H2 Energy Power Station

Groundwater Scoping Report

Project Number:

SAV4334

Prepared for:

H2 Clean Energy (Pty) Ltd

On behalf of

Savannah Environmental Consultants (Pty) Ltd

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1 INTRODUCTION

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Savannah Environmental (Pty) Ltd (Savannah) as the independent Geohydrology Specialists for the H2 Energy Power Station project.

The project involves the construction of a 600MW power station and associated infrastructure. The main coal stockpile will be located within the adjacent mine, and a 30-day strategic coal stockpile will be established onsite. Electricity generated by the project will feed into and supplement the national electricity grid. Power line route alternatives will be determined based on the final project layout and grid connection point. These will be assessed through a separate application for Authorisation.

The objective of this report is to provide current baseline groundwater conditions or a reference point against which potential power station impacts can be identified and compared to in future.

2 BASELINE ENVIRONMENT

The H2 Energy Power Station is proposed approximately 30 km north of Bronkhorstspruit and 60 km northwest of Emalahleni in the Thembisile Hani Local Municipality, within the Mpumalanga Province (Figure 2.1)

2.1 Topography and Drainage

The project area is located in the B31B and B32G quaternary catchments of upper drainage of the Olifants River WMA as revised in the 2016 Water Management Area (WMA) boundary descriptions. The B31B and B32G quaternary catchments have a net area of 385 and 968 km² which receive an average of 640 and 639 mm of rainfall per annum whilst the evaporation rate is an average of 1800 mm and 1850 per annum respectively.

Within the B31B quaternary, there is one perennial river, namely Hartbeespruit (approximately 3.5 km) draining the catchment from the southern side to north-western side of the quaternary catchment. Several non-perennial streams and drainage lines exist within this quaternary and few within the demarcated project area. In B32G quaternary catchment, Moses River is the major perennial stream draining the quaternary. This river originates in the north-eastern corner of the project area and flows in a north-easterly direction

2.2 Geology

The H2 Energy Power Station is geologically situated on the Nooitgedacht Outlier, an erosional relict of the Vryheid Formation in the Ecca Group of the Karoo Supergroup (Figure 2.2). The Karoo Supergroup hosts the largest coal deposit in South Africa, including the Witbank and Waterberg Coalfields.

The coal deposit of the area overlies tillite and diamictite of the Dwyka Group in the Karoo Supergroup. In the north, the Dwyka Group overlies felsite of the Selons River Formation of the Rooiberg Group, while in the south it overlies sandstone, grit and quartzitic sandstone of the Wilge River Formation, of the Waterberg Group.

2.3 Hydrogeology

The proposed site is located within the Western Bankeveld and Marico Bushveld regional hydrogeological division and borders the Eastern Highveld hydrogeological region (Figure 2.3). This region covers the whole eastern portion of the Mpumalanga Province. The rocks found here belong to the Vryheid Formation, which forms part of the Karoo Supergroup.

Based on the South African Aquifer Classification System (Parsons, 1995), the intergranular and fractured aquifer underlying the H2 Energy Power Station project area is classified as a Minor Aquifer System, with distinct zones that can be classified as Major Aquifer Systems towards the project boundary. A Minor Aquifer System can comprise aquifers of potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and in supplying base flow to rivers.

However, this classification is only applicable to the heterogeneous and shallow, weathered and unconfined aquifer system. High yielding boreholes are found on occasion associated with zones of deep weathering or along geological features such as dykes.

Groundwater in the area is dominantly represented by a sodium-potassium bicarbonate water type or calcium-bicarbonate water type with few samples around the area showing the impact of mining. The groundwater quality, based on the chemistry analysis is reasonably stable with slight variations. Poor water quality is however expected in areas affected by mining and industrial activities, especially on a local scale. The measured groundwater levels of the area range between 6.0-30.0 mbgl.

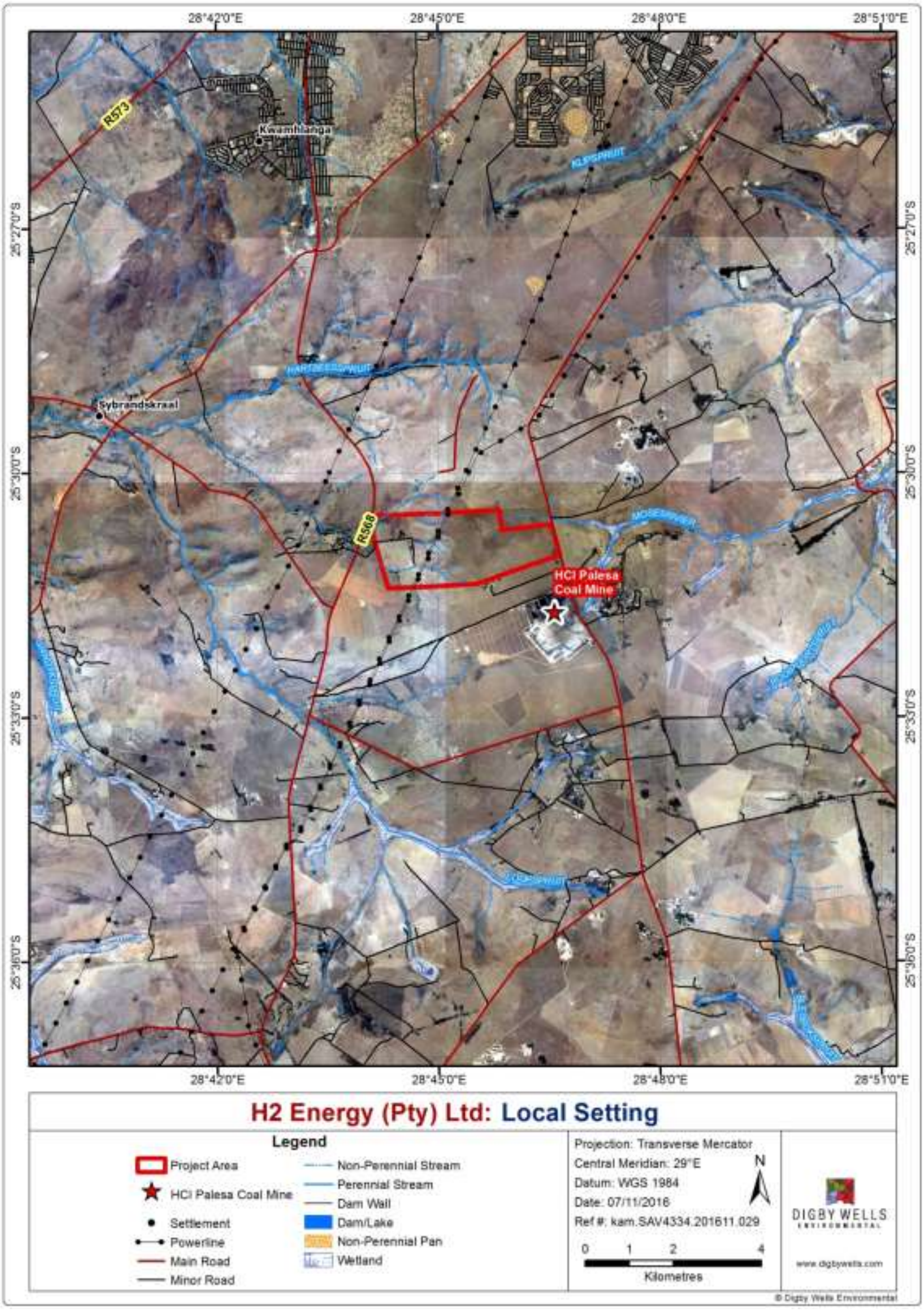

Figure 2.1: Project Locality Map

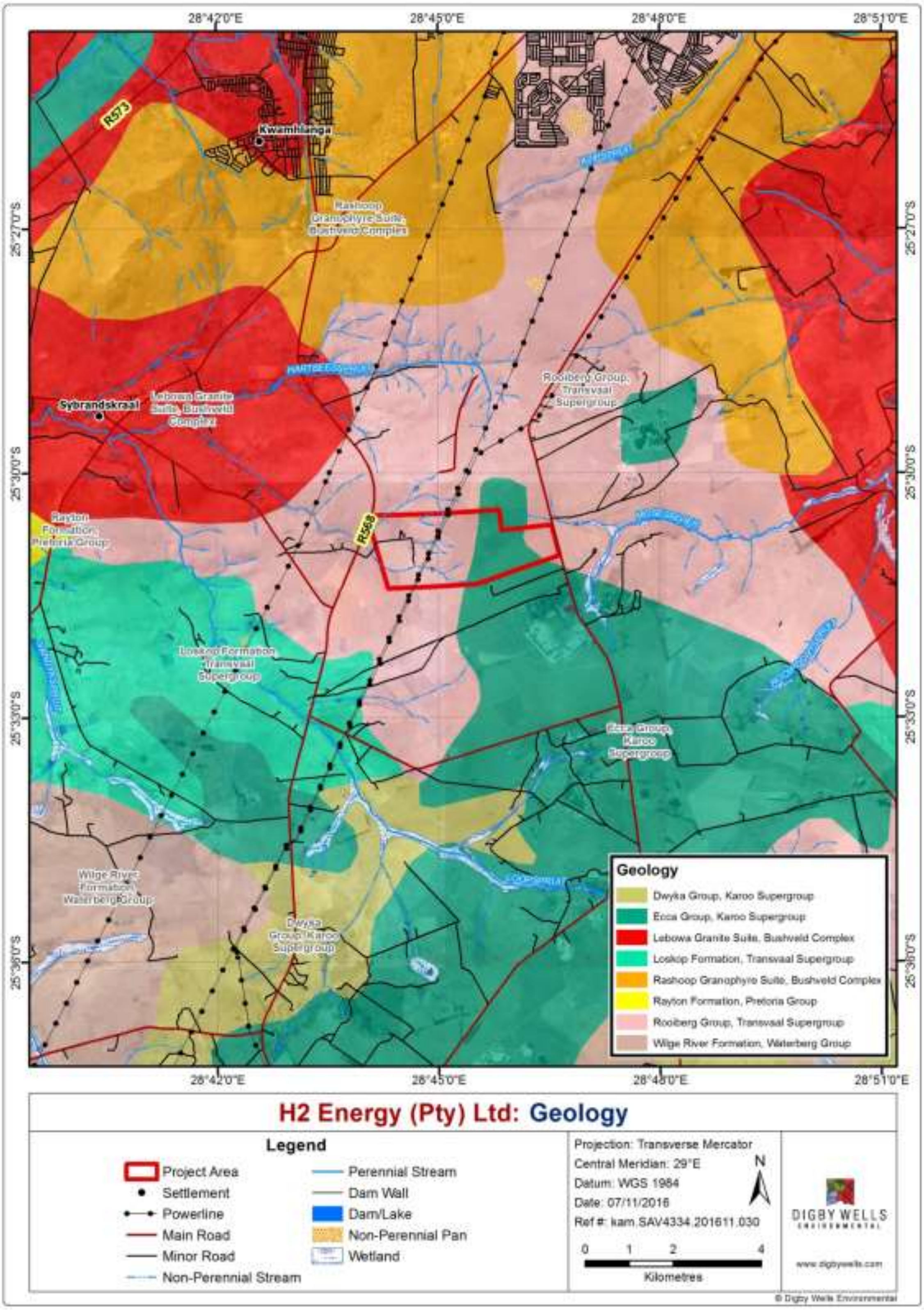

Figure 2.2: Site Geological Map

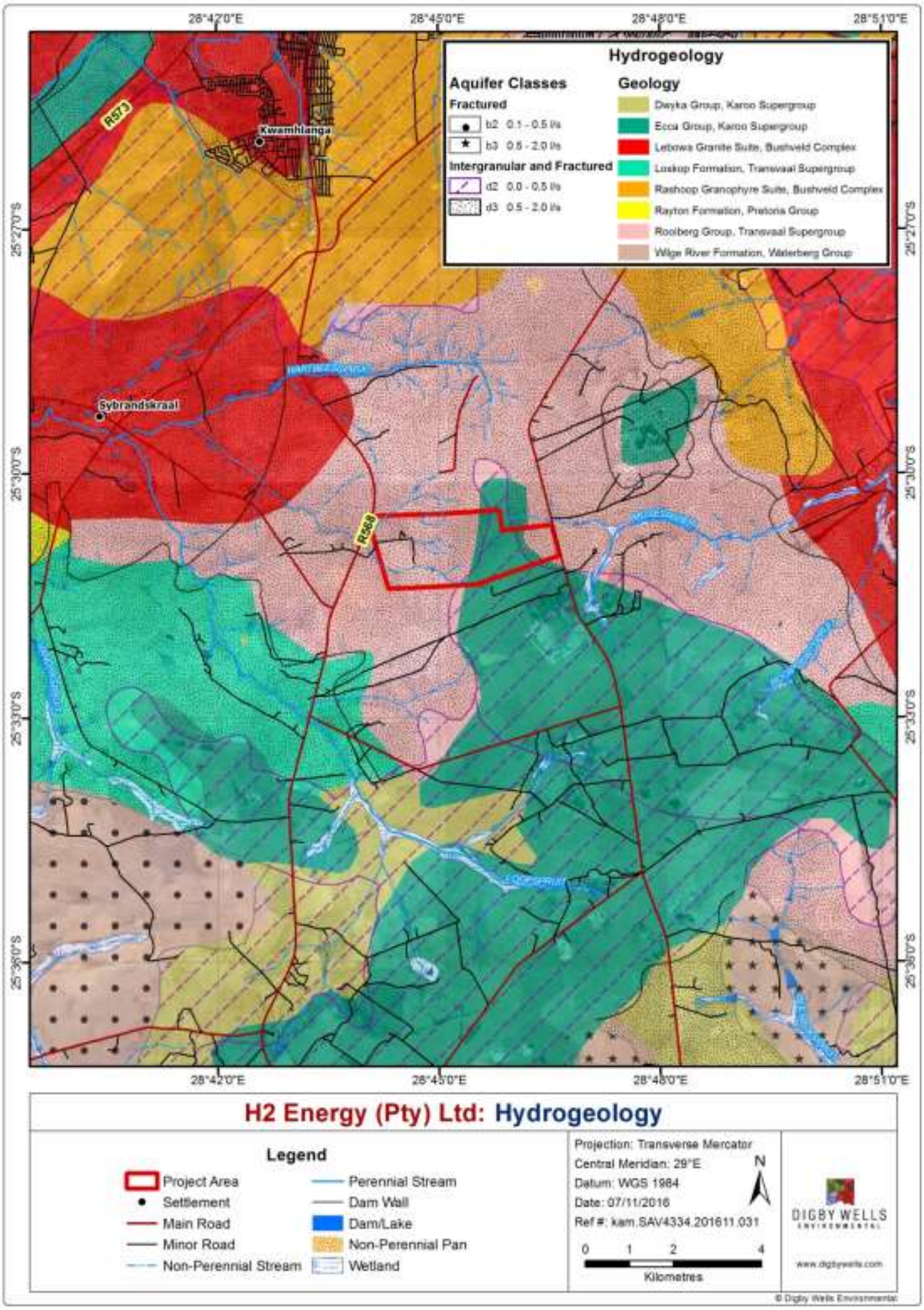

Figure 2.3: Site Hydrogeological Map

3 POTENTIAL GROUNDWATER IMPACTS

The potential groundwater impacts were assessed considering the three phases of the life of project: the construction, operation and decommissioning phases.

3.1 Construction Phase

The main activities during the construction phase that could result in groundwater impacts are associated with the site clearing and construction of the various power station infrastructure, including the pollution control dams, ash dump and coal stockpile.

The water table in the power station area is expected to be deeper than 5 m below the ground surface. All activities are expected to take place above this and no impact on the groundwater is envisaged as a result. If any of the activities involve excavation to below the water table, there could be a potential impact on the groundwater quantity. Table 3-1 summarises potential groundwater impacts identified during the construction phase.

Table 3-1: Identified Potential Impacts during the construction phase

<table>
<tr><td colspan="4">Impact:
Lowering of the water table
Desktop Sensitivity Analysis of the Site:
Site clearing through the removal of the topsoil and weathered rocks could impact shallow water table</td></tr>
<tr><td>Issue</td><td>Nature of Impact</td><td>Extent Impact</td><td>No-Go Areas</td></tr>
<tr><td>Lowering of the water table</td><td>Groundwater quantity and quality</td><td>Local</td><td>Localised areas where infrastructure foundation has to be constructed below the water table</td></tr>
<tr><td colspan="4">Description of expected significance of impact
This impact is not expected to be significant depending on the depth of the water table. In areas where the foundation of structures is to be installed below the water level, dewatering of the aquifer to locally lower the water table can be considered. The abstracted water can be utilised for dust suppression, vegetation or discharged to the stormwater dams.</td></tr>
</table>

Impact: Lowering of the water table **Desktop Sensitivity Analysis of the Site:** Site clearing through the removal of the topsoil and weathered rocks could impact shallow water table			
Issue	**Nature of Impact**	**Extent Impact**	**No-Go Areas**
Gaps in knowledge & recommendations for further study A hydrocensus has to be conducted to investigate how shallow the water table is. If no sufficient boreholes are present, monitoring boreholes should be drilled. Avoid constructing below the water table as far as possible. Install long term monitoring boreholes.			

3.2 Operation Phase

The activities associated with the power generation that could potentially impact the groundwater include: ash disposal, coal stockpiling, dirty water dams, domestic and other solid waste and sewage.

- The ash dump and associated stormwater dams will be lined and this is expected to significantly reduce seepage of contaminants to the subsurface. Dry ash disposal has been proposed for the project site, whereby the ash is partially wetted to contain approximately 15% moisture. This dry ashing has an advantage over wet ashing as it would minimise the infiltration of ash water to the subsurface.
- Coal stockyards, by virtue of the fact that the coal contains pyrite, have a far greater pollution potential than fly ash. The potential for the coal stockyard to generate acid is, however, greatly reduced and expected to be insignificant due to the following assumptions:
  - The floor of the coal stockpile is expected to be a well-compacted flat surface. This would be designed for the ease of operation and coal recovery, but also to prevent seepage to the groundwater; and
  - The coal is assumed to be stored for less than 30 days and thus the time required for seepage to occur will be minimal.
- No onsite domestic waste facilities are proposed at the project site. Domestic waste will be collected by an independent contractor and disposed of offsite.

Table 3-2: Identified Potential Impacts during the operation phase

Impact: Groundwater contamination **Desktop Sensitivity Analysis of the Site:** The main impact that a power generation may have is from ash disposal on the surface. The typical ash water chemistries within ash disposal site include high pH (>12), calcium, aluminium, sodium and sulphate. However, such impacts are expected to be negligible with the application of a liner, together with a dry ash disposal.			
Issue	**Nature of Impact**	**Extent Impact**	**No-Go Areas**
Groundwater contamination as a result of seepage from the ash dump and coal stockpile	Groundwater quality deterioration	Contamination plume is expected to be within and immediately around the dump area	Approximately 100 m radius of the ash dump
***Description of expected significance of* impact** Groundwater is expected to feed the rivers in the project area. If the groundwater is contaminated, the plume can reach the local streams as base flow. With the implementation of a liner and dry deposition, however, such impacts are estimated to be negligible.			
Gaps in knowledge & recommendations for further study A geophysics survey has to be conducted to delineate fractures along which contaminates will migrate. Borehole drilling and aquifer testing is required to determine the rock permeability and groundwater flow speed. A geochemical study is required to determine the expected leachate quality from the ash material and coal stockpile. A numerical model is finally required to predict the size of the contamination plume and the risk of private borehole and rivers from contamination.			

3.3 Decommissioning and Post-Closure Phase

The closure phase is characterised by the decommissioning of the power plant and associated infrastructure, including the coal stockpile and PCD. However the ash dump will remain on surface even after closure. Rain water seeping through the dump is expected to dissolve contaminants. This is however is unlikely to pollute the groundwater considering the proposed liner and post-closure dump rehabilitation.

At dry ash dams, carbon dioxide moves into the ash with the rain water. The carbon dioxide reacts with the calcium oxide in the ash and lime ($CaCO3$) precipitates forming a hard layer known as pozzolanic layer. Hodgson et al. (1998) reported that pozzolanic layer at a dry ash dump is typically up to 500 mm thick. As the crystallisation of lime continues, the top portion of the ash becomes less and less permeable. A stage should therefore be reached where the hydraulic conductivity of the pozzolanic layer has been reduced to such an extent, that rainwater can no longer effectively penetrate into the ash. The ability of pozzolanic ash to successfully act as a sealant, has also been demonstrated by Edil et al. (1992) in the US, in which they state that ash permeabilities are reduced to less than 10^{-7} m/s with time.

Table 3-3: Identified Potential Impacts during the post-closure phase

Impact: Groundwater contamination **Desktop Sensitivity Analysis of the Site:** Rain water seeping through the ash dump is expected to dissolve contaminants and that would pollute the groundwater. Although the rain water infiltration rate can be minimised by the liner and rehabilitation of the dump, the amount of salt load reaching the groundwater could be significant over many years.			
Issue	**Nature of Impact**	**Extent Impact**	**No-Go Areas**
Groundwater contamination as a result of seepage from the ash dump and coal stockpile	Groundwater quality deterioration	Contamination plume is expected to be within and immediately around the dump area	Approximately 500 m radius of the ash dump
***Description of expected significance of* impact** The ash dump is expected to remain on ground surface long after the mine is closed. The amount of salt load released from the dump could be significant over time and pose risk to the groundwater receptors. Depending on the integrity of the liner and rehabilitation maintenance in the post-closure phase, the impact could be moderate.			
Gaps in knowledge & recommendations for further study Continuous post-closure monitoring is required to ensure that no drastic water quality changes are recorded. The numerical model needs to be updated and should be calibrated with the recorded monitoring data. Once the model is calibrated, it should be used to predict the shape and size of contamination plume up to 100 years after closure.			

4 TERMS OF REFERENCE AND PLAN OF STUDY FOR EIA

A detailed groundwater impact assessment will be conducted to identify and assess potential impacts that may arise from the proposed H2 Energy Power Station and the associated activities. The impact assessment will make use of a rating system adopted by Digby Wells that takes into consideration the intensity, duration, spatial scale and probability of the impacts.

The groundwater impact assessment will be conducted in line with the DWS Best Practice Guideline for Impact Prediction and is guided by following legislative requirements:

- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA);
- Regulation 636 under the National Environmental Management: Waste Act.
- National Water Act (Act 36 of 1998) (NWA); and
- NWA amendment of Regulation 704 (GN R 704) of 1999.

4.1 Objectives of the Study

The objectives include the assessment of the potential impact and mitigation plans of the proposed power station on the groundwater environment. The report will be compiled in support of obtaining the relevant environmental authorisations for the project to go ahead.

4.2 Methodology for Groundwater Impact Assessment

The groundwater impact assessment, which is a detailed assessment of an area, will be carried out to define the groundwater system of the area and determine the extent of an impact on the groundwater resource. Tasks related to the site-specific geohydrological evaluation of the H2 Energy Power Station project area will be included (as detailed in the sections which follow).

An impact assessment will be used to address the possible impacts of all power station related activities on the quantity and quality of the groundwater resources in the project area, according to the conceptual model and monitoring data available.

The methodology used to obtain quantitative and qualitative information will be site specific. The methodology will entail the acquisition of all relevant hydrogeological background information and data. This normally comprises site specific surveys, intrusive studies (drilling and aquifer testing), data interpretation, geochemical assessment, numerical flow and contamination modelling and reporting. Once completed, a specialist report will be compiled from all relevant data and will feed into the EIA.

4.2.1 Field Surveys and Intrusive Work

This phase comprises detailed investigations to a definitive level to enable accurate project planning and to comply with regulatory requirements.

4.2.1.1 Hydrocensus

A hydrocensus study will be overseen by Digby Wells. During hydrocensus data pertaining to the current groundwater conditions and use will be collected, including the localities of current groundwater abstraction points (boreholes, hand dug wells or springs), ownership, current usage volumes and types, equipment and groundwater levels. Hydrochemical samples will also be taken from selected boreholes. This data will serve as a reference point against historical and future groundwater conditions in the area.

The area covered by the hydrocensus will span an approximate 1 km radius from the proposed project area and will take into account the sub-catchment boundaries in which activities takes place.

Digby Wells will liaise with the client to obtain details of surrounding land use and to discuss access to privately owned properties. Property owners will be notified in advance of the hydrocensus, and the survey will include interviews with landowners/ managers of abstraction points, visits to individual boreholes, measuring of water levels, as well as selective collection of groundwater samples. Information to be recorded on a field sheets include the following:

- Owner and property details;
- Borehole locality and depth;
- Rest water level;
- Borehole installation date, status and equipment;
- Groundwater abstraction rates;
- Primary groundwater usage; and
- Electrical conductivity, pH and groundwater sample details.

Water samples will be collected either by pumping water from the installed borehole pumps or an open-end bailer, depending on the specific field conditions. Samples will be submitted to an accredited water laboratory. The analysis will include major cations, anion and metals.

Upon completion of the desktop study and hydrocensus, a gap analysis will be performed to identify any possible short comings in the current groundwater study. The outcome will be discussed with the client.

All the previous work conducted is culminated into a decision tool used to plan the intrusive stage where more accurate characterisation of the hydrogeological system is conducted to outline and define the aquifer system/s in the area.

4.2.1.2 Geophysical Survey

A ground geophysical survey will be conducted to delineate weathered zones and vertical to sub-vertical features adjacent to the workings. This survey will assist in locating preferential groundwater flow paths and in positioning of drilling targets.

The magnetic and electromagnetic geophysical surveying techniques will be applied during the study.

4.2.1.3 Drilling

Drilling will be conducted to gain general aquifer characteristics for the site area. The boreholes will be placed across the area in order to gain a representative understanding of the project area. Three characterisation boreholes are proposed to be drilled in close proximity to the proposed ash dump area. Provision is made for the drilling of 3 boreholes, to a depth of 10 m below the water table, or a maximum of 50 m. These boreholes will be incorporated in the monitoring programme to be utilised during operations and post closure phase.

4.2.1.4 Aquifer Testing

It is imperative that the most strategic and successful boreholes drilled during this investigation be aquifer tested to determine aquifer responses and to calculate the parameters presenting the aquifer hydro dynamics underlying the investigation area. All boreholes yielding more than 0.5 L/s will be step-tested, followed by an 8 hour constant drawdown test and recovery test. Low yielding boreholes (less than 0.5 L/s) will be slug tested.

Supervision during the aquifer testing programme will be done by a Digby Wells hydrogeologist. Water quality samples will be collected following each aquifer test for chemical analysis and these samples will be sent to a SANAS accredited laboratory in Pretoria.

4.2.2 Geochemical and Waste Assessment

Ten rock samples which represent the coal and waste rock material will be collected. The analysis to be performed includes Acid-Base Accounting (ABA), Sulphur speciation, XRD, XRF, Leachate test and aqua regia (for total element analysis).

4.2.3 Hydrogeological Modelling

4.2.3.1 Conceptual Modelling

This is a vital step in the impact assessment process, and the development of a good conceptual model will ensure reasonable results. The conceptual model aims to describe the groundwater environment in terms of the source-pathway-receptor interlinkage:
Pathways (aquifer system)

- Aquifers - these are rock units or open faults and fractures within rock units that are sufficiently permeable (effectively porous) to allow water flow;
- Interconnections between aquifers;
- Hydraulic parameters; and
- Boundaries that result in the change or interruption of groundwater flow.

The sources:

- Ash dump and other power plant activities that could potentially release contaminants to the groundwater
- Precipitation, evapotranspiration;
- Runoff, groundwater head data which yields groundwater flow;
- Recharge and discharge areas, exchange of groundwater and surface water; and
- Hydro-chemical data including major ions and metals and ash leachate characteristics.

The groundwater receptors (i.e. the groundwater users, streams and natural ecosystem that depends on the groundwater)

4.2.3.2 Numerical Modelling

The conceptual hydrogeological model will be encoded into a numerical model. The Processing MODFLOW interface will be will be used for this task. Groundwater flow will be simulated using MODFLOW while contaminant transport will be assessed utilising MT3DMS. The model domain will extend to the closest groundwater boundaries not expected to be impacted by the operation.

The model will be calibrated to the latest water levels (steady state), as well as historic water level monitoring (transient). Once calibrated the model will be utilised to run the required scenario’s to determine the likely impacts of the proposed power station as required by the scope of work. The scenario modelling will cover all current and future plans, as well as 100 years after closure.

4.2.3.3 Monitoring Network Design and/or Dewatering

Recommendations and methodology of the monitoring and dewatering will be provided based on the results of the groundwater study, latest power station plan and the numerical model results. Frequency of sampling and reporting will be a function of the EIA and the life of power station and its effect on the receiving environment.

4.2.4 Reporting

All information, data, maps and interpretations will be compiled into a detailed technical report that is the final deliverable of the hydrogeological specialist investigation of the project EIA, with conclusions and recommendations on risks, mitigation and monitoring requirements as stipulated by the authorities.

The site specific Groundwater Impact Assessment methodology and risk rating that will be used is the same as described in the EIA and is in accordance with the corresponding regulations.

A groundwater monitoring plan will be compiled based on the conditions and activities on site and will include the location of the monitoring boreholes, frequency of monitoring, list of chemical parameters to be monitored, sampling methodology, description of data capturing and reporting requirements.

4.3 Project Specialist

The groundwater specialists that will be involved in the project are:

Dr Robel Gebrekristos:

Robel is a qualified natural scientist, having completed his doctorate (PhD) in hydrogeology from the University of the Free State in 2007. Robel is a Department Manager of the Water Geosciences and specialises in groundwater modelling, environmental impact assessment, geochemical interpretation and groundwater resource management. Robel has over 15 years of experience in the fields of hydrogeology and geology, both as a corporate consultant and a researcher. Robel's experience with groundwater modelling includes using finite difference (PMWIN and VMOD) and finite element (FEFLOW) software packages, seepage modelling (using SEEP/W), water balance evaluations (using GoldSim or spreadsheet), hydrogeological database management, appraisals of mining and industrial impact assessments, and monitoring and analysis of contaminants (both organic and inorganic) in groundwater. He is competent in VB and C++ programming and is able to design databases. Robel has published more than 18 papers, documents and manuals on his field of expertise and presented in international conferences.

Karabo Lenkoe-Magagula

Karabo is a professional scientist with honours in Hydrogeology from the University of Pretoria. Karabo is a senior hydrogeologist at Digby Wells within Water Geosciences Department and specialises in environmental impact assessment, geochemical interpretation and groundwater resource management. Karabo has 9 years of experience in the fields of hydrogeology as a corporate consultant. Karabo's fields of expertise include hydrogeological assessments, geochemistry assessment, waste classification assessment, mine dewatering management and EIA/EMP assessments, drilling supervision, groundwater contamination investigation and groundwater geophysical exploration. Her experience includes the Southern African mining sectors where she investigates groundwater resource evaluations, as well as conceptualising and quantification of groundwater flow/contaminant transport to specialist groundwater investigations.

Bridget Moeketsi

Bridget is a hydrogeologist employed within the Water Geosciences Department. She holds a B-tech degree in Environmental sciences (waiting project completion). She joined Digby Wells in August 2010 as water geoscience intern. She has been involved with geophysics investigations, drilling supervision, water sampling, aquifer testing and water monitoring reports.

Ayabonga Mpelwane

Ayabonga is a junior hydrogeologist employed within the Water Geosciences Department. She holds a BSc degree in Geology, BSc Honours degree in Hydrogeology and is currently attaining her MSc in Hydrogeology; all qualifications were/are being attained from the University of the Free State. She joined Digby Wells Environmental in November 2014, as a water geoscience intern. She has been producing numerical and analytical groundwater models which involve groundwater related impact assessments and groundwater management plans.

5 REFERENCES

Barnard HC (2000), an Explanation of the 1:500 000 General Hydrogeological Map

Edil TB, Sandstrom IK, Berthouex PM (1992). Interaction of inorganic leachate with compacted pozzolanic fly-ash. J. Geotechn. Eng.- ASCE, 118(9): 1410-1430.

Hodgson F.D.I. and Krantz R.M. (1998). Investigation into Groundwater Quality Deterioration in the Olifants River Catchment above the Loskop Dam with Specialised Investigation in the Witbank Dam Sub-Catchment. WRC Report No. 291/1/95, ISBN 1 86845 182 8.

Scott, R. (1995) Flooding of Central and East Rand Gold Mines: An investigation into controls over the inflow rate, water quality and the predicted impacts of flooded mines. Institute for Groundwater Studies, University of the Orange Free State, Bloemfontein: Prepared for: Water Research Commission.