impacts on the groundwater environment are therefore rated as Low.

No impact is expected on the water quantity during the construction phase.

OPERATIONAL PHASE

The potential sources of pollution associated with the compositing and pelletizing / pelleting facility, during operation are:

- Contaminated storm water runoff due to ineffective storm water management measures;
- Seepage water from the return water dams;
- Recharge of contaminated water by means of seepage from the composting heaps;
- Groundwater contamination due to poor management and accidental spills of diesel, greases and oils used on site; and
- Irrigation of lands with affected water.

Groundwater quality could be negatively affected with a potential increase in bacterial / coliform counts and salt loads, especially from nitrogen, phosphorous and potassium elements. The only possible risk relates to seepage of leachate from the compost heaps into the underlying aquifers, or uncontrolled surface water runoff during high rainfall episodes. Effective site management and storm water management will however mitigate this risk. If surface water / ponding / dams / reservoirs are effectively managed and maintained, including the storm water management systems, then the risk of groundwater contamination will be low, in view of the existing impacts.

The geological and associated hydrogeological properties (transmissivity / hydraulic conductivity) suggest that the spread of contamination in the weathered and deeper fractured aquifers will be slow, especially in the diabase and vertically through the shale. The potential plumes will generally be limited to the weathered zone and could extend in a south- and easterly direction towards the Osspruit. The concentration of pollutants generally decreases as it moves further away from the point source, due to dispersion and dilution.

Impacts on the groundwater environment are therefore rated as Low.

The proposed Astral composting facility will not have any significant impacts on the groundwater quantity. Impacts on the groundwater environment are therefore rated as Low.

POST CLOSURE

Overall, there should be an improvement in the groundwater qualities during post closure. Rehabilitation of the soil in the footprint area of the composting and pelletizing / pelleting facility is required to stabilise the salt and bacterial load and minimise infiltration of contaminated water. The area must be seeded with local grass as soon as possible to limit erosion and flushing of soil during rainfall events.

Impacts on the groundwater environment are therefore rated as Low.

No impact is expected on the water quantity post-closure.

Recommendations:

It is recommended that strong consideration is given to again sample actively used boreholes (used for domestic and agricultural purposes) before the operational phase, to update the pre-development status and build a water quality database. The database will help the client identify water quality and level trends and will serve as reference to identify and quantify potential impacts on private boreholes.

Dedicated monitoring boreholes must be available on site prior to the operational phase; at least 2 downstream and 1 upstream monitoring site. Table 6 presents preliminary and approximate localities. Four existing and three new boreholes are included in the groundwater monitoring network.

An effective storm water management plan must be implemented from the construction phase to limit negative surface and groundwater impacts associated with runoff water and increased silt loads.

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Abbreviations

Abbreviation	Description
AD	Anaerobic digestion
BBP	Bronkhorstspruit Biogas Plant
Bh	Borehole
BPG	Best Practice Guideline
CoC	Chemicals of Concern
CV	Curriculum Vitae
DEFF	Department of Environment, Forestry and Fisheries
DWS	Department of Water and Sanitation
EA	Environmental Authorisations
EAP	Environmental Assessment Practitioner
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
GDARD	Gauteng Department of Agriculture and Rural Development
GPS	Global Positioning System
k	Hydraulic conductivity
km	kilometre
L	Litres
L/s	Litre per second
L/hr	Litre per hour
LOW	Limit of weathering
m	metre
m^3	cubic metre
m^3/day	cubic metre per day
m amsl	metres above mean sea level
MAP	Mean Annual Precipitation
m bgl	metres below ground level
meq/L	milli-equivalents per litre
mg/ℓ	milligrams per litre
ml	millilitre
mm	millimetre
mm/a	millimetre per annum

mS/m	milli Siemens per metre
MW	Megawatt
NEMA	National Environmental Management Act, 1998 (Act 107 of 1998)
NWA	National Water Act (Act 36 of 1998)
RWD	Return water dam
RWQO	Resource water quality objectives
SANAS	South African National Accreditation System
SANS	South African National Standards
S	Storage coefficient (-)
SP	Significance points
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
T	Transmissivity
USGS	United States Geological Survey
WMA	Water Management Area
WRC	Water Research Commission
WULA	Water Use Licence Application

1 INTRODUCTION

IQS Holdings (Pty) Ltd (hereinafter IQS) was appointed by Astral Operations Limited (Ltd) as an independent Environmental Assessment Practitioner (EAP) to undertake the Environmental Impact Assessment (EIA) and Water Use Licence Application (WULA) processes, associated with the proposed organic composting and pelletizing / pelleting facility, envisaged by Astral Operations Ltd.

The proposed Astral Organic Composting and Pelletizing / Pelleting Facility will be situated in the City of Tshwane Metropolitan area, on the Farm Boschkop 543-JR. The study area is approximately 7 kilometres (km) west of Bronkhorstspruit Dam, Gauteng Province (Figure 1).

Chicken litter from Astral will be composted using windrows that are monitored and periodically turned around until fully decomposed. Astral is currently selling their chicken manure, but would like to establish their own organic material composting facility as part of their environmental sustainability corporate vision. Organic material such as chicken manure is recycled to form stable useful material such as organic fertilizer, in bulk or as pellets. The compost contains carbon, phosphate and nitrogen. Decomposed material will be biologically stable and odourless.

Farm-scale composting is an efficient means of recycling agricultural waste. The composting process is an aerobic degradation of fresh organic matter in mature compost. The main environmental components potentially affected by composting are air and water. The effect on water quality can be evaluated by assessing nitrate (NO_3^-), ammonium (NH_4^+), orthophosphate (PO_4^{3-}) and organic compounds (e.g., carbohydrates, lipids and proteins). The impact of composting on the water resources are influenced by the location of the heap, protection against rain, water addition during the process, the use of covers and the recovery of leaching and runoff water (Joséphine Peigné, March 2004).

According to the Tilth Alliance webpage (www.Tilthalliance.org) chicken manure is too strong to be used raw as fertilizer, but it can be composted and converted to a good fertilizer medium. Once it is composted chicken manure is:

- A good soil amendment, as it adds organic matter and increases the water holding capacity and beneficial biota in soil; and
- A good fertilizer; as it provides Nitrogen, Phosphorus and Potassium to the plants.

The Boschkop Farm area is currently associated with (amongst others) chicken faming, organic composting, the Bio2Watt, Bronkhorstspruit Biogas Plant on the north and the Beefcor feedlot that can beneficially co-exist with the proposed compositing facility (Figure 2). The potential cumulative impacts will be assessed as part of the EIA study.

Alternative sites will be considered within the EIA process, on Boschkop Farm, for the proposed composting facility. Identifying alternative sites will be done to limit negative environmental impacts, but is also as a legal requirement.

The waste management activities application will be done at the Gauteng Department of Agricultural and Rural Development (GDARD) and is subject to a Scoping and Environmental Impact Assessment process as contemplated in Chapters 3 and 6 of GN R. 982 in of 4 December 2014 (amended in Government Notice 599 dated 29 May 2020).

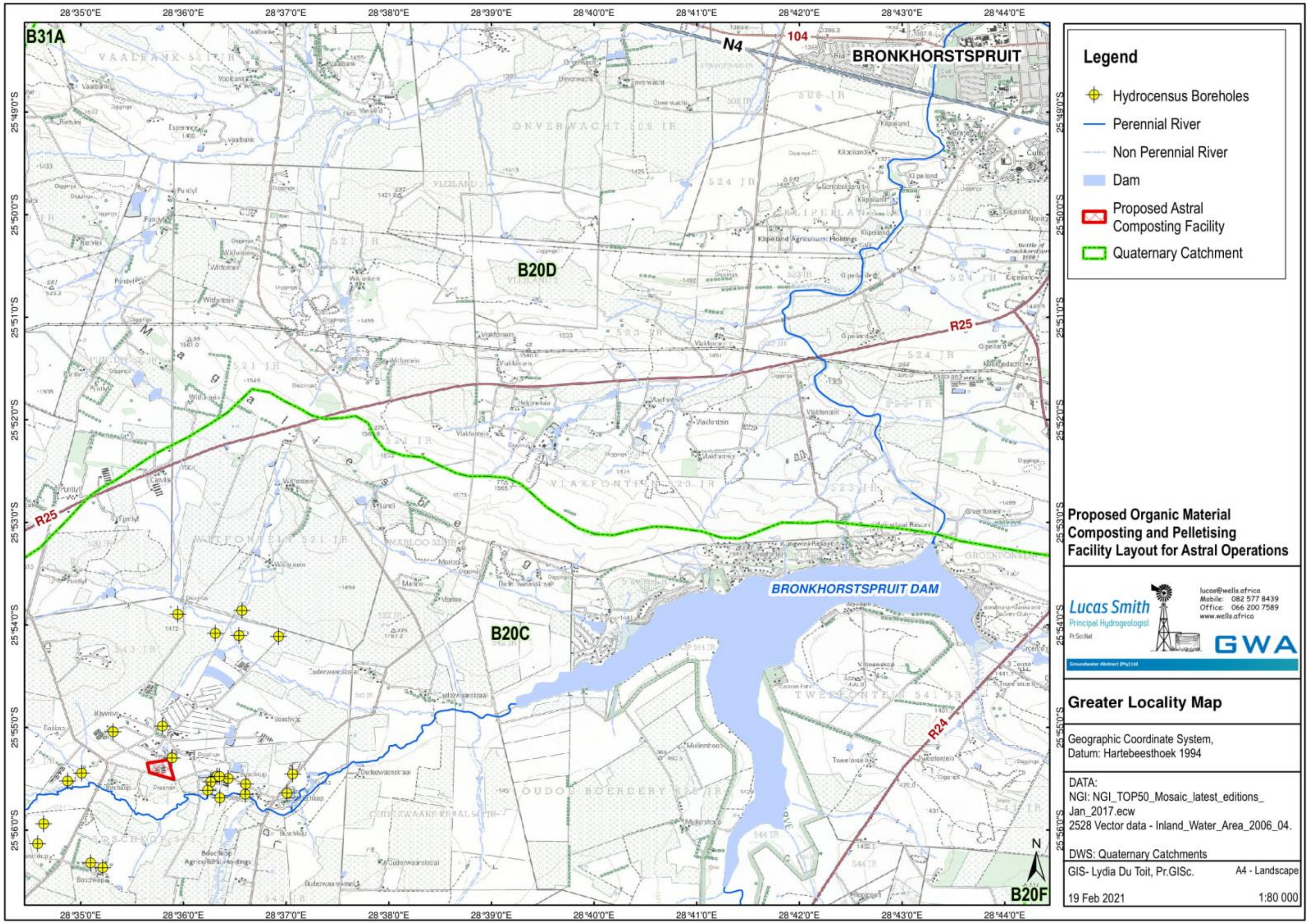

Figure 1. Regional area map

Figure 2. Study area map

The Water Use Licence Application will be submitted to the Department of Water and Sanitation (DWS) and will be performed in terms of the most recent Water Use Authorisation Application Process Guidelines of the DWS.

The waste management activities include recycling or recovery and/or treatment of waste as related to composting and pelletising. The water uses in the accompanying application are 21 (c), (i) and (g) as associated with potential impacts on a water resource.

Groundwater Abstract (Pty) Ltd (hereinafter GWA) was appointed by IQS Holdings to assist with the groundwater assessment.

The sensitivity of the environment has been assessed by IQS using the environmental screening tool in terms of section 24(5)(h) of the NEMA, 1998 (Act No 107 of 1998) and regulation 16(1)(b)(v) of the EIA regulations, 2014, as amended. The Screening Tool has been developed by the Department of Environment, Forestry and Fisheries (DEFF) which is a web application with spatial datasets.

2 Groundwater Assessment Framework

An understanding of the hydrogeological environment is essential to understand the impact of the proposed development on the receiving environment and to help design a groundwater management plan that reduces or removes the risk of negative groundwater quality and quantity impacts.

2.1 Groundwater Study Objectives

The groundwater assessment will focus on the following objectives:

- Define the current groundwater use in the area;
- Define the aquifers underlying the Boschkop Farm area, as well as current groundwater table depth, groundwater quality, and flow characteristics;
- Define what impact the proposed activities might have on the groundwater environment; and
- Recommend an initial groundwater monitoring network to monitor the groundwater quality and level changes over time.

2.2 Compliance Framework

The groundwater assessment was undertaken to South African Best Practice Guidelines as defined by the Department of Water and Sanitation. The water quality assessment was based on South African National Standard (SANS) 241-1:2015, Drinking Water.

2.3 Groundwater Assessment Team

The following hydrogeologist is involved in the proposed Astral Organic Composting and Pelletizing / Pelleting Facility groundwater assessment:

- Lucas Smith (MSc Geohydrology) Pr.Sci.Nat:
  - Project hydrogeologist.
  - Field work, data analysis, interpretations, and reporting.

A Curriculum Vitae (CV) is appended to Appendix A.

2.4 Report Structure

The remainder of the report is structured as follow:

- Section 3 – Environmental Setting.
- Section 4 – Groundwater Site Assessments.
- Section 5 – Groundwater Impact Assessment.
- Section 6 – Cumulative Impacts.
- Section 7 – Considering of Alternatives.
- Section 8 – Groundwater Management Measures.
- Section 9 – Groundwater Monitoring.
- Section 10 – Conclusions.
- Section 11 – Recommendations.

Appendices:

- Appendix A: Curricula Vitae.
- Appendix B: Water Laboratory Certificates.
- Appendix C: Impact Assessment Ratings.

3 Environmental Setting

The proposed Astral composting and pelletizing / pelleting facility is located approximately 7 km west of Bronkhorstspruit Dam. The topography is generally flat to undulating with the surface elevation that varies from 1500 metres above mean sea level (m amsl) in the northwest (highest point), to 1445 m amsl at the Osspruit, at the Oxbow Country Estate, and with a regional dip from west to east (Figure 4). An elevated area (small ridge) extends from the homestead of Mr Conradie (Conradie Organics), in a north-westerly direction past the Astral / Festive Chickens office and workshop area, and further west. This elevated area would act as a small water divide, from where surface runoff will flow in either a northerly, easterly or southerly direction, depending on small positional shifts on this ridge. The proposed Astral composting and pelletizing / pelleting facility is located on the southern slope of this elevated area (Figure 4).

3.1 Catchment

The proposed Astral development is in the Bronkhorstspruit Dam catchment, in the B20C quaternary catchment, forming part of the Olifants Water Management Area (WMA:2). The main drainage is the Osspruit, with the Kleinspruit approximately 2.3 km to the north (Figure 1 and Figure 2). Both streams discharge in the Bronkhorstspruit Dam, approximately 7 km downstream from the proposed development.

The proposed Astral development is located on the southern slope of an elevated area. Natural surface runoff will therefor be in a southerly to south-easterly direction. The Beefcor feedlot is directly north of the proposed Astral development. Natural surface runoff at Beefcor will be in an easterly to north-easterly direction.

Additional / detailed information with regards to the catchment, surface drainage and wetlands can be found in the specialist report prepared by "Limosella Consulting, December 2020. Aquatic Biodiversity Compliance Statement".

3.2 Climate and Rainfall

The study area is on the Gauteng Highveld with a moderate, dry, subtropical climate. The climate is characterised by hot and rainy summers for a long period, as well as cool and dry winters. The area has an average annual temperature of approximately 18.7°C.

The temperature in summer, between October and March is around 30°C and stays warm throughout the day. Between November and February, the area receives thunderstorm during the afternoon, but it doesn't last for a long period. It experiences cold waves during June and July when the maximum temperature is around 20°C (Figure 3). The evenings in winter are very cold.

The mean annual precipitation (MAP) is 697 millimetres, although this varies from 559 mm to 960 mm and is mostly concentrated in the summer months (Table 1). Infrequent showers occur through the course of the winter months (Climate-Data.org). Based on the WR2012 database, the mean annual evaporation for the area is 1700 mm; more than double the precipitation. This means a negative water balance, implying that (theoretically speaking) more water will evaporate compared to the precipitation.

Table 1. Precipitation data for Tshwane area

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Avg. Temp (°C)	22.4	21.9	20.5	17.8	14.1	11.2	11	13.7	17.3	20.5	21.1	22
Min. Temp (°C)	16.1	15.6	14	10.5	5.8	2.3	2.1	4.6	8.8	12.8	14.3	15.4
Max. Temp (°C)	28.8	28.3	27.1	25.2	22.5	20.1	20	22.8	25.9	28.3	28	28.7
Precipitation (mm)	128	89	80	48	19	6	6	6	19	69	112	115

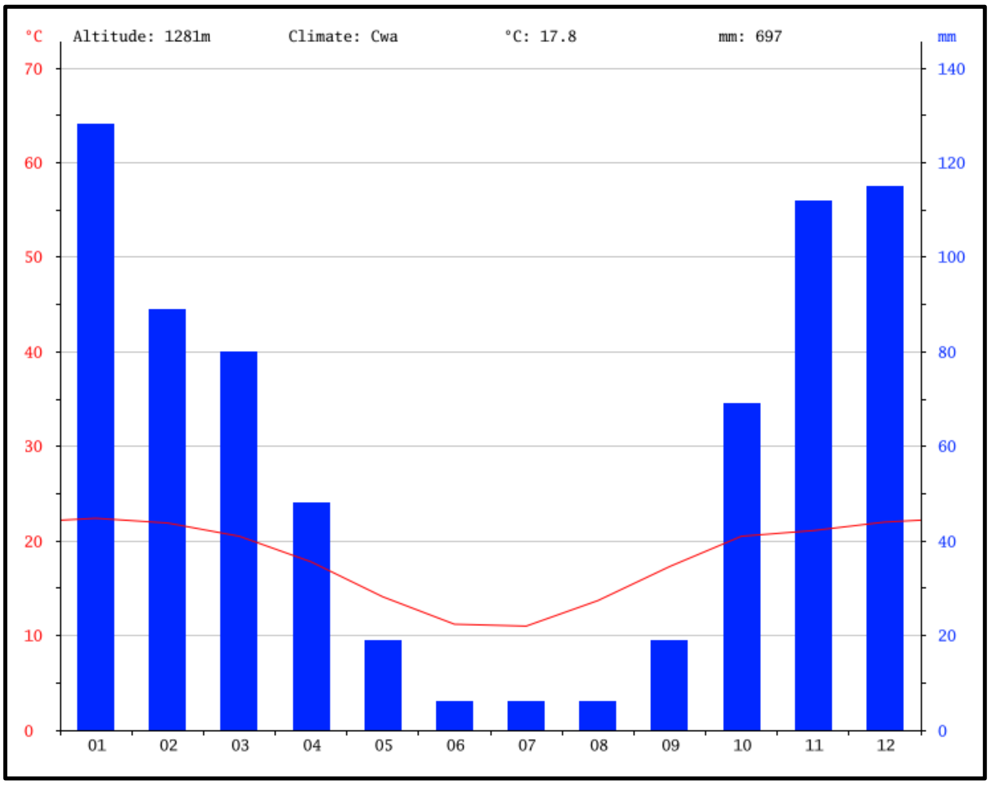

Figure 3. Tshwane area climate data (Climate-Data.org)

3.3 Geology

The geology description was taken from "Palaeontological Impact Assessment: Desktop Study. Dr. H Fourie, November 2020".

The Transvaal Supergroup fills an east-west elongated basin in the south-central part of Northwest, Gauteng and Mpumalanga. It is of Vaalian age, approximately 2600 Ma to 2100 Ma. A maximum thickness of the Transvaal Supergroup reaches 2000 meters (m) in the north-eastern section. The east-west elongated basin is filled with clastic, volcanic and chemical sedimentary rocks. Three groups based on lithological differences have been established: they are the Rooiberg, Pretoria and

Chuniespoort Groups, as well as other smaller groups (Kent 1980, Snyman 1996). It is the Bushveld Igneous Complex that is responsible for the tilting of the Transvaal sediments. This Transvaal Supergroup is underlain by the Ventersdorp, Witwatersrand and Pongola Supergroups, and the Dominion Group. Three prominent ridges are present from the oldest to the youngest, the Time Ball Hill, Daspoort and Magaliesberg Formations (Norman and Whitfield 2006).

The Pretoria Group consists predominantly of quartzite and shale, together with a prominent volcanic unit, minor conglomerate, chemical and volcanic members. It comprises the Hekpoort andesite, Dullstroom basalt, Time Ball Hill, Silverton, and Magaliesberg quartzite formations, as well as several smaller formations and overlies the Chuniespoort Group (Kent 1980). In the central part of the basin the quartzite and shale overlying the Magaliesberg Quartzite are combined into the Rayton Formation because intrusion of numerous diabase sills has made it impossible to recognise all the individual formations (Kent 1980). The Magaliesberg Formation which is approximately 300 m thick in the Pretoria region (Visser 1989).

The proposed Astral development will be situated on shale of the Silverton Formation, Pretoria Group, with diabase present along its northern boundary, as well as in the south, near the Osspruit (Figure 5).

The Silverton Formation shale is rich in carbon and pyrite and show cross-bedding. Brown to khaki-weathering shale is stratigraphically below the Magaliesberg Formation. The Silverton shale is the thickest of all the shale formations of the Pretoria Group (300 to 3000 m). It forms wide valleys and when changed to hornfels it can be used for roof coverings (Visser 1989).

Vaalian to post-Mokolian diabase intrusions occur throughout the area in the form of sills and dykes. These sills are common in the Transvaal Supergroup and when present in the Pretoria Group they are referred to as the Transvaal diabase (Kent 1980, Visser 1989).

A fault was identified traversing the area, running in a northeast-southwest direction, towards the southeast (dotted black line, Figure 5). It has been assumed that higher water strikes are associated with this linear geological feature. Linear geological features are most often preferred groundwater flow paths and aid in the movement of groundwater.

The soil profile for the area consists of a thin growing medium or topsoil that is underlain by a nodular or hardpan ferricrete transition zone or pebble marker (Shangoni, 2020). The residual soils associated with the diabase comprise yellowish brown clayey silt, while the Silverton shale has been slightly decomposed to soft rock. The shale and diabase are fine-grained and as such are of low permeability, except where sections of decomposed bedrock are fractured or jointed (Shangoni, 2020).

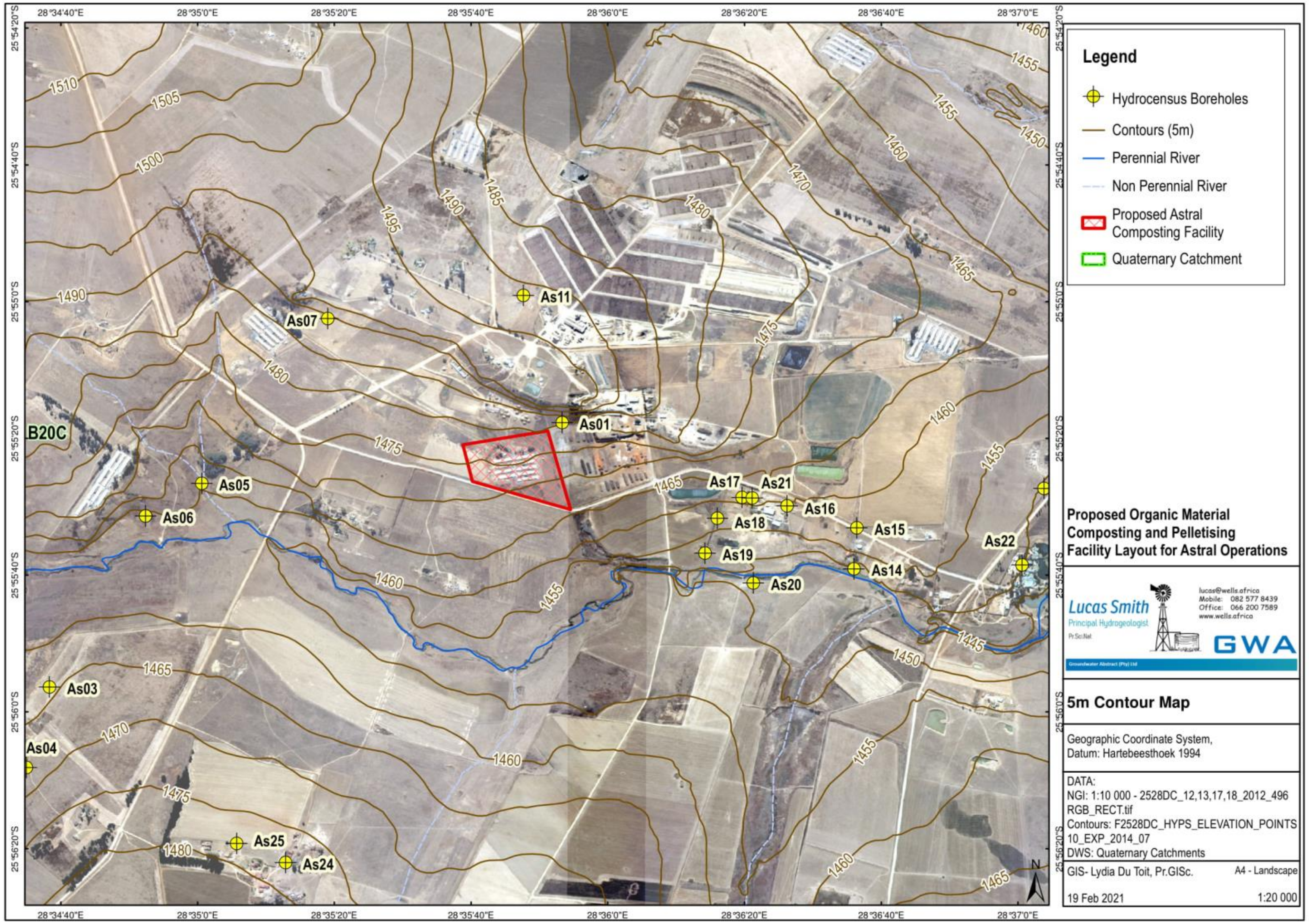

Figure 4. Local topography contour map

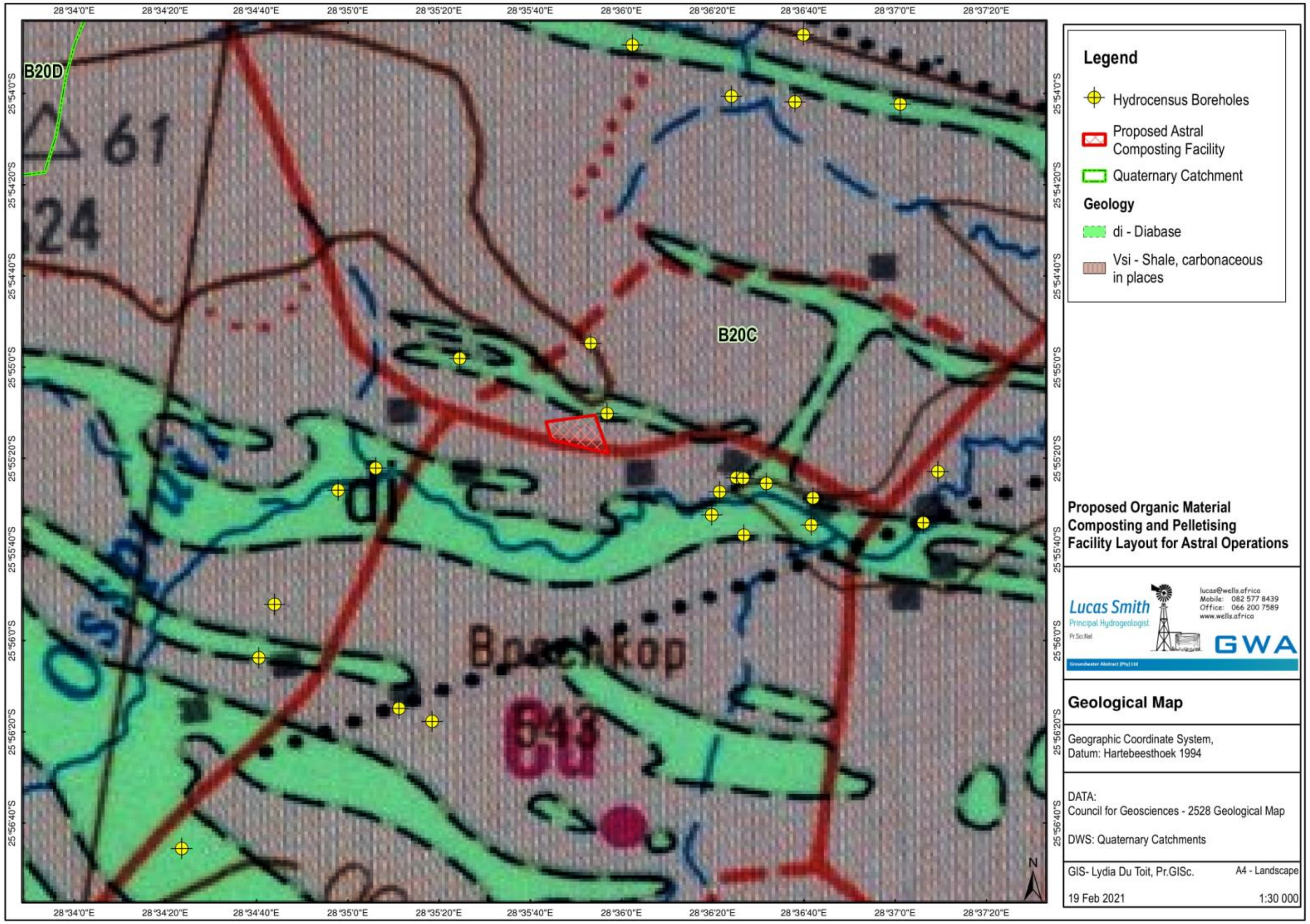

Figure 5: Geology map

3.4 Groundwater Occurrence

The proposed Astral development is underlain by shale and diabase of the Pretoria Group.

The depth to groundwater in the area varies between 1 and 18.5 m below surface, depending on borehole position and surface elevation (Table 2). Boreholes close to the Osspruit present shallow groundwater levels (boreholes AS14 and AS20 – 1 to 1.3 km downstream from the Astral site), compared to boreholes located higher up against the rolling hills and ridges e.g., borehole AS08 (3 km north from the Astral site) (Figure 9). The water table in the area mimics the topography and drains on a local scale (at the proposed Astral development) towards the Osspruit and on a regional scale towards the east (Figure 7).

According to Barnard (October 2000) the mean electrical conductivity (EC) value, associated with boreholes in the Silverton shale is 58 mS/m, with an average pH value of 7.6.

Groundwater occurrence in the local formations favours the weathered shale, but is more common in the brecciated and jointed zones, and the contact zone between the diabase and the shale. The depth of weathering generally varies between 10 and 25 m gbl.

The local formations generally support good yielding boreholes (up to 2 L/s or 7200 L/hr), with approximately 20% of the borehole yielding more than 5 L/s. Higher yielding boreholes are often associated with surface water systems (rivers, streams), along the broad valley bottoms.

Most fault and joint zones in the area are steeply dipping structures that tend to narrow and even pinch out at depth, with a corresponding decrease in permeability. The porosity is usually less than 1% while the fresh rock may be regarded as impermeable, unless fractured and associated with a fault or intrusive dyke.

Shangoni (2020) indicates that the Silverton shale of the Pretoria Group, is characterised by low hydraulic conductivities and very few primary voids. Shale naturally forms flow barriers (aquitards), rather than aquifers because water is confined within the narrow discontinuities, like jointing and fracturing and most often flows along the layering. The low hydraulic conductivities limit the spread of possible contaminants entering the saturated groundwater zone.

The aquifer system underlying the site is classified as minor, which can be defined as an aquifer system that is composed of fractured or potentially fractured rocks not having a high primary permeability (Shangoni, 2020). The extent of the aquifer is limited and the water quality variable, but they are important for local supply and supporting base flow for rivers.

3.5 Groundwater Recharge

Recharge is defined as the process by which water is added to the zone of saturation of an aquifer. It is considered that recharge to the underlying aquifers may be 3.6% to 7.9% of MAP (Vegter-, Harvest Potential- and Geology Maps). Experiments by Bredenkamp (1978), at the Rietondale experimental farm indicated a recharge rate of 8% for the Silverton shale unit.

The B20C quaternary catchment covers an area of approximately 347 km^2. The following volume of rain water is added to this sub-catchment, considering the groundwater recharge range given:

- 3.6% recharge per annum = approx. 8.796 Mm^3 per annum.
- 7.9% recharge per annum = approx. 19.123 Mm^3 per annum.
- An average of 5.8% recharge per annum = approx. 13.942 Mm^3 per annum.

There are several routes by which precipitation recharges groundwater in the study area. In addition to direct recharge, localized recharge often occurs along edges of paths and roads, where no formal storm water drainage exists. Land covered by an impermeable surface decreases recharge.

Surface water features (e.g., streams and wetlands) interact with groundwater. In many situations, surface water bodies gain water from groundwater systems (known as baseflow) and in others the surface water body is a source of groundwater recharge and causes changes in groundwater quality. Pollution of surface water can cause degradation of groundwater quality and conversely pollution of groundwater can degrade surface water (USGS Circular 1139: Ground Water and Surface Water: A Single Resource). Borehole AS14 is next to the Osspruit and has a water level of approximately 1.1 m below surface. This was measured during December (summer period). This borehole is located approximately 1.3 km downstream from the proposed Astral site. There is a strong possibility for surface water-groundwater interaction and a system that changes from a losing to gaining stream, across seasons. Additional / detailed information with regards to the surface drainage and wetlands can be found in the specialist report prepared by "Limosella Consulting, December 2020. Aquatic Biodiversity Compliance Statement".

The exchange of the water is a critical part of the hydrological cycle. Surface water supplies recharge to the underlying aquifer (losing stream) (Figure 6), where the groundwater can remain in storage for days, months, years, centuries, or even millennia. Eventually the groundwater discharges back into the stream (gaining stream) (Figure 6).

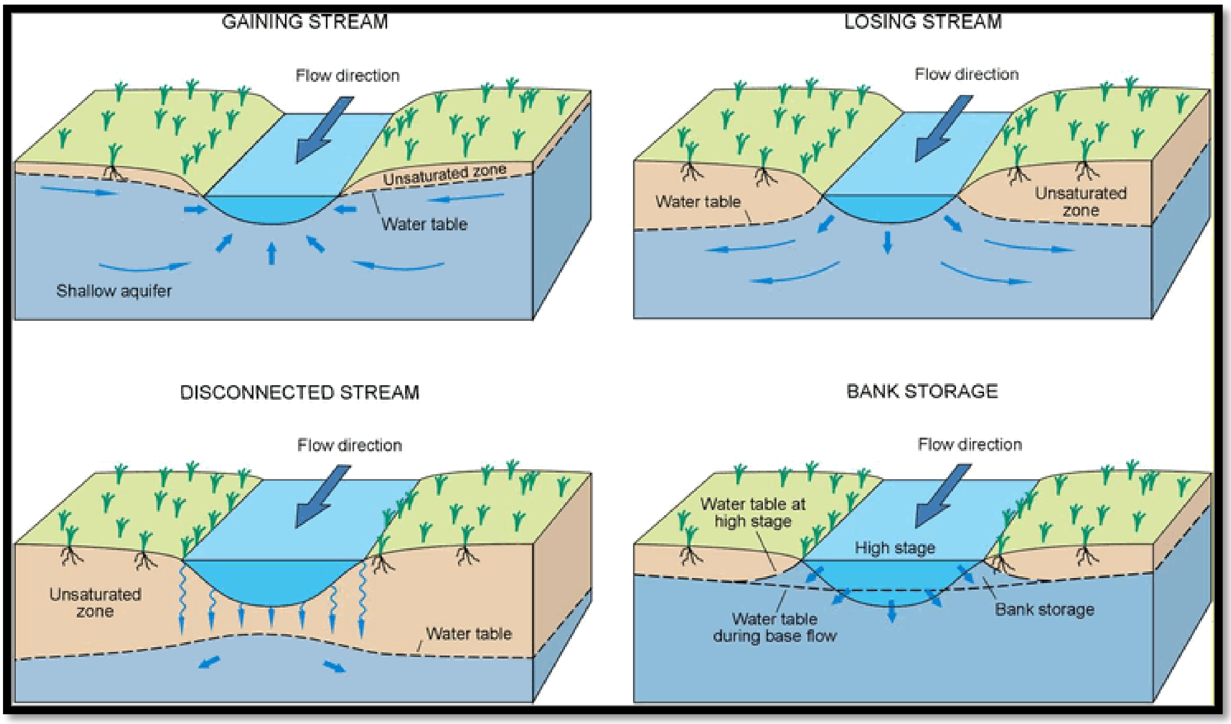

Figure 6. Interaction of groundwater and surface water (USGS Circular 1139, 1998)

4 Groundwater Site Assessments

Site-specific groundwater investigations included:

4.1 Hydrocensus

A hydrocensus was conducted across the Farm Boschkop during December 2020. The survey included the proposed Astral development area and adjacent properties, and concentrated on identifying existing boreholes to enhance the knowledge of the groundwater systems and current groundwater use. Twenty-five (25) boreholes and 1 spring were identified (Table 2) (Figure 9). There are no boreholes on the proposed Astral development site. Subsequently all interpretations and conclusions are based on borehole information from surrounding properties.

In terms of identified borehole use:

- 21 boreholes are currently in use and all are fitted with submersible pumps. These boreholes are located around the proposed Astral site (Figure 9);
- 1 borehole (AS02) is equipped with a submersible pump, but is not in use currently. This borehole is approximately 3.5 km southwest (upstream) from the proposed Astral site; and
- 3 open / unequipped boreholes are not in use. Boreholes AS14, AS15 and AS21 are between 700 m and 1.1 km downstream from the proposed Astral site. Boreholes AS14 and AS15 are not in use due to water quality concerns.

Groundwater level measurements were possible from 22 boreholes; pumping equipment / security measures did not allow access to the remaining 3 boreholes – all Beefcor boreholes (refer to Table 2). Three groundwater samples were collected for water quality analysis – from boreholes AS03, AS14 and AS22 (Table 3).

During the hydrocensus the following information was collected for each site:

- Borehole position (X, Y, Z-coordinates);
- Information relating to equipment installed;
- Borehole yield – if known;
- Groundwater level, if possible; and
- Current use.

A summary of the hydrocensus information is available in Table 2. All coordinates were taken with a hand-held Garmin GPS (Global Positioning System) (WGS84).

The spring is located on the property of Mr J Joubert, Farm Rooigras and is located between boreholes AS18 and AS19. This is approximately 600 m downstream (southeast) from the proposed Astral site. Mr Joubert noted a spring discharge rate of approximately 3500 L/hr.

Water levels were measured by using a dip meter to measure the distance from the mouth of the borehole (borehole collar elevation) to the groundwater table depth in the borehole. The height of the borehole collar was subtracted from the measured water level to define a water level below surface (measured in m bgl) (Table 2). The m bgl measurement was subtracted from the borehole's surface elevation to define the elevation in metres above mean sea level, for all water table measurements.

The groundwater level below surface varied between 1.18 m bgl (borehole AS18 – 600 m eats from the Astral site), and 18.34 m bgl for borehole AS22 (approximately 1.8 km east) (Figure 9). GWA assumed that borehole AS22 was pumping shortly before the water level measurement was taken – therefor the deep water level. The second deepest water level is 8.56 m below surface (borehole AS08 – approximately 3 km north from the proposed Astral site). If the groundwater levels are viewed as elevation above sea level, then the highest water elevations can be found at boreholes AS02 and AS24 – approximately 2 to 3.5 km to the south of the proposed Astral site. The lowest water table elevation is at boreholes AS15 and AS14 – approximately 1.1 km east from the proposed Astral site. This confirms a regional groundwater flow direction from southwest to northeast in the study area (Figure 7). On a local scale groundwater flow will be towards the streams, predominantly east and northeast.

The closest boreholes to the proposed Astral site are:

- boreholes AS01 – 100 m east; only borehole for Conradie Organics property; and
- boreholes AS16 to AS21 – 600 to 900 m east to southeast. All owned by Jan Joubert and all in production except AS21.
- The groundwater level depth at these boreholes range between 1.18 m and 5.41 m below surface, indicating a shallow groundwater table in the proposed Astral development area.

Figure 7. Groundwater contour map

The correlation between topography and groundwater elevation is approximately 98%, as shown in Figure 8. This means that the depth to groundwater correlates well with the surface elevations (topography), indicating that on a local scale groundwater flow follows topography.

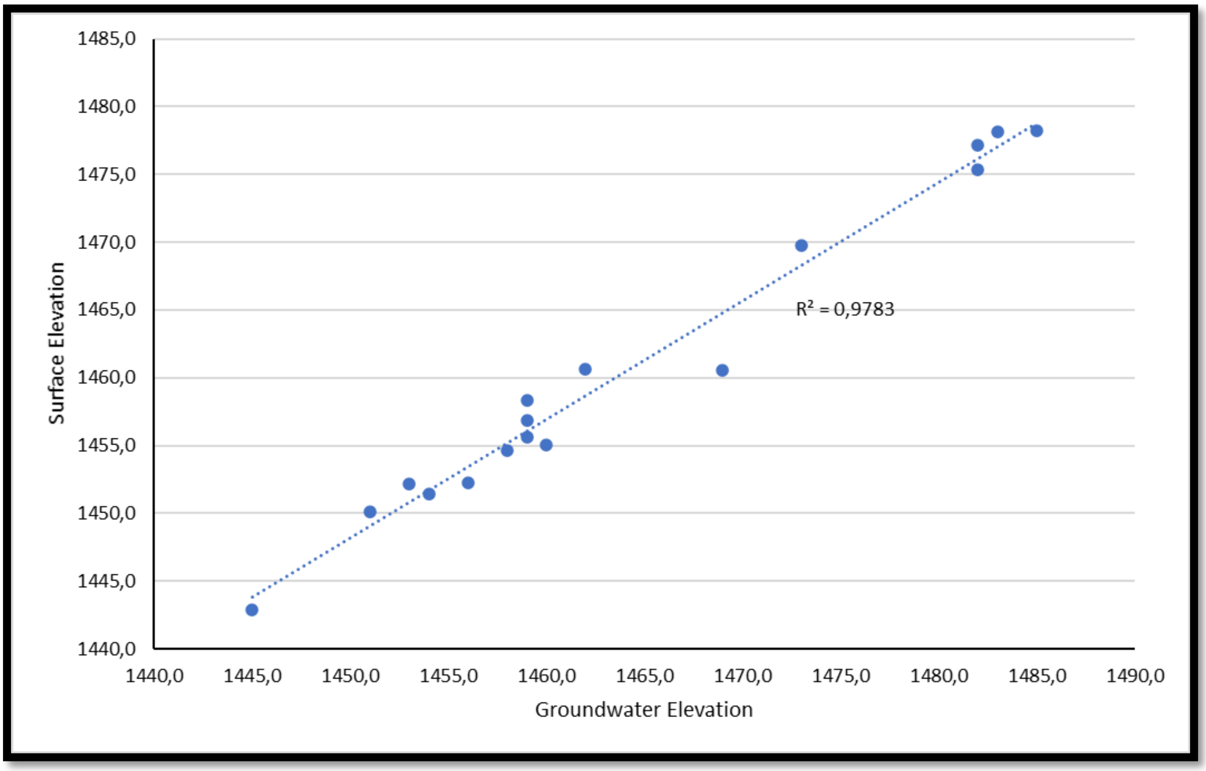

Figure 8. Correlation between surface and groundwater elevations

Detailed information in terms of borehole construction and yields, plus borehole depths and water strike depths are not known for most of the identified sites. Time series groundwater level or quality data are also not available to determine seasonal groundwater changes.

The information provided by the landowners indicate low borehole yields (1000 to 3000 L/hr) for most of the Boschkop area, with the existing boreholes often serving as only water supply source to the landowner / occupant.

Higher borehole yields are possibly related to the northern boundary of the diabase sills (e.g., borehole AS16 and AS17), as well as the northeast-southwest orientation, mapped geological structure visible in the south-eastern portion of the Boschkop area (possibly intercepted by boreholes AS02, AS22 and AS24 / 25) (Figure 5). The mapped linear geological feature is not near the proposed Astral site.

Communication with Astral / Festive Chickens indicates that the 9 boreholes are currently in production and are used continuously, but they operate on a rotational system to allow recovery of the water table and aquifer on their land (Table 2) (Figure 9). These boreholes are monitored and rotated on a weekly basis, depending on water requirements and performance. When compared to the proposed Astral composting and pelletizing / pelleting facility, these boreholes are all upstream from the proposed project site – thus all towards the southwest, west and north of the proposed project site.

Figure 9. Hydrocensus boreholes

Table 2. Hydrocensus summary – August 2019

Borehole name	Property / farm	Latitude (WGS84)	Longitude	Elevation	In use	Water level (mbgl)	Yield	Sampled	Depth (m)	Pump	Contact
As01	Boschkop 648	S 25°55'17,7"	E 28°35'53,3"	1482	yes	5	1500 L/hr	no	30	submersible	Alec Conradie
As02		S 25°56'49,9"	E 28°34'18,0"	1485	not now	6,97	strong	no		submersible	Astral Cassidy Roets / Joseph
As03		S 25°55'56,3"	E 28°34'38,4"	1470	yes	6,91 pumping	strong	yes	60	submersible	
As04		S 25°56'08,1"	E 28°34'35,0"	1473	yes	14,59 pumping		no	60	submersible	
As05		S 25°55'26,6"	E 28°35'00,6"	1464	yes	21,13 pumping		no		submersible	
As06		S 25°55'31,3"	E 28°34'52,4"	1459	yes	2,18		no		submersible	
As07		S 25°55'02,4"	E 28°35'19,0"	1488	yes	24,42 pumping		no		submersible	
As08		S 25°54'06,7"	E 28°36'55,5"	1469	yes	8,56		no		submersible	
As09		S 25°54'06,2"	E 28°36'32,4"	1456	yes	3,72		no	45	submersible	
As10		S 25°53'51,5"	E 28°36'34,3"	1462	yes	1,38		no	45	submersible	
As11		S 25°54'59,0"	E 28°35'47,7"	1493	yes	closed	800 L/hr	no	30	submersible	Robin Watson
As12		S 25°54'04,9"	E 28°36'18,6"	1457	yes	closed	3000 L/hr	no	36	submersible	
As13		S 25°53'53,6"	E 28°35'56,8"	1468	yes	closed	7000 L/hr	no	36	submersible	
As14		S 25°55'39,0"	E 28°36'36,0"	1451	no	1,45		yes	10	none	Jannie Vermeulen
As15		S 25°55'33,0"	E 28°36'36,4"	1445	no	2,38	200 L/hr	no	15	none	Gerhard Steyn
As16		S 25°55'29,9"	E 28°36'26,2"	1460	yes	5,41		no		submersible	Jan Joubert
As17		S 25°55'28,6"	E 28°36'19,7"	1459	yes	3,63		no		submersible	
As18		S 25°55'31,7"	E 28°36'16,0"	1459	yes	1,18		no		submersible	
As19		S 25°55'36,8"	E 28°36'14,2"	1453	yes	1,58		no		submersible	
As20		S 25°55'41,1"	E 28°36'21,3"	1454	yes	2,95		no		submersible	
As21		S 25°55'28,7"	E 28°36'21,1"	1473	no	3,33		no		none	
As22		S 25°55'38,5"	E 28°37'00,6"	1468	yes	18,34		yes	30	submersible	Frank Lovell
As23		S 25°55'27,3"	E 28°37'03,8"	1458	yes	3,51	low	no	30	submersible	
As24		S 25°56'22,0"	E 28°35'12,9"	1483	yes	5,04		no	40	submersible	Hendrik Smith
As25		S 25°56'19,2"	E 28°35'05,7"	1482	yes	6,64		no	40	submersible	

The hydrocensus identified several surface water dams in the study area (Figure 4). The dams were not surveyed during the hydrocensus, and no water samples were collected for quality analysis, as it is outside the scope of work for the groundwater specialist study and associated with the wetlands risk assessment, forming part of the EIA process (refer to Limosella Consulting, December 2020. Aquatic Biodiversity Compliance Statement). It was however noted that dams were present along the north-western to south-eastern perimeter of the Beefcor feedlot – along the downstream areas. Four dams are also present downstream (east to south) from the Conradie composting facility. Several recreational dams were observed at Oxbow Country Estate.

During the hydrocensus trenches were observed on the Beefcor property, along the northern areas. All runoff from the cattle feedlots leads into culverts and collects in the Beefcor dams. Shangoni (2020) reported that the water in the dams is contaminated with manure, cattle feed and debris. Based on the Shangoni Report the water within these dams has pH levels between 7 and 8; total dissolved solids values between 1500 and 2500 mg/L; high levels of potassium, between 600 and 800 mg/L and high chemical oxygen demand due to the presence of microorganisms in manure. This water is generally used for irrigation.

Several properties receive water from Beefcor, amongst others Bio2Watt Bronkhorstspruit Biogas Plant, the J Vermeulen property (where borehole AS14 is) and the G Steyn property (where borehole AS15 is) (Figure 9). Beefcor has 3 boreholes (AS11, AS12, AS13), but also use water from the surface dams, the Osspruit and a pipeline from the Bronkhorstspruit Dam.

Mr Lovell from Oxbow Country Estate indicated that most of the boreholes and several surface water bodies were recently sampled (independently) to assess the water quality in the Boschkop area. The data was unfortunately not available to assess and include in this report.

The number of properties in the study area, budget and time constraints, and land access limited the hydrocensus in terms of surveying every borehole in the area. The study did aim at identifying boreholes close to the proposed Astral development to ensure a data set representative of the study area.

4.1.1 Groundwater Quality

Three (3) groundwater samples were collected during the December 2020 hydrocensus (Table 3). The 3 boreholes sampled are:

- Borehole AS03 – approximately 2 kilometres southwest from the proposed Astral site. On Festive Chicken / Astral property. Used as an upstream sample point.
- Borehole AS14 – approximately 1.3 kilometres southeast. On property of Mr. Jannie Vermeulen. Used as a downstream sample point and next to Osspruit.
- Borehole AS22 – approximately 2 kilometres southeast. On Oxbow Country Estate property. Used as a downstream sample point.

The groundwater sampling points were randomly selected and based on local catchment and possible groundwater flow characteristics.

The water samples were submitted to Aquatico Laboratories for analysis. Aquatico is a SANAS accredited laboratory (South African National Accreditation System). The water samples were analysed for basic inorganic parameters and the results were compared against the SANS 241:2015 Drinking Water Standards. It is recommended that strong consideration is given to again sample actively used boreholes (used for domestic and agricultural purposes) before the operational phase, to update the pre-development status and build a water quality database. The database will help the client identify water quality and level trends and will serve as reference to identify and quantify potential impacts on private boreholes.

Samples were taken from pump discharge lines as all boreholes were equipped and in use. A sterile disposable bailer was used to draw water from borehole AS14. Sterilized 1 litre (L) sample bottles were used and filled to the top. Samples were stored in a cooler box during the site survey.

Water quality data is presented by means of a table and a Piper diagram (Figure 10).

Piper Diagram:

A Piper Diagram uses the relationship of chemical parameters to classify water samples according to their dominant cations and anions, as well as allowing for the grouping of water according to hydrogeological facies. The Piper Diagram uses concentrations calculated in meq/L to represent a percentage of the total cations or anions. The cations and anions of each sample are plotted on the respective triangular plot and the points are then projected onto the central diamond graph (Figure 10). Depending on where the sample point falls on the diamond graph, basic assumptions can be attributed to the sample, and for this reason the diamond graph is divided into quarters.

The left quarter in a Piper Diagram represents freshly recharged groundwater, dominated by calcium-magnesium-bicarbonate signature. The right quarter is associated with stagnant or slow-moving groundwater and is dominated by sodium and chloride. The bottom quarter is typical of dynamic groundwater flow and is dominated by sodium and bicarbonates; and the top quarter typically indicates contamination and is dominated by sulphate.

The water quality results are presented in Table 3. The laboratory certificates are attached in Appendix B.

Based on Figure 10 the dominant cation in sample AS14 is sodium (Na), with the other two sampling sites presenting a well-mixed cation concentration. The dominant anion is bicarbonate (HCO_3) at the three sites. The water quality is characteristic of recent recharged water, except for borehole AS14 where ion exchange processes replaced the calcium and magnesium with sodium. The borehole is next to the Osspruit and is only 10m deep. Old stagnant water is most probably not the reason for the sodium dominant characteristic and could relate to the geology.

Based on the SANS 241 Drinking Water Guideline, the following conclusions were drawn:

1. Health effects:
   i. E. coli – E. coli counts of 1 and 640 units per 100 ml were recorded for boreholes AS03 and AS22 respectively – no E. coli should be present. Escherichia coli is a specific indicator of faecal pollution which originates from humans or warm-blooded animals. These enterobacteria can be transmitted via the oral route and may cause diseases such as gastroenteritis.

      Borehole AS03 is an upstream control sample (approximately 2 km southwest from the proposed Astral site) and the E. coli count possibly relates to cattle movement near the borehole.

Borehole AS22 is at Oxbow Country Estate (approximately 2 km downstream from the proposed Astral site) and the borehole is close to the main Estate complex and residential units. Oxbow Country Estate is also next to the Osspruit and in the lowest topographical point in the Farm Boschkop study area. The very high E. coli count possibly relates to a combination of on-site impacts, plus commercial / agricultural activities upstream / to the west. It is recommended that strong consideration is given to again sample actively used boreholes, plus the Osspruit to assess the E. coli count, across the area, in detail.

The water from boreholes AS03 and AS22 is not suitable for human consumption, unless treated.

ii. Fluoride – boreholes AS14 and AS22 have a high fluoride concentration (16.2 and 1.95 mg/L respectively), compared to 1.5 mg/L allowed. Fluoride is the most electronegative member of the halogens. It has a strong affinity for positive ions and readily forms complexes with many metals. Apart from the alkali metal fluorides, most fluorides are insoluble in water. Fluoride reacts readily with calcium to form calcium fluoride, which is reasonably insoluble and can be found in sediments. Where phosphate is present, an even more insoluble apatite or hydroxy apatite may form.

The presence of fluoride in drinking water reduces the occurrence of dental caries in adults and children. A small amount of fluoride is necessary for proper hardening of dental enamel and to increase resistance to attack on tooth enamel by bacterial acids. In humans and animals, fluoride accumulates in the skeleton.

Elevated fluoride concentrations are often associated with intrusive formations and could be associated with the diabase intrusions.

2. Operational effects:

i. Total Coliforms – Total coliform bacteria are common in the environment (soil or vegetation) and are generally harmless.

Total coliform bacteria are frequently used to assess the general hygienic quality of water and to evaluate the efficiency of drinking water treatment and the integrity of the distribution system. They should not be detectable in treated water supplies. If found, they suggest inadequate treatment, post-treatment contamination and/or aftergrowth or an excessive concentration of nutrients. In some instances, they may indicate the presence of pathogens. Some bacteria classified as coliforms are not of faecal origin (Department of Water and Environmental Affairs & Water Research Commission, First Edition 2000: Quality of Domestic Water Supplies: Volume 2: Sampling Guide).

Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. High Total Coliform counts were observed in borehole AS22; borehole at Oxbow Country Estate.

ii. Total Hardness – high total hardness levels were measured for boreholes AS03 and AS22 and relate to elevated Calcium concentrations in the groundwater. Scaling is likely to occur in water heating appliances such as kettles and geysers, and results in low efficiencies and the partial obstruction of pipes.

Calcium – an elevated calcium concentration was measured in borehole AS03 and is geology induced.

The pH levels for the three samples were between 7.6 and 9.6. Boreholes AS14 and AS22 present an alkaline water character, based on the pH levels (Table 3). Normal drinking water generally has a neutral pH of 7. Alkaline water typically has a pH of 8 or 9.

Excessively high and low pH levels can be detrimental for the use of water. High pH causes a bitter taste, water pipes and water-using appliances become encrusted with deposits, and it depresses the effectiveness of the disinfection of chlorine, thereby causing the need for additional chlorine when pH is high (USGS.gov website).

The effect of the composting process on water quality can be evaluated by assessing nitrate (NO_3^-), ammonium (NH_4^+), orthophosphate (PO_4^{3-}) and organic compounds (e.g., carbohydrates, lipids and proteins). Nitrogen, Phosphorus and Potassium element concentrations could potentially be measured in elevated concentrations at the chicken batteries and/ or composting area.

High bacterial counts and high fluoride concentrations are the chemicals of concern currently associated with the Farm Boschkop 543-JR project area (properties / boreholes surrounding the proposed Astral site), based on the list of parameters used for the water quality analysis during the December 2020 hydrocensus. Most salts and metals were present in concentrations below the SANS241 drinking water guideline limits. Based on the SANS241 guideline and on the sampled borehole water results, the groundwater sampled from the 3 boreholes (Table 3) are not fit for human consumption, unless treated. There are no boreholes on the proposed Astral development site. Subsequently all interpretations and groundwater quality conclusions are based on borehole information from surrounding properties.

4.1.2 HISTORICAL WATER QUALITY DATA

Bronkhorstspruit Biogas Plant:

Based on the Shangoni baseline report (October 2020), associated with the upgrade of the Bronkhorstspruit Biogas Plant, sampling of nearby monitoring boreholes revealed elevated concentrations of manganese (approximately 0.4 mg/L), that translates to high staining properties of the water and adverse taste, but poses no health risks. The data relates to water quality data for surrounding properties as there are no boreholes at the Biogas Plant.

Shangoni reported that high (1.2 mg/L) iron concentrations were also reported which are attributed to the regional geology and only pose a health risk to infants and sensitive individuals. Nitrate levels were below the 6 mg/L. The ammonia concentrations of 1.5 mg/L indicate that manure runoff from farming activities has impacted on groundwater (Shangoni, 2020). Feedlot contamination of groundwater was also indicated by the chemical oxygen demand of the samples, while the use of industrial pesticides in agricultural practice was also implied by slightly elevated levels of arsenic and mercury.

The Shagoni baseline report (October 2020) also reported that a Beefcor borehole was tested. Samples were taken on the 3 of July 2020 and was analysed and interpreted according to the SANS 241:2015 guideline. The following was concluded from the sample analysis:

- Fluoride:

The risk posed by this is related to chronic health and it arises from the ability of a chemical determinant that causes adverse health effects after prolonged periods of exposure.

- Nitrate:

The risk associated with this is acute health, which is of concern to a consumer's health over a lifetime of consumption.

- Total Coliforms:

This is an operational risk, which is an indicator for treatment efficiency and aftergrowth.

Based on the Shangoni analysis it was concluded that the groundwater at the Beefcor borehole was not safe for human consumption, as the indicators exceeded that of the acceptable limits.

The Bronkhorstspruit Biogas Plant (BBP) is a renewable energy industrial facility that is on the Beefcor property and approximately 1.3 km north from the proposed Astral development.

Land owner communication and private water quality analysis:

Previous water quality testing at borehole AS14 indicated that borehole water is not suitable for human consumption and the landowner (Mr J Vermeulen) was advised to stop using the borehole. The borehole is approximately 1.1 km downgradient from the proposed Astral development, but also downgradient of the Beefcor site, Conradie Organics and a horse farm. Mr J Vermeulen currently receives water from Beefcor. Mr J Vermeulen claims negative impacts over past 8 years and recently had to drilled a new borehole to the far south to allow him access to his own water source.

Borehole AS15 (Mr G Steyn) is not in use anymore due to contaminated water. This borehole was one of the first boreholes in the area to show negative quality impacts and is the only borehole on the property. The borehole is approximately 250 m downgradient from two surface water dams. Mr G Steyn noted that when it rains surface run-off flows over his borehole and black slime is visible in his borehole. Mr G Steyn also gets water from Beefcor.

The Rooigras horse farm is adjacent to the Osspruit and downgradient from Conradie Organics. Mr Joubert stated that his groundwater is of acceptable quality.

Mr Lovell from Oxbow Country Estate indicated that most of the boreholes and several surface water bodies were recently sampled (independently) to assess the water quality on in the study area. The data was unfortunately not available to assess and include in this report.

Table 3. Water quality results – December 2020

Parameter	Unit	SANS241 Standard Limits		DWS Drinking Standards	AS 3	AS 14	AS 22
Ammonium	mg N/ℓ	Aesthetic ≥ 1.5			0.124	0.046	0.055
Chloride	mg Cl/ℓ	Aesthetic ≥ 300			77.4	24.9	39.7
Aluminium	mg Al/ℓ	≥ 0.3			-0.002	0.011	0.035
Cadmium	mg Cd/ℓ		Chronic health ≥ 0.003		-0.002	-0.002	-0.002
Calcium	mg Ca/ℓ			No health. Scaling intensifies from 32mg/L	32.6	1.19	21.0
Copper	mg Cu/ℓ		Chronic health ≥ 2		-0.002	-0.002	-0.002
Iron	mg Fe/ℓ	Aesthetic ≥ 0.3	Chronic health ≥ 2		-0.004	-0.004	-0.004
Lead	mg Pb/ℓ		Chronic health ≥ 0.01		-0.004	-0.004	-0.004
Magnesium	mg Mg/ℓ			Diarrhoea and scaling issues from 70mg/L	34.3	0.488	21.7
Manganese	mg Mn/ℓ	Aesthetic ≥ 0.1	Chronic health ≥ 0.4		-0.001	-0.001	-0.001
Nickel	mg Ni/ℓ		Chronic health ≥ 0.07		-0.002	-0.002	-0.002
Zinc	mg Zn/ℓ	Aesthetic ≥ 5			-0.002	-0.002	-0.002
Electrical Conductivity at 25°C	mS/m	Aesthetic ≥ 170			53.9	38.0	41.4
Fluoride	mg/ℓ		Chronic health ≥ 1.5		-0.263	16.2	1.95
Nitrate	mg/ℓ		Acute health ≥ 11		10.6	0.26	1.78
pH at 25°C		≥5 - ≤9.7			7.63	9.61	8.24
Potassium	mg K/ℓ			No aesthetic or health effects below 50mg/L	1.29	0.871	1.33
Sodium	mg Na/ℓ	Aesthetic ≥ 200			12.4	86.6	29.6
Sulphate	mg SO_4/ℓ	Aesthetic ≥ 250	Acute health ≥ 500		6.56	-0.141	12.5
Total Alkalinity	mg $CaCO_3$/ℓ				78	116	132
Total Dissolved Solids	mg/ℓ	Aesthetic ≥ 1200			259	202	216
Total Hardness	mg $CaCO_3$/ℓ	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	222	5	142
Orthophosphate (PO_4) as P	mg/ℓ				0.049	0.039	-0.005
Cobalt	mg/ℓ				-0.003	-0.003	-0.003
Turbidity	NTU	Aesthetic ≥ 5			0.492	0.416	0.368

E.Coli	CFU/100ml		Chronic health – Not detected		1	-1	640
Total Coliforms	CFU/100ml	Aesthetic ≥ 10			2	3	920
Total organic carbon (TOC)	mg/ℓ		Chronic health ≥ 10		3.58	3.41	3.36
Oil and grease (SOG)	mg/ℓ				-0.1	-0.1	-0.1

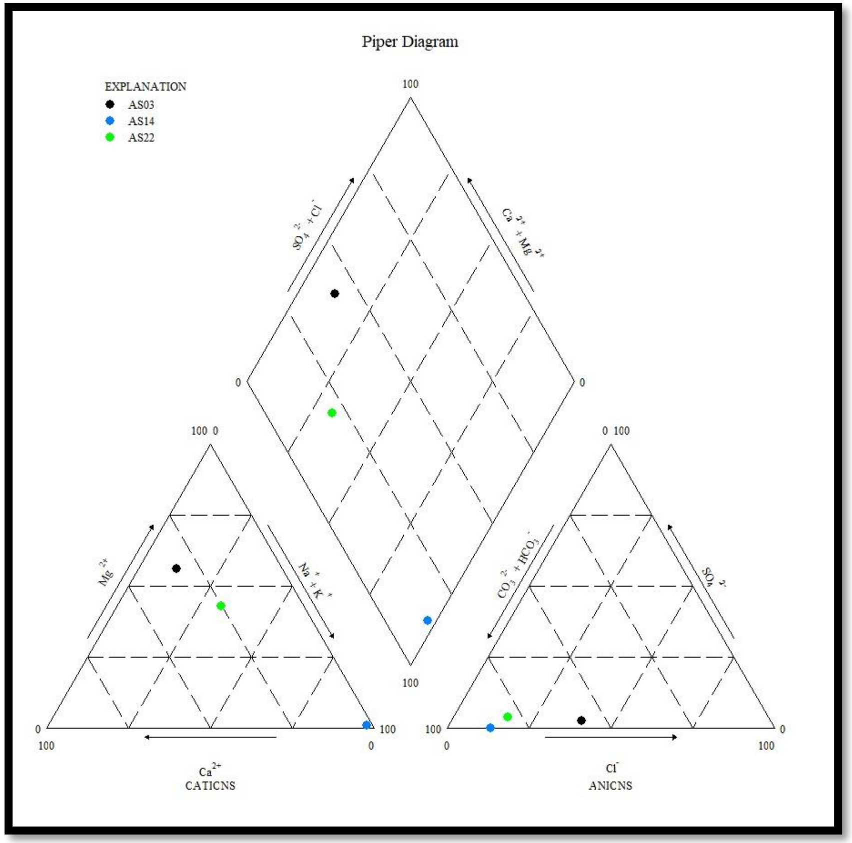

Figure 10. Piper diagram

4.2 Aquifer Classification

The aquifer classification system developed by the Water Research Commission (WRC) (Parsons, RP. 1995) was created for strategic purposes as it allows the grouping of aquifer areas into types according to their supply potential, water quality and local importance as a resource. The geology underlying the study area was classified according to the Parsons system and the DWS's aquifer classification maps.

The groundwater quality in the Boschkop area present low salt and metal concentrations, except for fluoride and microbiological counts. The sedimentary and volcanic rocks do not have a high primary permeability and the aquifer extent may be limited and water quality variable. The aquifers associated with regional, linear and fractured aquifers present high transmissivity and storage values.

The following aquifer characterisation is done based on guidelines and maps provided by the Department of Water and Sanitation.

4.2.1 Groundwater Vulnerability

Groundwater vulnerability indicates the tendency or likelihood for contamination to reach a specified position in the groundwater system, after introduction at some location above the uppermost aquifer. Based on the aquifer vulnerability map published by the DWS in July 2013, the formations are moderately vulnerable to contamination.

4.2.2 Aquifer Classification

Based on the aquifer classification map published by the DWS in August 2012, the area is associated with minor aquifer systems.

4.2.3 Aquifer Susceptibility

Aquifer susceptibility is a qualitative measure of the relative ease with which a groundwater body can potentially be contaminated by anthropogenic activities and includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification. Based on the classification above the local formations have a medium susceptibility to contamination.

5 Groundwater Impact Assessment

A detailed impact assessment table with mitigation measures is presented in Appendix C with groundwater management and mitigation options presented in Chapter 8.

Based on the impact ratings the highest negative risks are associated with the groundwater quality impacts during the operational phase of the composting and pelletizing / pelleting facility, where potential nitrate, ammonium and phosphate seepage could lead to groundwater quality impacts (unless appropriately mitigated).

5.1 Methodology

The significance of the identified impacts has been determined using the approach outlined below (Table 4). This incorporates two aspects for assessing the potential significance of impacts (terminology from the Department of Environmental Affairs Guideline document on EIA Regulations, April 1998), namely occurrence and severity, which are further sub-divided as follows:

Table 4. Impact Assessment Criteria

Occurrence		**Severity**	
Probability of occurrence	Duration of occurrence	Magnitude (severity) of impact	Scale / extent of impact
To assess each of these factors for each impact, the following four ranking scales are used:			
Probability		**Duration**	
5 – Definite/don't know		5 – Permanent	
4 – Highly probable		4 – Long-term	
3 – Medium probability		3 –Medium-term (8-15 years)	
2 – Low probability		2 – Short-term (0-7 years) (impact ceases after the operational life of the activity)	
1 – Improbable		1 – Immediate	
0 – None			
Scale		**Magnitude**	
5 – International		10 – Very high/don't know	
4 – National		8 – High	
3 – Regional		6 – Moderate	
2 – Local		4 – Low	
1 – Site only		2 – Minor	
0 – None			

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (probability + duration + scale) x magnitude

The maximum value is 150 significance points (SP). The impact significance will then be rated as follows:

SP >75	Indicates high environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates **moderate** environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates **low** environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.

5.2 Construction Phase

5.2.1 Groundwater Quality

Negative groundwater quality impacts are already recorded (pre-development) and have been observed in the boreholes around the Boschkop project area (Table 3). The groundwater presents alkaline pH levels and most of the salt and metal concentrations are within SANS 241 Drinking Water Limits. High fluoride (boreholes AS14 and AS22), and E. coli and Total Coliform counts (AS03 and AS22) were recorded for the sampled boreholes. The fluoride concentrations possibly relate to leaching from geological material and the current elevated E. coli and Total Coliform counts could relate to any of the current agricultural, commercial and domestic point sources in the study area.

An increased impact is not expected in terms of groundwater quality during the construction phase. Construction will be conducted in a relatively short period compared to the operational and post-closure phases, with the only possible risk related to site clearing and the flushing of soil and silt into the Osspruit and downstream boreholes, during high rainfall episodes. Effective storm water management will however mitigate this risk. Impacts on the groundwater environment are therefore rated as Low (Appendix C).

5.2.2 Groundwater Quantity

No impact is expected on the water quantity during the construction phase.

5.3 Operational Phase

The following impacts can be expected during the proposed composting and pelletizing / pelleting process:

5.3.1 Groundwater Quality

The potential sources of pollution associated with the compositing and pelletizing / pelleting facility, during operation are:

- Contaminated storm water runoff due to ineffective storm water management measures;
- Seepage water from the polluted storm water dams;
- Recharge of contaminated water by means of seepage from the composting heaps;
- Groundwater contamination due to poor management and accidental spills of diesel and oils used by the heavy machinery on site; and
- Irrigation of lands with affected water.

Groundwater quality could be negatively affected with a potential increase in bacterial / coliform counts and salt loads, especially from nitrogen, phosphorous and potassium elements. The only possible risk relates to seepage of leachate from the compost heaps into the underlying aquifers, or uncontrolled surface water runoff during high rainfall episodes. Effective site management and storm water management will however mitigate this risk. If surface water / ponding / dams / reservoirs are effectively managed and maintained, including the storm water management systems, then the risk of groundwater contamination will be low, in view of the existing impacts. The surface water management and containment guidelines must be improved and maintained at all current point source sites to ensure mitigation and improvement of current groundwater quality impacts.

The geological and associated hydrogeological properties (transmissivity / hydraulic conductivity) suggest that the spread of contamination in the weathered and deeper fractured aquifers will be slow, especially in the diabase and vertically through the shale. If leachate / seepage does enter the subsurface at the proposed Astral development then the contaminant migration could possibly be slow, especially in the absence for highly conductive preferential groundwater flow paths and the barrier effect related to the dolerite sill. The potential plumes will generally be limited to the weathered zone and could extend in a south- and easterly direction towards the Osspruit. The concentration of pollutants generally decreases as it moves further away from the point source, due to dispersion and dilution.

Monitoring of groundwater quality and water levels is recommended, up- and downgradient of the proposed Astral facility, with continuous review and updating of the monitoring network based on the monitoring results (refer to Section 9).

Impacts on the groundwater environment are therefore rated as Moderate (Appendix C).

5.3.2 Groundwater Quantity

The proposed Astral composting facility will not have any significant impacts on the groundwater quantity. Large volumes of water are not used in the process. There is a possibility that water will seep into the underlaying formations, but the additional recharge should be negligible and should have no impact on the groundwater table elevation. The boreholes identified during the hydrocensus must be used to monitor groundwater level fluctuations over time.

Impacts on the groundwater environment are therefore rated as Low (Appendix C).

5.4 Post Closure

The following impacts can be expected after closure:

5.4.1 Groundwater Quality

Overall, there should be an improvement in the groundwater qualities post closure as the source of contamination (composting heaps and infrastructure) has been removed.

Rehabilitation of the soil in the footprint area of the composting and pelletizing / pelleting facility is required to stabilise the salt and bacterial load and minimise infiltration of contaminated water. The area must be seeded with local grass as soon as possible to limit erosion and flushing of soil during rainfall events.

Impacts on the groundwater environment are therefore rated as Low (Appendix C).

5.4.2 Groundwater Quantity

No impact is expected on the water quantity post-closure.

6 Cumulative Impacts

Cumulative impacts result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities (e.g., discharges of high salt or metal loads to a river that combine to cause a reduction in the use of the resource that is greater than the additive impacts of each pollutant). Cumulative impacts can occur from the collective impacts of individual minor actions over a period and can include both direct and indirect impacts.

Land use surrounding the proposed Astral development comprise of agricultural, commercial and domestic activities. Negative groundwater quality impacts already exist and have been observed in boreholes around the Boschkop area (Table 3). The aquifers present alkaline pH levels and most of the salt and metal concentrations are within SANS 241 Drinking Water Limits. High fluoride (boreholes AS14 and AS22), and E. coli and Total Coliform counts (AS03 and AS22) were recorded for the sampled boreholes.

Impacts from the proposed composting and pelletizing / pelleting facility can add to the existing impacts and negatively influence the downstream water resources, if storm water (surface run-of) is not managed and monitored effectively. With effective storm water management impacts of the local surface and groundwater resources will be mitigate and reduced. The surface water management and containment guidelines must be improved and maintained at all current point source sites to ensure mitigation and improvement of current groundwater quality impacts.

Depending on the underlaying geological conditions, aquifer flow properties and borehole use (volumes abstracted), a contaminant or pollution plume could be drawn towards a production borehole, in a specific area (due to cone of dewatering). This is often more pronounced in downstream boreholes, compared to upstream boreholes – due to flow gradient and pressures.

Currently, the storm water management issues, groundwater abstraction for household and farming use, discharges from sewage systems, plus herbicides and pesticides are the potential impacts to the local groundwater environment.

Establishing monitoring boreholes (Section 9) around the proposed development area is required to assess the implications that the proposed Astral development will have on the aquifers and to identify if poor quality groundwater reach a sensitive receptor. The monitoring data recorded must be used to update the monitoring programme.

7 Consideration of Alternatives

"No-Go" Option – if the proposed Astral composting and pelletizing / pelleting facility is not approved the impacts currently observed will remain and have to be resolved. The environmental and socio-economic benefits of the project will however be lost to the region and the economic contribution of Astral to the community, municipality and the region will not occur.

If the composting and pelletizing / pelleting facility is approved there will be benefits to the local economy through possible job creation, poverty alleviation, and local supplier procurement, as well as the people living in the area.

8 Groundwater Management Measures

The following objectives and targets are proposed for groundwater management in the area:

- Implement a water management plan aimed at reducing and/or eliminating adverse impacts on the downstream receptors identified. These includes existing private groundwater users and the Osspruit.
- Implement sufficient monitoring procedures to measure the effectiveness of groundwater management and impacts on private boreholes.
- Analyse the information obtained from all monitoring programmes against compliance targets, to establish trends.
- Should the trends indicate adverse impacts on groundwater levels and/or quality, implement suitable measures within the shortest possible time to remediate and/or eliminate such adverse impacts.

8.1 Principal Groundwater Management Measures

Groundwater management measures should be implemented for the proposed Astral project to minimise impacts on groundwater. Most of these form part of good house-keeping measures (Table 5).

Table 5. General groundwater management measures

Operational Phase
Ensure that sufficient information is available on all private boreholes around the proposed development (1km radius) to quantify existing groundwater status and use. This information will form the basis for future assessments and pollution claims.
Ensure sufficient budget to implement the groundwater monitoring programme before the construction starts.
Develop effective surface runoff management plans to ensure that all dirty runoff is contained on site.
Ensure that silt traps are designed to contain all dirty water generated on site to prevent overflows and spillages.
Drill additional monitoring boreholes to improve on the accuracy and effectiveness of the groundwater monitoring programme.
Implement sound house-keeping measures to prevent and clean spills, address leaks and undertake regular inspections.
Complete regular inspections of silt traps and the polluted water / storm water dam, specifically noting incidences of overflow and leakage. If the latter is identified, measures must be taken to rectify immediately.
Post Closure (if relevant)
Complete all rehabilitation to a satisfactory level, focussing specifically on the storm water drainage and collection system. Effective rehabilitation of the footprint area must be done and if contaminated soil is present it must be excavated and removed from site.
Re-instate vegetation as soon as possible to limit erosion and run-off impacts.
Continue with the groundwater monitoring even after closure. The continued need for groundwater monitoring will depend on the outcome of the closure impact assessment.

The following specific groundwater management measures are recommended. The measures are related to two broad impacts, namely the availability of groundwater and the quality of groundwater.

8.2 Measures to Address Impacts on Groundwater Availability

The following specific measures are recommended to minimise and/or eliminate the impacts on groundwater levels and availability:

- All boreholes listed in Section 9.1 must be included in the groundwater monitoring programme.
- Feedback must be provided to owners of boreholes within the area on a quarterly basis when groundwater monitoring will take place, to ensure that they are informed of aspects that may be of significance.
- Ensure that an effective surface water collection and retention system is in place to ensure that all flow and collected water is directed towards the containing facilities and not allowed to freely drain away from the area.

8.3 Measures to Address Impacts on Groundwater Quality

The following specific measures are recommended to minimise and/or eliminate the impacts on groundwater quality:

- Ensure that clean and dirty water is separated, and that dirty water is contained on site. Contain dirty water in adequately sized reservoirs. Prevent dirty water runoff from leaving the area.

- To limit the volume of dirty water to be managed, clean surface runoff must be directed around the area. If there is a need to discharge the water to the natural environment, the Resource Water Quality Objectives (RWQO) should be met, prior to discharge.
- A monitoring programme must be implemented to establish possible seepage quality impacts during the life of operations.

9 Groundwater Monitoring

It is recommended to implement the initial groundwater monitoring programme presented in this report. The key objectives of a Groundwater Monitoring Programme are to:

- Detect short and long-term trends;
- Recognise changes in groundwater quality and levels;
- Measure impacts and define mitigation measures; and
- Develop improved monitoring systems.

Groundwater monitoring will be undertaken to establish the extent of contamination (if present) in the shallow weathered and deeper fractured aquifers.

It is recommended that strong consideration is given to again sample actively used boreholes (used for domestic and agricultural purposes) before the operational phase, to update the pre-development status and build a water quality database. The database will help the client identify water quality and level trends and will serve as reference to identify and quantify potential impacts on private boreholes.

9.1 Monitoring Locations

The proposed groundwater monitoring network is listed in Table 6. If additional / new private boreholes are identified within a 1 km radius, they must be included in the monitoring programme.

Dedicated monitoring boreholes (not used for groundwater abstraction) must be available on site prior to the construction phase; at least 2 downstream and 1 upstream monitoring site. Table 6 presents preliminary and approximate localities (Figure 11). The depth of the boreholes must be at least 50 m.

Table 6. Proposed groundwater monitoring positions

Borehole	Latitude (WGS84)	Longitude
Existing boreholes:		
AS 01	25°55'17.68"S	28°35'53.33"E
AS 07	25°55'2.39"S	28°35'19.01"E
AS18	25°55'31.69"S	28°36'15.99"E
AS19	25°55'36.79"S	28°36'14.23"E
New proposed boreholes:		
Mon01	25°54'52.84"S	28°35'14.77"E
Mon02	25°55'29.20"S	28°35'23.71"E
Mon03	25°55'32.33"S	28°35'58.14"E

9.2 Monitoring Requirements

The monitoring requirements are presented in Table 7.

Table 7. Groundwater monitoring requirements

Monitoring parameter	Element for analysis	Monitoring frequency
Depth to groundwater level	Groundwater level	Monthly
Water quality	A full spectrum of heavy metals, salts and microbiology	Quarterly

All monitoring information must be entered into a spreadsheet for record keeping and analysis. Copies of the certificates of analyses must be kept on file for inspection. Regular monitoring reports must be prepared for internal use, as well as for submission to the authorities.

10 Conclusions

The effect of organic composting on water quality can be evaluated by assessing nitrate (NO_3^-), ammonium (NH_4^+), orthophosphate (PO_4^{3-}) and organic compounds (e.g., carbohydrates, lipids and proteins). The impact of composting on the water resources are influenced by the location of the heap, protection against rain, water addition during the process, the use of covers and the recovery of leaching and runoff water (Joséphine Peigné, March 2004).

The Astral development is in the Bronkhorstspruit Dam catchment, in the B20C quaternary catchment, forming part of the Olifants Water Management Area (WMA:2). The main drainage is the Osspruit, with the Kleinspruit approximately 2.3 km to the north.

Groundwater occurrence in the local formations favours the weathered shale, but is more common in the brecciated and jointed zones, and the contact zone between the diabase and the shale. The depth of weathering generally varies between 10 and 25 m gbl.

Shangoni (2020) indicates that the Silverton shale is characterised by low hydraulic conductivities and very few primary voids. Shale naturally forms flow barriers (aquitards), rather than aquifers because water is confined within the narrow discontinuities, like jointing and fracturing and most often flows along the layering. The low hydraulic conductivities limit the spread of possible contaminants entering the saturated groundwater zone.

The aquifer system underlying the site is classified as minor, which can be defined as an aquifer system that is composed of rocks not having a high primary permeability (Shangoni, 2020). The extent of the aquifer is limited and the water quality variable, but they are important for local supply and supporting base flow for rivers.

There are no boreholes on the proposed Astral development site. Subsequently all interpretations and conclusions are based on borehole information from surrounding properties.

Figure 11. Proposed groundwater monitoring sites

The groundwater level below surface varied between 1.18 m bgl (borehole AS18 – 600 m east from the proposed Astral site), and 8.56 m below surface (borehole AS08 – approximately 3 km north). If the groundwater levels are viewed as elevation above sea level, then the highest water elevations can be found at boreholes AS02 and AS24 – approximately 2 to 3.5 km to the south of the proposed Astral site. The lowest water table elevation is at boreholes AS15 and AS14 – approximately 1.1 km east from the proposed Astral site. This confirms a regional groundwater flow direction from southwest to northeast in the study area (Figure 7). On a local scale groundwater flow will be towards the streams, predominantly east and northeast.

The closest boreholes to the proposed Astral site are:

- Boreholes AS01 – 100 m east from the proposed Astral site; only borehole for Conradie Organics property; and
- Boreholes AS16 to AS21 – 600 to 900 m east to southeast. All owned by Jan Joubert and all in production except AS21.
- The groundwater level depth at these boreholes range between 1.18 m and 5.41 m below surface, indicating a shallow groundwater table in the proposed Astral development area.

The information provided by the land owners indicated low borehole yields (1000 to 3000 L/hr) for f the project area, with the existing boreholes often serving as only water supply source to the landowner / occupant.

Higher borehole yields possibly relate to the northern boundary of the diabase sills (e.g., borehole AS16 and AS17), as well as the northeast-southwest orientation, mapped geological structure visible in the south-eastern portion of the study area (possibly intercepted by boreholes AS02, AS22 and AS24 / 25) (Figure 5).

Based on the SANS 241 Drinking Water Guideline, the following conclusions were drawn:

3. Health effects:
    i. E. coli – E. coli counts of 1 and 640 units per 100 ml were recorded for boreholes AS03 and AS22 respectively – no E. coli should be present. Escherichia coli is a specific indicator of faecal pollution which originates from humans or warm-blooded animals.

       Borehole AS03 is an upstream control sample (approximately 2 km southwest from the proposed Astral site) and the E. coli count possibly relates to cattle movement near the borehole.

       Borehole AS22 is at Oxbow Country Estate (approximately 2 km downstream from the proposed Astral site) and the borehole is close to the main Estate complex and residential units. Oxbow Country Estate is also next to the Osspruit and in the lowest topographical point in the Farm Boschkop study area. The very high E. coli count possibly relates to a combination of on-site impacts, plus commercial / agricultural activities upstream / to the west.

    ii. Fluoride – boreholes AS14 and AS22 have a high fluoride concentration (16.2 and 1.95 mg/L respectively), compared to 1.5 mg/L allowed. Elevated fluoride concentrations are often associated with intrusive formations.

4. Operational effects:
   i. Total Coliforms – Total coliform bacteria are common in the environment (soil or vegetation) and are generally harmless. High Total Coliform counts were observed in borehole AS22; borehole at Oxbow Country Estate.
   ii. Total Hardness – high total hardness levels were measured for boreholes AS03 and AS22 and relate to elevated Calcium concentrations in the groundwater.

High bacterial counts and high fluoride concentrations are the chemicals of concern currently associated with the Farm Boschkop 543-JR project area (properties / boreholes surrounding the proposed Astral site), based on the list of parameters used for the water quality analysis during the December 2020 hydrocensus. Most salts and metals were present in concentrations below the SANS241 drinking water guideline limits. The 3 boreholes sampled are:

- Borehole AS 3 – approximately 2 kilometres southwest from the proposed Astral site. On Festive Chicken / Astral property. Used as an upstream sample point.
- Borehole AS 14 – approximately 1.3 kilometres southeast. On property of Mr. Jannie Vermeulen. Used as a downstream sample point and next to Osspruit.
- Borehole AS 22 – approximately 2 kilometres southeast. On Oxbow Country Estate property. Used as a downstream sample point.

The groundwater sampling points were randomly selected and based on local catchment and possible groundwater flow characteristics.

CONSTRUCTION PHASE

GROUNDWATER QUALITY

Negative groundwater quality impacts already exist in the groundwater resources around the study area. The boreholes present alkaline pH levels and high fluoride (boreholes AS14 and AS22), and E. coli and Total Coliform counts (AS03 and AS22) were recorded for the sampled boreholes.

An increased impact is not expected in terms of the groundwater quality during the construction phase. Construction will be conducted in a relatively short period compared to the operational and post-closure phases, with the only possible risk related to site clearing and the flushing of soil and silt into the Osspruit and downstream boreholes during high rainfall episodes. Effective storm water management will however mitigate this risk. Impacts on the groundwater environment are therefore rated as Low.

GROUNDWATER QUANTITY

No impact is expected on the water quantity during the construction phase.

OPERATIONAL PHASE

GROUNDWATER QUALITY

The potential sources of pollution associated with the compositing and pelletizing / pelleting facility, during operation are:

- Contaminated storm water runoff due to ineffective storm water management measures;
- Seepage water from the polluted water / storm water dams;
- Recharge of contaminated water by means of seepage from the composting heaps;
- Groundwater contamination due to poor management and accidental spills of diesel oils used by heavy machinery on site; and
- Irrigation of lands with affected water.

Groundwater quality could be negatively affected with a potential increase in bacterial / coliform counts and salt loads, especially from nitrogen, phosphorous and potassium elements. The only possible risk relates to seepage of leachate from the compost heaps into the underlying aquifers, or uncontrolled surface water runoff during high rainfall episodes. Effective site management and storm water management will however mitigate this risk. If surface water / ponding / dams / reservoirs are effectively managed and maintained, including the storm water management systems, then the risk of groundwater contamination will be low, in view of the existing impacts.

The geological and associated hydrogeological properties (transmissivity / hydraulic conductivity) suggest that the spread of contamination in the weathered and deeper fractured aquifers will be slow, especially in the diabase and vertically through the shale. The potential plumes will generally be limited to the weathered zone and could extend in a south- and easterly direction towards the Osspruit. The concentration of pollutants generally decreases as it moves further away from the point source, due to dispersion and dilution.

Impacts on the groundwater environment are therefore rated as Low.

GROUNDWATER QUANTITY

The proposed Astral composting facility will not have any significant impacts on the groundwater quantity. Large volumes of water are not used in the process. There is a possibility that water will seep into the underlaying formations, but the additional recharge should be negligible and should have no impact on the groundwater table elevation.

Impacts on the groundwater environment are therefore rated as Low (Appendix C).

POST CLOSURE

GROUNDWATER QUALITY

Overall, there should be an improvement in the groundwater qualities post closure. Rehabilitation of the soil in the footprint area of the composting and pelletizing / pelleting facility is required to stabilise the salt and bacterial load and minimise infiltration of contaminated water. The area must be seeded with local grass as soon as possible to limit erosion and flushing of soil during rainfall events.

Impacts on the groundwater environment are therefore rated as Low (Appendix C).

GROUNDWATER QUANTITY

No impact is expected on the water quantity post-closure.

Based on the impact ratings the highest negative risks are associated with the groundwater quality impacts during the operational phase of the composting and pelletizing / pelleting facility, where potential nitrate, ammonium and phosphate seepage, as well as an increased bacterial count could lead to groundwater quality impacts.

11 RECOMMENDATIONS

It is recommended that all identified boreholes, actively used for domestic and agricultural purposes be sampled again before the operational phase (if successful), to update the pre-development status and build a water quality database. The database will help the client identify water quality and level trends and will serve as reference to identify and quantify potential impacts on private boreholes.

Dedicated monitoring boreholes must be available on site prior to the operational phase; at least 2 downstream and 1 upstream monitoring site. Table 6 presents preliminary and approximate localities. Four existing and three new boreholes are included in the groundwater monitoring network.

An effective storm water management plan must be implemented from the construction phase to limit negative surface and groundwater impacts associated with runoff water and increased silt loads.

12 References

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www.Tilthalliance.org

Appendix A

Lucas Smith CV

Curriculum Vitae

Lucas Andries Smith (Pr.Sci.Nat)

Independent Hydrogeological Consultant

Principal Hydrogeologist

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QUALIFICATIONS

MSc Geohydrology, IGS (UFS) Bloemfontein, South Africa, 2003.

Baccalaureus Technology Geology, Technicon Pretoria, South Africa, 1997.

National Diploma Geotechnology, Technicon Pretoria, South Africa, 1992.

EMPLOYMENT HISTORY

Department of Water and Sanitation – 17 years.

ERM Consulting – 3.5 years.

Digby Wells Environmental – 5.5 years.

ASST Group – 12 months.

Current – Director, Groundwater Abstract Pty Ltd

FIELDS OF SPECIAL COMPETENCE

- Water use assessments (hydrocensus)
- Geophysical investigations
- Borehole drilling and rehabilitation studies
- Aquifer testing
- Community water supply and resource management
- Mine dewatering, water supply and management programmes
- Groundwater quality assessments
- Groundwater, catchment and impact assessments
- Design and management of water monitoring programmes
- Integrated Water and Waste Management Plans
- Water Use License Applications and compliance assessments
- Geochemistry assessments and waste classification
- Staff management
- Project management

SUMMARY OF COMPETENCIES

Lucas has 27 years of experience in the field of hydrogeology. Before moving to environmental consulting he was a principal hydrogeologist at the Department of Water Affairs and Forestry (now Dept. Water and Sanitation) (South Africa) where he devoted 17 years to groundwater research and exploration programmes; rural water supply-, larger municipal water supply-, and government water supply schemes projects; artificial groundwater recharge projects; as well as borehole and aquifer development and remediation projects.

He executed and managed different hydrogeological projects, focussing on aspects such as community water supply programmes, geophysical investigations, characterisation of aquifers, pollution studies, in-stream flow requirements, hydraulic fracturing, dolomite and karst investigations and monitoring, chemical borehole rehabilitation (biofouling) and hydro-chemical analyses.

Over the past 10 years Lucas' environmental consulting experiences include the Southern African and Central- and West African mining sectors, as well as Energy sectors (Eskom and alternatives) where he manages groundwater and surface water resource evaluations and interaction, as well as conceptualising and quantification of groundwater flow/contaminant transport, ultimately for input to Environmental and Social Impact Assessments (ESIA), Environmental Management Programme reports (EMPr), Feasibility Studies and mine water management. Integrated water management is key to any business, mine, industry, or communities to ensure a sustainable resource for the environment and local communities to benefit from.

At Digby Wells Environmental Lucas was part of the EXCO committee; where he managed a team of 14 surface and groundwater specialists and several projects.

He served on the H&S Committee at ERM and Digby Wells where he also served as Chairperson for the H&S Committee for 1 year.

Lucas is a dedicated employee, husband, farther, patriot; and passionate about managing and protecting our natural resources and the environment.

RECENT RELEVANT PROJECT EXPERIENCE

During the 27 years in the Water Geosciences industry Lucas was involved in many projects where he served as team member on many field works and research programmes; he managed staff and various projects throughout Africa and even as far as Pakistan, and played a prominent role in being the overall Sponsor on projects, as well as acting as key client manager for clients like Sasol and Universal Coal.

A list of clients and projects over the last couple of years can be provided on request, but due to the extent of the experience it has been omitted from this CV.

Appendix B

Water Laboratory Certificate

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: Groundwater Abstract Pty Ltd GWA
Address: 828 20th Avenue , Rietfontein, Pretoria, 0084
Report no: 97076
Project: Groundwater Abstract Pty Ltd

Date of report: 18 December 2020
Date accepted: 10 December 2020
Date completed: 16 December 2020
Date received: 10 December 2020

Lab no:				70822	70823	70824
Date sampled:				09-Dec-20	09-Dec-20	09-Dec-20
Aquatico sampled:				No	No	No
Sample type:				Water	Water	Water
Locality description:				AS03	AS14	AS22
	Analyses	**Unit**	**Method**			
A	pH @ 25°C	pH	ALM 20	7.63	9.61	8.24
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	53.9	38.0	41.4
A	Total dissolved solids (TDS)	mg/l	ALM 26	259	202	216
A	Total alkalinity	mg CaCO3/l	ALM 01	78.0	116	132
A	Chloride (Cl)	mg/l	ALM 02	77.4	24.9	39.7
A	Sulphate (SO_4)	mg/l	ALM 03	6.56	<0.141	12.5
A	Nitrate (NO_3) as N	mg/l	ALM 06	10.6	0.260	1.78
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.124	0.046	0.055
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.049	0.039	<0.005
A	Fluoride (F)	mg/l	ALM 08	<0.263	16.2	1.95
A	Calcium (Ca)	mg/l	ALM 30	32.6	1.19	21.0
A	Magnesium (Mg)	mg/l	ALM 30	34.3	0.488	21.7
A	Sodium (Na)	mg/l	ALM 30	12.4	86.6	29.6
A	Potassium (K)	mg/l	ALM 30	1.29	0.871	1.33
A	Aluminium (Al)	mg/l	ALM 31	<0.002	0.011	0.035
A	Iron (Fe)	mg/l	ALM 31	<0.004	<0.004	<0.004
A	Manganese (Mn)	mg/l	ALM 31	<0.001	<0.001	<0.001
A	Copper (Cu)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Nickel (Ni)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Zinc (Zn)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Cobalt (Co)	mg/l	ALM 31	<0.003	<0.003	<0.003
A	Cadmium (Cd)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Lead (Pb)	mg/l	ALM 31	<0.004	<0.004	<0.004
A	E.coli	CFU/100ml	ALM 40	1	<1	640
A	Total coliform	CFU/100ml	ALM 40	2	3	920
A	Turbidity	NTU	ALM 21	0.492	0.416	0.368
A	Total hardness	mg CaCO3/l	ALM 26	222	5	142
A	Oil and grease (SOG)	mg/l	ALM 29	<0.100	<0.100	<0.100

A = Accredited N = Non accredited Out = Outsourced Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results only apply to the samples as received and tested; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in thi are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory
The results apply to the sample received.

M. Swanepoel
Technical Signatory

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report **Page 2 of 2**

Client:	Groundwater Abstract Pty Ltd GWA	**Date of report:**	18 December 2020
Address:	828 20th Avenue , Rietfontein, Pretoria, 0084	**Date accepted:**	10 December 2020
Report no:	97076	**Date completed:**	16 December 2020
Project:	Groundwater Abstract Pty Ltd	**Date received:**	10 December 2020

Lab no:				70822	70823	70824
Date sampled:				09-Dec-20	09-Dec-20	09-Dec-20
Aquatico sampled:				No	No	No
Sample type:				Water	Water	Water
Locality description:				AS03	AS14	AS22
	Analyses	**Unit**	**Method**			
A	Total organic carbon (TOC)	mg/l	ALM 63	3.58	3.41	3.36

A = Accredited N = Non accredited Out = Outsourced Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results only apply to the samples as received and tested; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in thi are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory
The results apply to the sample received.

Authenticated signature on first page

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Appendix C

Impact Assessment Ratings

Groundwater	Construction Phase	water quality - Existing groundwater quality impacts have been observed in the study area in terms of high fluoride, E. coli and Total Coliform counts. Risk of erosion and silt build up due to surface clearing	2	3	2	4	28	low	12 low	- Implement the proposed groundwater monitoring programme before activities start. Additional groundwater monitoring boreholes are required to effectively measure the current groundwater status, impacts of the composting activities on the groundwater environment and changes in groundwater qualities and levels. - Develop sound surface runoff management plans to ensure that all dirty runoff is contained and diverted to the return water dams. No pooling of water on surface allowed. The groundwater table is near surface and contaminated seepage will quickly enter the underlying aquifers if not managed effectively. - Ensure that return water dams are designed to contain all dirty water generated on site, to prevent overflows. - Ensure that silt traps / trenches are designed to contain all dirty water generated on site to prevent overflows and spillages.
		water quantity - no impacts expected	1	1	2	2	8	low	6 low	- Monitor groundwater levels in all boreholes. The groundwater monitoring network efficiency must be assessed and adjusted, if required.
	Operational Phase	water quality - Existing groundwater quality impacts. Risk of increase in bacterial and salt loads, especially sodium, nitrate, ammonia and phosphate concentrations as a result of storm water management issues, spills or leaking return water dams	3	3	2	8	64	moderate	28 low	- Develop sound surface runoff management plans to ensure that all dirty runoff is contained and diverted to the return water dams. No pooling of water on surface allowed. The groundwater table is near surface and contaminated seepage will quickly enter the underlying aquifers if not managed effectively. - The Osspruit and boreholes for Conradie Organics and Mr J Joubert is at greatest risk and as a result the proposed monitoring boreholes is required. - Monitor groundwater quality in all boreholes included in the monitoring plan The groundwater monitoring network efficiency must be assessed and new monitoring boreholes drilled, if required. Additional mitigation measures need to be implemented if pollution is found migrating off site. - Intercept trenches and possible contamination intercept wells might have to be installed if the monitoring shows deterioration of local groundwater quality. - Ensure that return water dams can contain all dirty water generated on site to prevent overflows. - Ensure that silt traps / trenches are designed to contain all dirty water generated on site to prevent overflows and spillages. - Prepare a replacement water supply strategy for private boreholes that may be affected in anticipation of the potential impacts of increased bacterial and salt loads, as well as organic contamination.
		water quantity - The composting facility will not have any significant impacts on the groundwater quantity. Large volumes of water are not used in the process. There is a possibility that water will seep into the underlaying formations, but the additional recharge should be negligible	2	2	2	4	24	low	10 low	- Monitor groundwater levels in all boreholes included in the monitoring plan
	Post Closure	water quality - there should be an improvement in the groundwater qualities post closure as the source of contamination (composting heaps and infrastructure) has been removed. Risk of erosion and silt build up if surface is not rehabilitated fast	2	2	2	4	24	low	20 low	- Monitor groundwater quality in all boreholes. Intercept trenches and possible contamination intercept wells might have to be installed if the monitoring shows deterioration post closure. - Maintain sound surface runoff management. No pooling of water on surface allowed. - Re-instate vegetation as soon as possible to limit erosion and run-off impacts.
		water quantity - no impacts expected	0	2	1	4	12	low	4 low	- Monitor groundwater levels in all boreholes. The groundwater monitoring network efficiency must be assessed and adjusted, if required.