Technical Report
2015/05/02/GENV

Port of East London:
HFO Tank Site Geo-Environmental Assessment

May 2015 Prepared for: **Transnet National Ports Authority**

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Port of East London:

HFO Tank Site Geo-Environmental Assessment

29 May 2015

Conducted for:

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LIST OF ABBREVIATIONS

Abbreviation	Carbon Bands	Description
BTEX	N/A	Benzene; Toluene; Ethyl benzene; m+p – Xylene; o-Xylene
Crude Oil	C10-C40	Crude Oil
DNAPL		Dense Non Aqueous Phase Liquid
DRO	C10-C28	Diesel Range Organics
GRO	C6-C12	Gasoline Range Organics (Includes BTEX)
HFO		Heavy Furnace Oil
L		Litres
LNAPL		Light Non Aqueous Phase Liquid (refers to botresidual product)
MAMSL		Meters Above Mean Sea Level
mbgl		Metres Below Ground Level
mg/kg		Milligrams per Kilogram
mg/L		Milligrams per Litre
MTBE		Methyl Tert-butyl Ether
NGA		National Groundwater Archive
ORO	C20-C35	Oil Range Organics
ppm		Parts per Million
RRO	C25-C36	Residual Range Organics
TNPA		Transnet National Ports Authority
TPH		Total Petroleum Hydrocarbons
µg/L		Micrograms per Litre
VOC		Volatile Organic Compound

Table of contents

List of Figures

List of Maps

List of Photos

List of Tables

1 EXECUTIVE SUMMARY

AGES Eastern Cape (Pty) Ltd was appointed by the Transnet National Ports Authority Group after the submission of a quotation to conduct a HFO Tank site assessment with specific attention to contaminated areas, environmental risks, safety health, negative business impacts and potential negative impacts to the community living nearby.

From the results of the study carried for BP in 2013 by SRK, it was stated in the report that the HFO site is free of significant contamination, but the areas where the HFO and AGO spills took place do contain TPH in the upper soil. In general, the shallow and deeper groundwater was found to be without detectable contamination.

It was further mentioned in the report that on 7 January 2012, prior to the study, the AGO diesel fuel line that leads to the East London Fuel Depot leaked diesel next to the HFO facility. Engen commissioned an investigation and the spill was attended to by SRK and Enviroserve. On 14 March 2012, SRK conducted a final Site assessment on the AGO spill. The initial work undertaken during the first phase formed part of the emergency response to the HFO and AGO releases. It entailed the containment and recovery of the free product in order to limit the extent and the impact on the surrounding environment. This was achieved with the assistance of Enviroserv, a remediation contractor. Reports were submitted on each of the incidents.

TPH groundwater pollution was however encountered during this 2015 study at borehole BP HFO2. The contamination is of a Diesel Range Organics origin. As this is the only borehole where this kind of pollution was encountered it will need to be investigated in order to determine the origin and extent of the pollution source. The exact history of activities at the HFO tank since the 2013 survey need to be confirmed.

The possibility of a diesel spill associated with the AGO pipeline or any related pumping infrastructure need to be investigated as a matter of urgency. The location of the AGO pipeline is indicated in MAP 9 but no information could be obtained from TNPA regarding any other pipelines that might occur on site. This will need to be obtained and reviewed in relation to the site where TPH pollution was noted at borehole BP HFO2

Perched groundwater within the sandy topsoil and weathered sandstone can be expected at 1.7 mbgl. This perched groundwater level is also expected to be associated with the potential wetland that is found approximately 400m south of the site where it has probably developed within unconsolidated weathered Nanaga Formation sediments.

Illustrated in the conceptual model is the expected groundwater flow within the perched shallow aquifer as well as vertical flow along joint sets that were observed on site. It is expected that most of this flow will be from the perched shallow aquifer along vertical joints until it intersects resistive horizontal bedding planes

Based on the topography and surface water drainage directions it is expected that groundwater flow will mimic surface topography and is therefore expected to be in a northeast direction, from the HFO site towards the Buffalo River and harbour

Based on the geotechnical findings a hydraulic conductivity of 4.86 m/d was calculated from the sieve analyses conducted on the dune sand sample taken from trial pit HFO TP3. The sand was selected due to its high permeability and it is located downstream of the HFO tank in the vicinity of the monitoring borehole BP HFO 2 that had a strong diesel odour during sampling. The seepage velocity was calculated using Darcy's Law and was determined to be 1.43 m/d.

Based on the geology of the site a second model was drafted in order to simulate flow of contaminants through the underlying fractured rock. The hydraulic conductivity of the fractured rock was estimated to be 300 m/d and a worst case effective porosity of 23%. Kruseman and De Ridder (1991). A seepage velocity of 104.02 m/d was calculated. From the fractured rock Domenico model we can also conclude that in a worst case scenario the contamination plume would travel approximately 250m in 1 day through fractured bedrock and have an end concentration of 0.3 mg/l.

It can be concluded that contamination transport through the fractured rock could be orders of magnitude faster and therefore further and wider than in the dune sand. Fractures in the underlying formation strike in a north east direction and are associated with horizontal bedding planes along which groundwater can flow towards the Buffalo River. It is further concluded that any contamination entering the overlying soil layers would most likely enter the fractured rock and flow along the bedding planes and would be discharged along the Buffalo River. Once contamination has entered the fractures it can be transported up to 250m in a single day under ideal conditions.

Based on the results of the investigation and previous investigations, a preliminary conceptual model of soil conditions on site was compiled. No accurate elevations were available to refine the topographical profile. Due to the nature of profiling of the previous investigation, only the soil colours could be utilised as a possible reference to the origin of the material. In the model it is shown that deeper sand occur in the zone directly north east of the HFO tank and also on the southeastern portion of the HFO tank site. This zone can act as a preferential pathway for shallow groundwater flow towards the Buffalo River and harbour within unconsolidated permeable sand.

Risks associated with the local communities have been defined based on the current status of the HFO tank site and history related to its use since 1976. As described before under the description of the site, the site is classified as hazardous with the nature and intensity of hazards varying from situation to situation. Applicable risks were addressed in the Overall Risk Assessment which is summarised in Chapter 4.15.

Recommendations are given in the report that will guide TNPA in terms of immediate action and future monitoring to comply with regulations and to implement the intended development.

2 INTRODUCTION

The Transnet National Ports Authority (TNPA) has identified a section of land within the port to be utilised and developed for future use. The TNPA needs to make decisions on the future use of this piece of land, but before any planning and decision can be made it was needed to appoint a service provider to assist them in providing sound scientific based information of this identified site.

The Port of East London has been in operation since before 1850 during its lifespan cargoes may have been handled or operational procedures may have been performed which may have caused environmental, health and safety impacts.

This assessment will assist TNPA in providing the needed information for planning; executing and or enforcing proper controls and remedies which in the short or long term may impact port development or land usage.

2.1 Terms of reference

AGES Eastern Cape (Pty) Ltd was appointed on 27 January 2015 by the Transnet National Ports Authority Group after the submission of a quotation with reference number EC-P-201412-15. This quotation was given in response to the RFQ document PAC 168 to conduct a HFO Tank site assessment with specific attention to contaminated areas, environmental risks, safety health, negative business impacts and potential negative impacts to the community living nearby.

2.2 Scope of work

The scope of work was defined to include the following:

- Identification of levels of contamination, and evaluation of the extent of contamination in groundwater, soil and sediment.
- Analysis of soil/sediment/groundwater interactions and transport
- Identification of potential receptors and simulation of the outcome of contaminants
- Analysis of sediment impact zone
- Modelling of contaminant flow and transport
- Assisting TNPA with the control measures to mitigate against all the impacts and risks
- Assist TNPA with the remedial cost to all the findings
- Assist TNPA by assessing the potential negative environmental impacts to the community living nearby; health risks, safety risks, infrastructural/technology risks; environmental risks; business risks

2.3 Deliverables

Based on the scope of work, the following deliverables were defined for the project:

- Research within existing port resources the current and historical use of each site

- Identify and list per site, the actual or potential contaminants; environmental risks; health risks; safety risks; risks to the business and potential risk to the community living nearby based on the above information
- Prepare and present an appropriate and cost effective sampling plan per site to meet minimum legal requirements.
- Collect samples using legally prescribed methodology and technology. The sampling plan and points must be indicated on an appropriate map or other format enabling the future location thereof
- Conduct sample analysis using legally prescribed methodology and technology in an appropriately accredited laboratory
- Compile a site specific report reflecting contaminants, environmental risks; health risks; safety risks; risks to the business and potential risk to the community living nearby based on the actual action levels and applicable legislated standards per sampling point
- Make recommendations for the optimal and cost effective treatment of contamination environmental risks; health risks; safety risks; risks to the business and potential risk to the community living nearby based per site
- Prepare and make a presentation of the survey results and recommendations to the Port Management and other interested affected parties and Authorities

2.4 Project area and location

The HFO tank site is located on the southern banks of the Buffalo River mouth, which forms the entrance of the East London Harbour. It is located in the Westbank suburb of East London in the Buffalo City Metropolitan Municipality. The exact locality of the site is indicated in Map 1 and Map 2. The central point of the investigated site is defined by the following coordinate (WGS84 Geographic Projection):

- Latitude: -33.028523° S
- Longitude: 27.905739° E

2.5 Available information

The following sources of information were used during the investigation:

Geological maps

- 3326 GRAHAMSTOWN; Scale 1:250 000

Topographical map

- 3327 BB East London, Fourth edition, 1998; scale 1:50 000

Previous Studies and documentation

- Risk Assessment Major Hazard Installation, MHR Consultants, 5 April 2009
- Risk Assessment Major Hazard Installation, MHR Consultants, 3 May 2012

- Progress Report, SRK Consulting, 14 June 2012
- HFO East London Soil and Groundwater Investigation, SRK Consulting, April 2013
- Port of East London Strategic Environmental Assessment Draft, Coastal & Environmental Services, December 2007
- East London Black Tank 19 Report, ECI, March 2014
- BP HFO East London, Soil and Groundwater Investigation, Report nr 449168, SRK Consulting, April 2013

2.6 Previous Studies

The main study that was referenced is the work done by SRK Consulting in 2012 and 2013.

Based on their investigation it was concluded:

- No strong odours or free phase were encountered during the augering or drilling except at one site;
- Soil samples from the three deep drilled wells (BPHFO1, BPHFO2 and BPHFO3) and from three shallow augered wells (BPHFO7, BPHFO9 and BPHFO11) plus a duplicate sample were taken;
- Soil samples were analysed for MTBE, BTEX and total petroleum hydrocarbons CWG,
- The results showed that all parameters were Below the Detection Limit (BDL) of the accredited laboratory, except for TPH which was present in the soil of monitoring wells BPHFO10 and BPHFO3.
- Water samples were taken from AH2, AH3, AH6, AH8, AH9, BPHFO7, BPHFO4, BPHFO5,
- BPHFO9, BPHFO1, BPHFO2 and BPHFO3;
- Water samples were analysed for MTBE, BTEX and total petroleum hydrocarbons CWG
- The results showed that all parameters were Below the Detection Limit (BDL) of the accredited laboratory.

From the results of the study it was stated in the report that the HFO site is free of significant contamination, but the areas where the HFO and AGO spills took place do contain TPH in the upper soil. In general, the shallow and deeper groundwater was found to be without detectable contamination.

It was further mentioned in the report that on 7 January 2012, prior to the study, the AGO diesel fuel line that leads to the East London Fuel Depot leaked diesel next to the HFO facility. Engen commissioned an investigation and the spill was attended to by SRK and Enviroserve. On 14 March 2012, SRK conducted a final Site assessment on the AGO spill. The initial work undertaken during the first phase formed part of the emergency response to the HFO and AGO releases. It entailed the containment and recovery of the free product in order to limit the extent and the impact on the surrounding environment. This was achieved with the assistance of Enviroserv, a remediation contractor. Reports were submitted on each of the incidents.

These reports were not available to the AGES team and conclusions could therefore not be made relating to where the spill took place and the likelihood of it occurring again.

The following additional study results and reports were made available to AGES:

East London Port Strategic Environmental Assessment – CES 2007

According to the East London Port Strategic Environmental Assessment (SEA) (CES 2007) the following are key environmental objectives for the port and key strategic environmental issues relevant to current and future projects. Various current and proposed projects were identified for the Port of East London. Again, the projects may be individually or collectively of strategic environmental importance particularly relating to the following aspects:

- Availability of suitable land where applicable;
- Risk of pollution and potential impacts on biodiversity;
- EIA requirements in terms of proposed activities;
- Existing contamination of site and possible need for site remediation;
- Applicability of TNPA environmental policies, principles and guidelines for port development and other requirements;
- Legal compliance and other legislative requirements (e.g. permits requirements); and
- International environmental guidelines

The continued utilisation and potential future development of the site will therefore need to comply with these strategic environmental issues and challenges to be in line with the SEA. The SEA did also highlight how industrial pollution entering the estuary needs to be minimised and it did also list the tank farm facilities and its associated pipelines as a high risk of ground pollution from petroleum products.

The following reports did not have the same terms of reference as this report, however were reviewed for content/relevance.

Risk Assessment In Terms of the Major Hazard Installation Regulations for BP Installations at Military Road, Gately, East London – MHR Consultants 2012

This report was for the nearby tank farm not the HFO site. Therefore could not be used as a basis for comparison to this study. It did however correctly state that during spills\incidents environmentally sensitive areas and water supplies must be protected from pollution.

Risk Assessment In terms of The Major Hazard Installation Regulations for BP East London Bulk Storage Facility – MHR Consultants 2014

Similar to the MHR 2012 report, this report was conducted for the nearby tank farm, not the HFO site. Therefore besides it not having the same terms of reference as this report, could not be used as a basis for comparison to this study. However it did state the following relating to environmental aspects:

"According to the NEMA act this any further developments on this installation requires that an Environmental Impact Assessment to be conducted before proceeding with construction."

Therefore TNPA just had to note that any further development of that tank farm site would result in an EIA study.

East London Black Tank 19 Report - ECI 2012

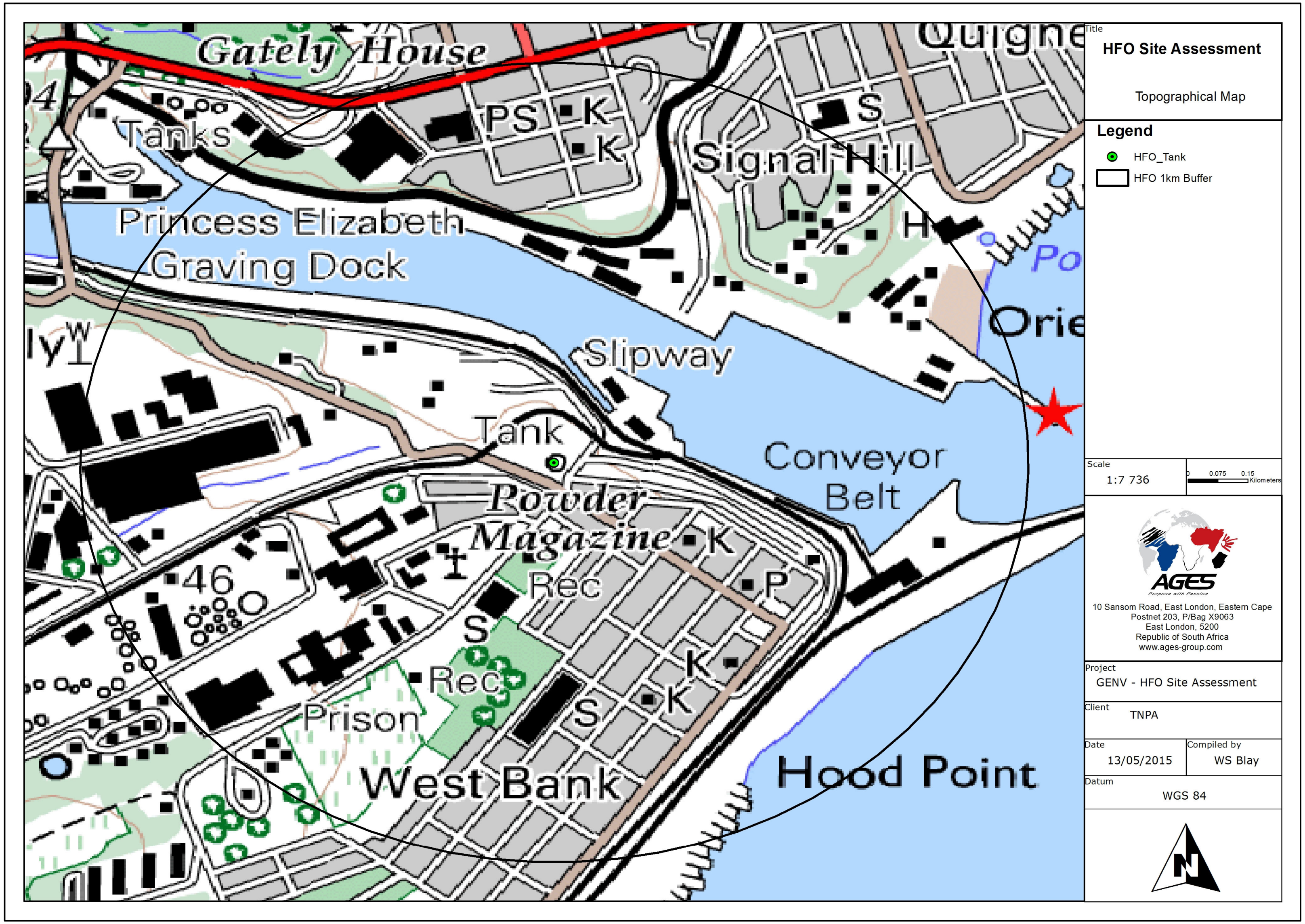
Lastly this report was relating to the HFO site, however was from an Engineering aspect and focused more on the condition of the facility, not on environmental aspects of the site.

2.7 Client Liaison

Project appointment was received from Ms. Nomasomi on the 27th of January 2015. This was also the date of the project introduction and inception meeting that was held to activate the project. The AGES technical team was inducted within the first 2 weeks of February to enable site surveys to commence as soon as possible.

The following dates of key activities are given as indication of project flow which was severely hampered by obtaining the necessary permissions for initial access to site and later for labourers for trial pit digging.

- 9 February 2015 - Request for team induction,
- 9 February 2015 – Team induction,
- 10 February 2015 - Request for site access,
- 16 February - Request for site access,
- 18 February 2015 – Progress report stating inaccessibility to the HFO Tank site is causing a delay,
- 23 February – Response from TNPA to information requested,
- 9 March 2015 - Site access granted, time and place confirmed,
- 10 March 2015 – HFO Tank site visit,
- 11 March 2015 – Progress report on site visit, one monitoring borehole not found, request for site clearing and request for detailed site layouts, coordination of labour for trial pit digging,
- 12 March 2015 – Follow up site investigation,
- 23 March 2015 – Resend request casual labour access to site for geotechnical trial pit digging
- 30 March 2015 – Resend request for casual labours
- 31 March 2015 – Confirm geotechnical site visit dates for trail pint digging
- 8 April 2015 – Induction of casual labour
- 6-8 April 2015 – Geotechnical site visit for trial pit digging,
- 10 April 2015 – Propose progress meeting with client at their boardroom
- 14 April 2015 – Second request for progress meeting with client at their boardroom
- 5 May 2015 – progress report on hydrogeological investigation done, lab results pending, soil sample results pending, report writing stage started, request for final documentations and site layouts,
- 02 June 2015 – Final draft report rendered
- 04 June 2015 – Presentation of final draft at TNPA office for discussion towards report finalisation



Map 1: HFO Tank Site Locality

Map 2: HFO Tank Site Locality

3 SITE DESCRIPTION

3.1 Hydrogeological setting

The regional geological setting of the project area was verified against the existing 1:250 000 scale geological map 3326 GRAHAMSTOWN. According to the geological map the site is underlain by Karoo Sequence lithologies consisting of grey and red mudstone and sandstone of the Middleton Formation. This formation forms part of the Adelaide Subgroup of the Beaufort Group. The geology map indicates the presence of an extensive dolerite sill intrusion directly south and to the west of the HFO tank site. The extent of this sill and other lithologies can be seen in MAP 3 and Figure 2.

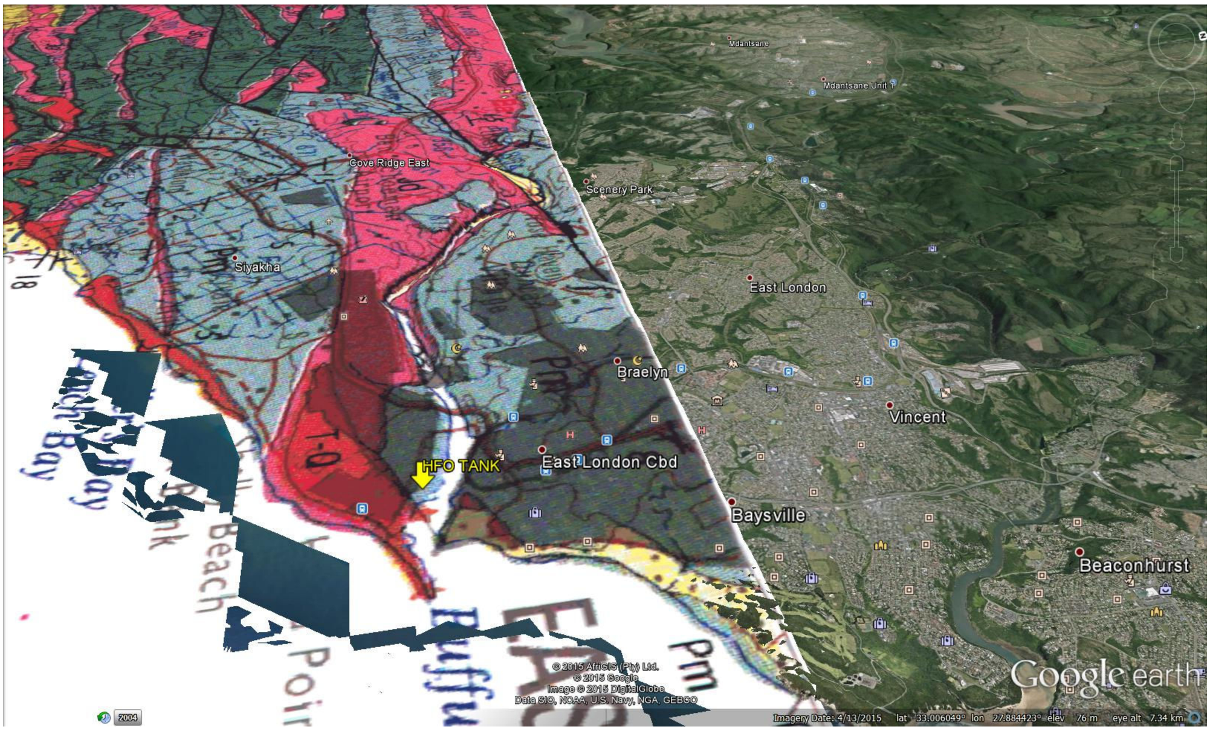


Figure 1: Extent of dolerite sill intrusion and regional faults

Younger deposits of Quaternary and Tertiary age cover the Karoo-aged rocks and dolerite towards the south of the site. Calcereous sandstone and sandy limestone of the Nanaga Formation of the Algoa Group can therefore be expected at the HFO site in varying thicknesses or where completely weathered, as sandy deposits. The main occurrence of this formation is shown in MAP 3 and Figure 1 where it is demarcated as T-Q.

The sandstone deposits that can be observed near the site are horizontally orientated with changes in mineralogy and texture, due to different depositional environments and proximity to the dolerite sill intrusion which has baked and altered it. This changing character can be noted as layers of different colour and texture as can be seen in Photo 1.

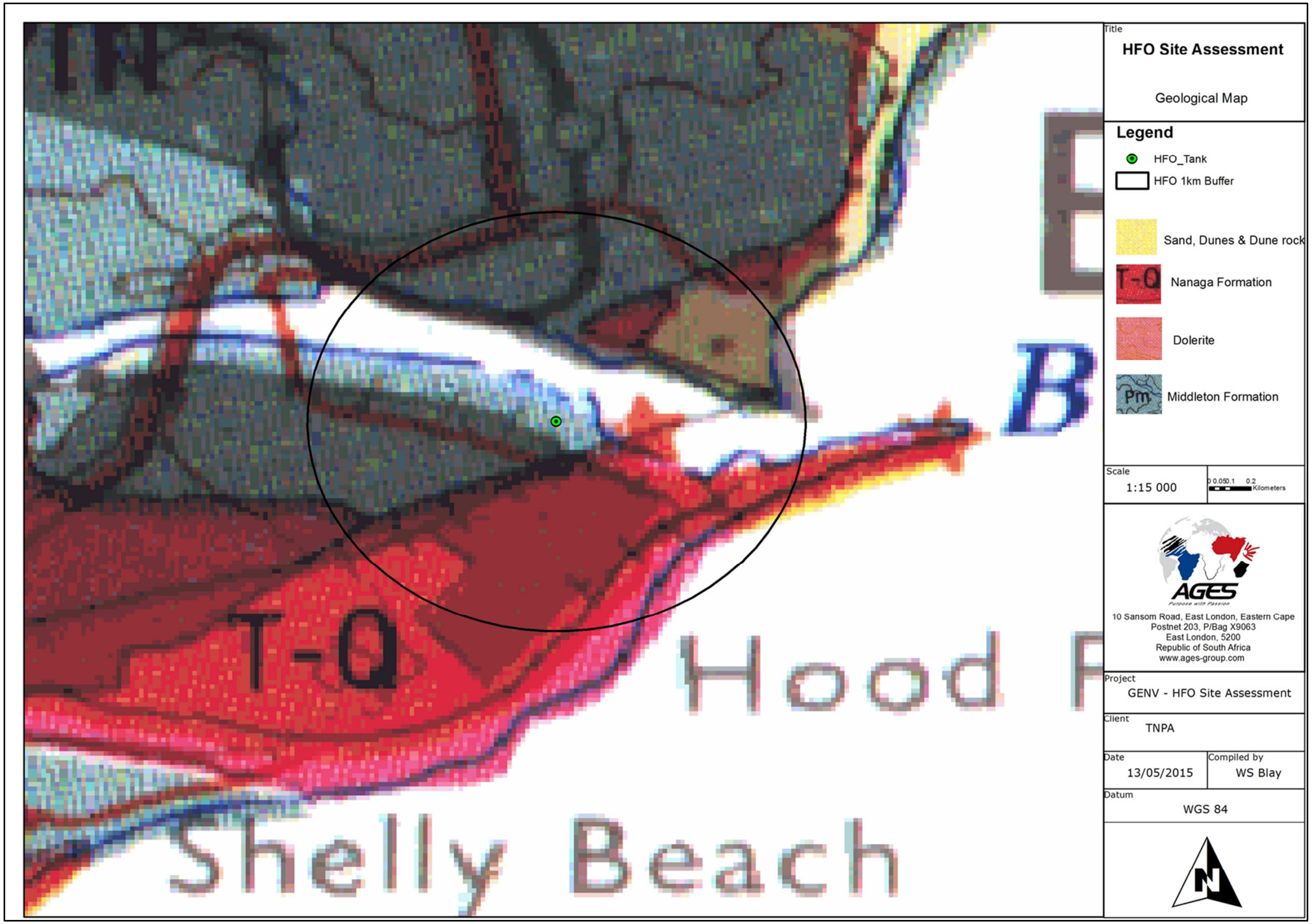
Photo 1: Layered sandstone exposure north of the HFO site

Numerous East-West trending faults occur in the region south of East London Harbour towards Kidds Beach. (Figure 1). These faults, which mostly dip to the north, have an intricate relationship with dolerite sill intrusion in the area and it is possible that such a fault forms the southern boundary of the dolerite sill that occurs south of the HFO tank site. It is not clear if the northern boundary of the dolerite sill is also due to faulting, but site observations have indicated the presences of NE striking vertical joint sets that could be associated with nearby faulting. Such structures can form preferential pathways for groundwater movement.

It was further observed that groundwater flow takes place along horizontal bedding planes where more resistive sandstone layers are encountered, hampering vertical infiltration along joints. (Photo 2).

Photo 2: Horizontal bedding planes showing signs of groundwater percolation below weathered zone

The area does not reflect any risk for the formation of sinkholes caused by the presence of water-soluble rocks such as dolomite or limestone because of the Nanaga formation not being extensive and thick in the study area. Minor subsidence could however be possible if structures are founded within the sandy limestone, that can be expected in places, and not on the more competent underlying sandstone and dolerite.



Map 3: Geological Setting

3.2 Topographical setting

The project area is located in the Quaternary Catchment R20G, within the Mzimvubu to Keiskamma Water Management Area. The site is drained by means of surface flow primarily in a north to northeasterly direction towards the Buffalo River, which forms the harbour mount located north of the site. The quaternary catchment has an average rainfall of 812 mm/a, and a stated groundwater recharge of 44.78 mm/a.

The site is located approximately 30 meters above mean sea level. Slope directions are indicated in Figure 5, where it can be seen that the site is located on a side slope with slope angles dipping towards the northeast. Based on the topography and surface water drainage directions it is expected that groundwater flow will mimic surface topography and is therefore expected to be in a northeast direction, from the HFO site towards the Buffalo River and harbour.

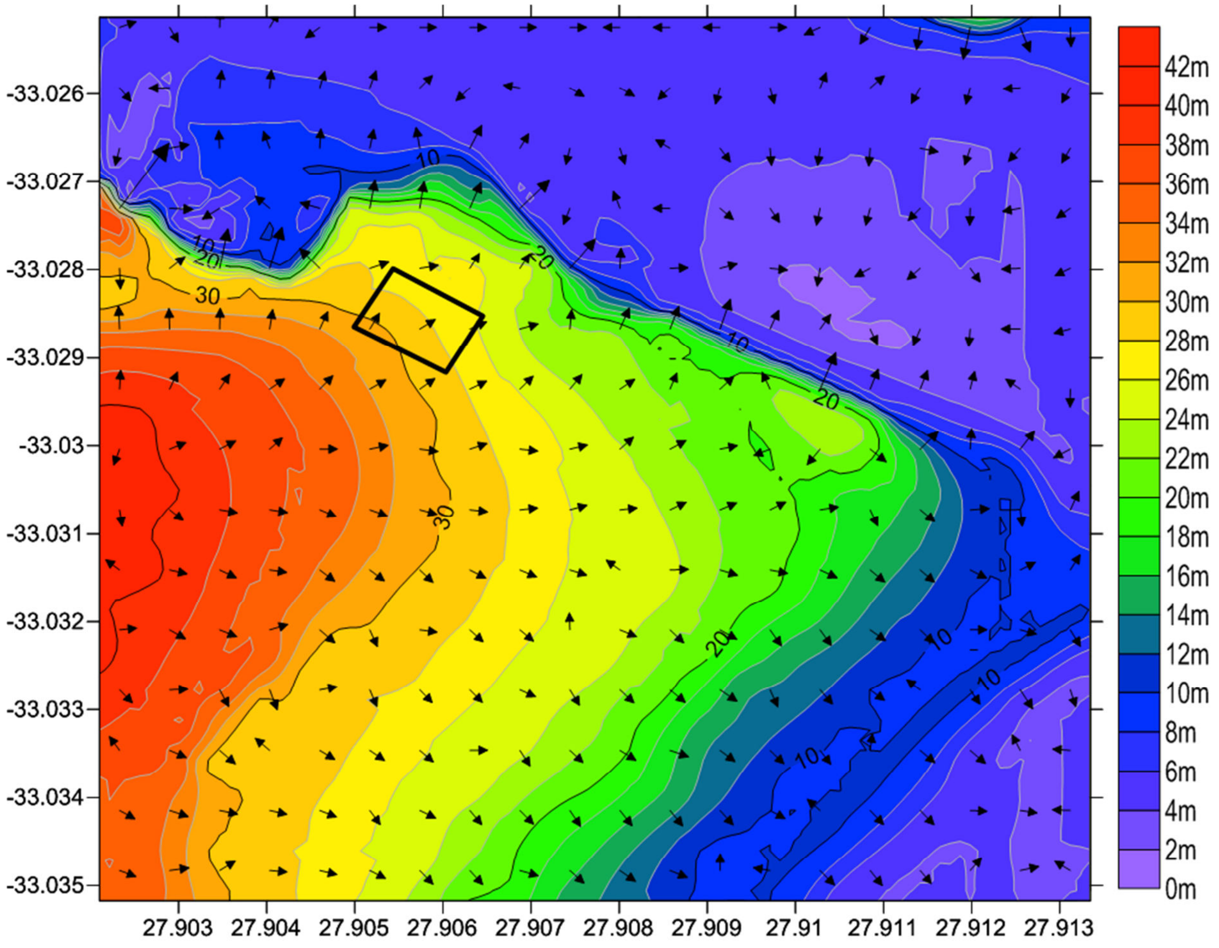


Figure 2: HFO site topography with 5 meter contours and Vector overlay

3.3 Environmental setting

Environmental considerations are central to any potential development and form a critical component in the Integrated Environmental Management (IEM) procedure. IEM is an approach that integrates environmental considerations into all stages of the planning and development process. Environmental considerations highlight key issues and potential fatal flaws at an early stage in any planning process, allowing decision makers to avoid such issues and plan accordingly. As an open and iterative process, it may continue throughout planning phase, depending on whether or not additional impacts or alternatives are introduced or eliminated because of new information.

Transnet National Port Authority (TNPA) currently wishes to assess the Heavy Fuel Oil (HFO) tank site and its neighbouring property as well its associated infrastructure, in terms of its environmental status quo and potential for future use. The site and its associated infrastructure were built in 1976 next to the railway line, in the industrial setting of the West Bank, Buffalo City Metropolitan Municipality, East London. It has historically being used to store bitumen as well as HFO. This environmental component of this report consists of a desktop review of existing ecological literature and environmental legislation, a site assessment and a way forward regarding any further environmental investigations/remediation actions which will need to be granted approval by relavant government department.

Although located in a developed industrial West Bank region of East London, the site borders the Buffalo River. Due to the Buffalo River's steep topography, portions of its indigenous riparian vegetation have remained relatively pristine. According to Mucina and Rutherford (2006 revised 2009) (MAP 4), the site is located on Buffels Thicket, as well as being located near the Albany Coastal Belt Vegetation units. A description of these two units is given below:

- Buffels Thicket, throughout Southern Africa, is classed as a vulnerable vegetation unit. With only 1% of this unit being statutorily conserved, Mucina and Rutherford (2006) set a target of 19% conservation required. This unit is best described as dominating steep Valley slopes, where short dense thicket stands reach 10m in height. 21% of this unit has already been transformed mainly by cultivation, urbanization and plantations. An additional 15% of this unit is in a degraded state.

- Albany Coastal Belt is classified as least threatened within Southern Africa, with only 1% of its entire coverage that is statutorily conserved. This vegetation unit is best described as short grassland punctuated by scattered bush clumps or solitary *Acacia natalitia* trees and occurs on gently to moderately undulating landscapes with dissected hilltop slopes close to the coast. Most of the vegetated areas of this unit in Southern Africa are secondary (result of overgrazing by cattle and anthropogenic influences).

Both of these vegetation units have are known to contain protected species.

Map 4: Vegetation map of the HFO site

3.3.1 Known protected species

Coastal habitat is under threat in South Africa from development and as a result of which, remaining habitat often contains several protected species. According to the South African National Biodiversity Institute: Integrated Biodiversity Information System (SANBI: SIBIS) (database accessed on the 17/02/2014), within the quarter degree square of the property there are 516 animal and 976 plants species known to occur within the region. According to the database however only 10 plant species are protected under International and National Environmental Management Biodiversity Act (NEMBA) legislation (Table 1). The international legislation includes the International Union for Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species (CITES) lists. Nationally the database makes use of the NEMBA species lists. A limitation of this system is though that other species lists such as those produced by the Department of Agriculture Forestry and Fisheries (DAFF) is not on this database. It is however still useful to act as a guide.

Table 1: A list of protected species known to occur within the quarter degree square of the region (SANBI: SIBIS)

Category	Family Name	Species Name	IUCN	CITES	NEMBA
Plants	AMARYLLIDACEAE	*Clivia nobilis*	VU		
Plants	AMARYLLIDACEAE	*Crinum moorei*	VU		
Plants	ANACARDIACEAE	*Searsia albomarginata*	CR		
Plants	FABACEAE	*Umtiza listeriana*	VU		
Plants	ISOETACEAE	*Isoetes wormaldii*	CR		
Plants	RHIZOPHORACEAE	*Cassipourea flanaganii*	EN		

Category	Family Name	Species Name	IUCN	CITES	NEMBA
Plants	STANGERIACEAE	*Stangeria eriopus*	VU		
Plants	ZAMIACEAE	*Encephalartos altensteinii*	VU	Appendix I	PR
Plants	ZAMIACEAE	*Encephalartos latifrons*	CR	Appendix I	CR
Plants	ZAMIACEAE	*Encephalartos villosus*		Appendix I	PR

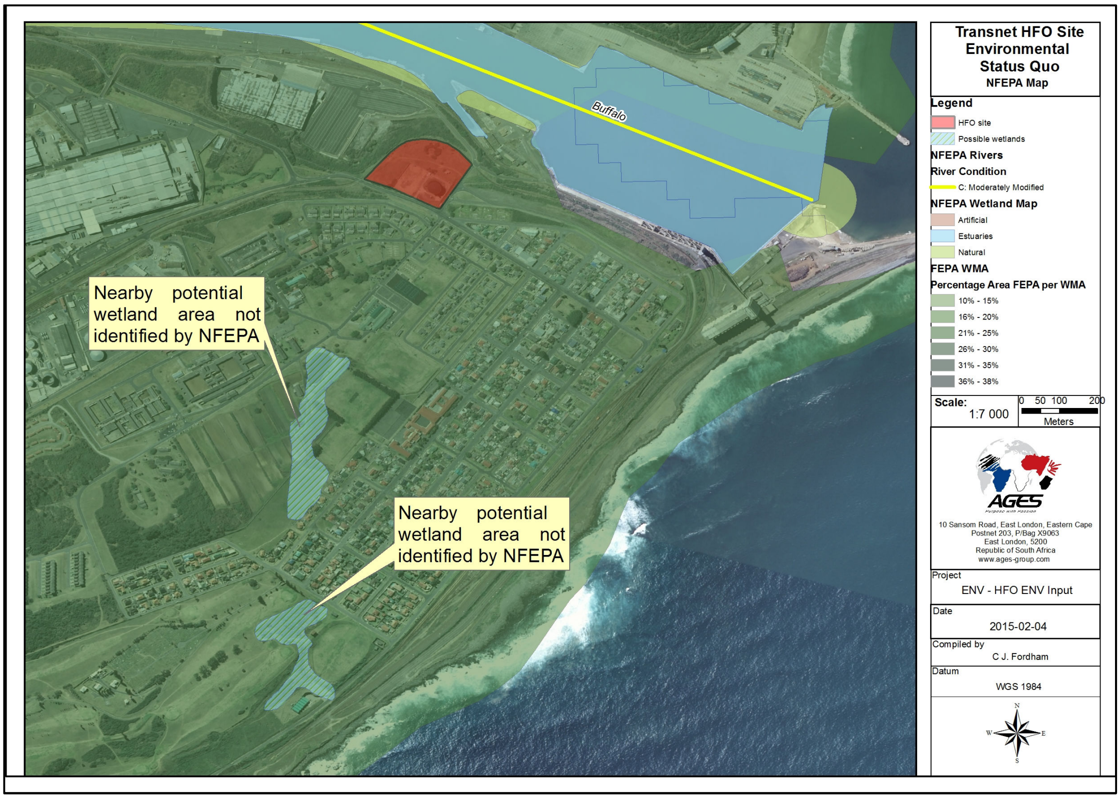
VU = Vulnerable CR = Critically Endangered PR = Protected

3.3.2 Conservation plans

The number of protected species found within a vegetation unit does influence conservation plans for the unit/region. Various conservation plans have been compiled to achieve biodiversity targets for South Africa. These plans are based on an array of literature which has delineated known sensitive ecosystems of high conservation value that need to be protected.

3.3.2.1 National Freshwater Ecosystem Priority Areas project (NFEPA (2011)

Aquatic systems are amongst the most threatened and sensitive ecosystems and are under the most pressure from a development aspect. The most recent literature which attempts to delineate sensitive wetlands in South Africa is the National Freshwater Ecosystem Priority Areas NFEPA (2011). Construction activities near/on wetlands or drainage lines often require approval from the relevant government department to proceed. It remains a challenge to remotely determine if wetlands are present (without a field visit) and according to NFEPA there are no known wetlands to occur on the property, but there are at least two possible wetland systems in the region (MAP 5). The nearest one is associated with a small non-perennial stream. However as can be seen from MAP 6, the property drains into the NFEPA delineated Buffalo River estuary. NFEPA (2011) has classified the Buffalo River as “Class C: Moderately Modified”. This score can be primarily attributed to the amount of development that has taken place within the Buffalo River catchment and the presence of the East London Harbour, Bridal Drift and Laing Dams changing the hydrological regime of the system. The region is also classed as only having 18% of its area classed as Freshwater Ecosystem Priority Area (FEPA), which is a moderately low score. Despite these relatively low scores, all South African estuaries play large roles in terms of ecological importance are classified as regions of paramount importance in terms of conservation plans and systems.



Map 5: The NFEPA classification of the property and its surrounds, showing the location of possible wetlands not identified in NFEPA (2011).

Map 6: The NFEPA classification of the property and its immediate surroundings.

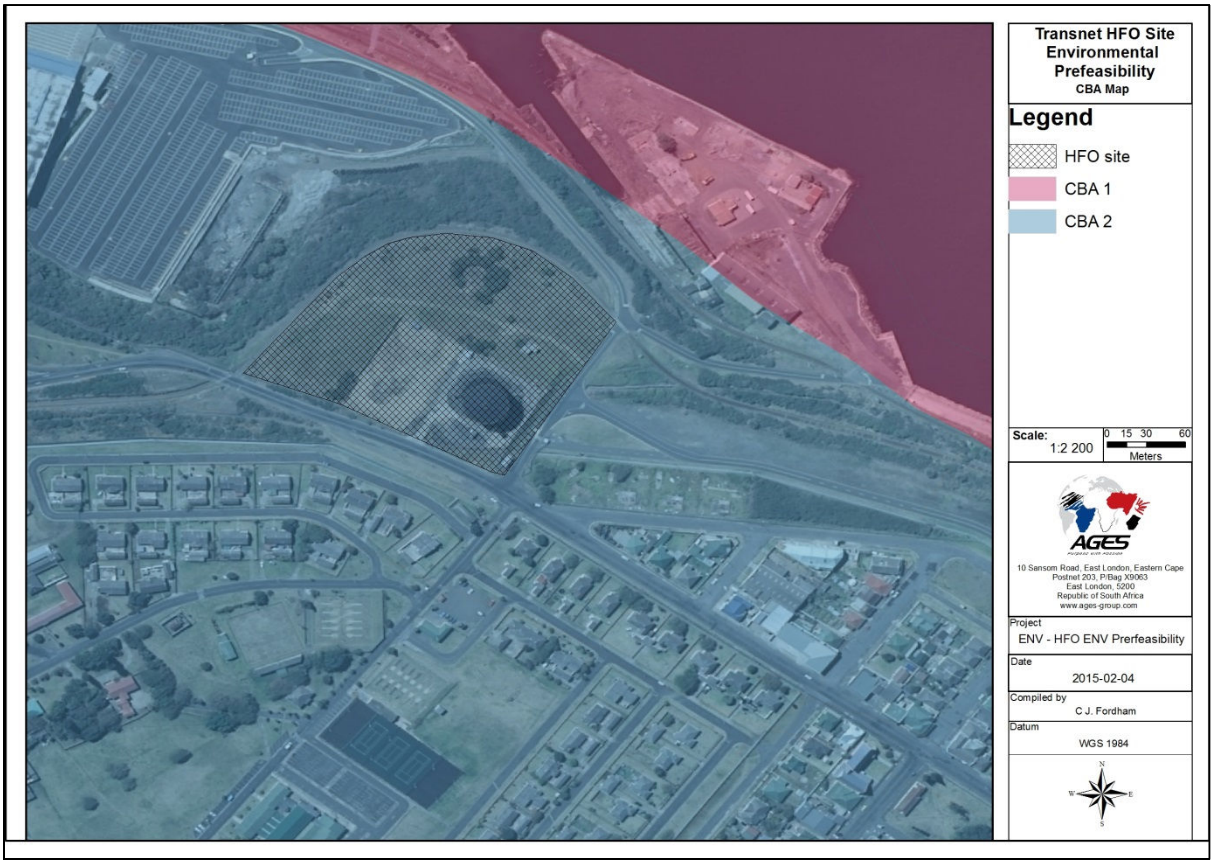
3.3.2.2 Eastern Cape Biodiversity Conservation Plan ECBCP (Berliner and Desmet 2006)

The Eastern Cape Biodiversity Conservation Plan ECBCP (Berliner and Desmet 2006) is another study that was conducted to delineate sensitive regions within the Eastern Cape. It designed a conservation network, connecting known sensitive regions known as Critical Biodiversity Areas (CBA) (Berliner and Desmet 2006).

Berliner and Desmet (2006) classified these areas as:

- **CBA 1 - Critically endangered:** Habitat that has been transformed to such an extent that the remaining habitat is less than that required to present 75% of species diversity, in other words one would expect species loss to take place in such vegetation types.
- **CBA 2 - Endangered:** These habitats have lost 40% of their original extent and are exposed to partial loss of ecosystem function.
- **CBA 3 -Vulnerable**: Habitats that have lost up to 20% of their original extent, which could result in some ecosystem function being altered.

Within CBA regions and corridors the ECBCP study concluded that any development should be restricted or undergo suitable Environmental Impact Assessment processes. According to the ECBCP the property falls within a CBA 2 region, however it is located near the CBA 1 classed Buffalo River estuary (MAP 7).



Map 7: CBA map of the map of the HFO site.

3.3.2.3 National Environmental Management Biodiversity Act (Act 10 of 2004) Threatened Ecosystems

Similarly to the ECBCP, the National Environmental Management Biodiversity Act (Act 10 of 2004) has its own list of threatened ecosystems which require suitable Environmental Impact Assessment processes for development approval. According to NEMBA there are no threatened ecosystem regions located in the vicinity of the project area. The National Environmental Management Act (Act 107 of 1998 revised 2014) recognised the importance of conserving these areas and has outlined stricter guidelines regarding the extent of development within both the ECBCP CBA and NEMBA Threatened Ecosystems regions.

3.3.2.4 Buffalo City Metropolitan Municipal Open Space System (MOSS)

In addition to both of these frameworks Buffalo City Metropolitan developed a Municipal Open Space System (MOSS). The BCM MOSS plan was developed to align the municipality with various national conservation plans. According to the BCM MOSS the property is dominated by thicket mosaic and has a high conservation priority, although is susceptible to alien encroachment.

All of these aspects are used as a background to when conducting field assessments of the property to determine the ecological sensitivity.

3.3.2.5 Ecological Sensitivity Assessment

The ecological sensitivity assessment uses the environmental literature review of vegetation units and conservation plans as a guide for determining the current Ecological sensitivity of the habitat present on a site. The following is a list of Ecological Sensitivity classes and a description of how they were determined:

- **High Sensitivity** – sensitive ecosystem with either low inherent resistance or low resilience towards disturbance factors or highly dynamic systems considered being important for the maintenance of ecosystem integrity. Most of these systems represent ecosystems with high connectivity with other important ecological systems or with high species diversity and usually provide suitable habitat for a number of threatened or rare species. These areas should be protected or developed with strict mitigation measures\specialist input.
- **Medium Sensitivity** – These are slightly modified systems which occur along gradients of disturbances of low-medium intensity with some degree of connectivity with other ecological systems or ecosystems with intermediate levels of species diversity but may include potential ephemeral habitat for threatened species; and
- **Low Sensitivity** – Degraded and highly disturbed / transformed systems with little ecological function and are generally very poor in species diversity.

The Ecological Sensitivity Assessment of the site will provide a framework to TNPA regarding how the site could potentially be developed, however any development will still be subject to South African Environmental Legislation.

3.3.3 Environmental Legislation

Any construction process should follow the Integrated Environmental Management principles as stipulated under the National Environmental Management Act (NEMA Act No. 107 of 1998). To ensure that all legislative requirements and processes are adhered during the environmental authorisation process a summary is provided hereunder. It should be noted that this section assumes that all relevant authorisations for the current buildings and infrastructure have already being obtained from the various authorities. It is mainly tasked with informing TNPA of the relevant authorisation and process it would have to undertake should further development be considered.

3.3.3.1 National Water Act (Act No. 36 of 1998)

The Department of Water Affairs (DWA) is the responsible authority that governs all requirements as set out in the National Water Act, Act no 36 of 1998 (NWA). The NWA requires that a water use must be licensed unless it is listed in Schedule I of this act, as an existing lawful use, or is permissible under a general authorisation, or if a responsible authority waives the need for a license. All water uses are listed in Section 21 of the NWA. Listed water uses that may be impacted and may need authorisation are: the taking of water, changing of characteristics to the banks of rivers, impeding structures in rivers, diverting the flow of a river and the discharge of material into water resources. Should any future development result in the destruction of the small dam on site, DWA authorisation for dam destruction will be required. Depending on the findings of the Geohydrological section of this report, DWA would also need to be notified of any groundwater contamination by the facility.

3.3.3.2 National Environmental Management Waste Act (Act No. 59 of 1998)

National Department of Environmental Affairs (DEA) is the custodian of the National Environmental Management Waste Act (NEMWA) (Act 59 of 1998), which classifies waste into numerous categories. NEMWA was revised in 2009, but this revision excluded Part 8 of Chapter 4 dealing with contaminated land. On the 2nd of May 2014 (revised again on the 2nd of June 2014), this section came into operation. NEMWA now defines “contaminated” in relation to land as:

“the presence in or under any land, site, buildings or structures of a substance or micro-organism above the concentration that is normally present in or under that land, which substance or micro-organism directly or indirectly affects or may affect the quality of soil or the environment adversely”.

This definition of contaminated means that, it is likely numerous industrial sites as across the country could be defined as contaminated land. The obligation then falls on the landowner (or the person that undertook the activity to cause the contamination), to notify the Minister of Environmental Affairs and Provincial Minister of the Executive Council (MEC) of Environmental Affairs of the possible contamination. The act also states that it doesn’t matter when the actual act of contamination took place.

Following receiving notification of contamination, the minister or MEC will then identify the area as being contaminated and will direct the applicant in writing in terms of remediation measures and the way forward for the property. Normally this in the form of the minister or MEC instructing the applicant to compile a Site Assessment Report, the content is of which is outlined in the act. Based on the findings of the Site Assessment Report, the minister or MEC will decide if the area must be remediated or not. Details of the minister or MEC’s decision will be contained issued Remediation Order document and the cost of remediation will be to the applicant.

It should also be noted that according to NEMWA section 40 (1) transfer of ownership of contaminated land may not take place without informing the new owner of status of the land and without notifying the minister or MEC of the proposed transfer of contaminated land to new ownership. The Minister or MEC may then stipulate conditions of transfer that need to be completed prior to transfer. Penalty provisions are stipulated in the act, should the landowner choose not to comply with NEMWA Section 40(1). Owners of potentially contaminated land or persons undertaking activities that have the potential to contaminate land are advised to take note of the operation of the Contaminated Land Provisions particularly the issues discussed above.

Other than the issue of if the land is contaminated is the fact that a portion of the land is undeveloped and therefore a potential future client may wish to develop this property to deal with waste. NEMWA categories of waste applicable for this development are the general, hazardous and inert waste. The HFO tank has been on site for many years and should already be registered as a hazardous waste storage unit. However depending on the findings of the Geotechnical and Groundwater portions of this report, the client may need to inform National DEA if the site is contaminated or not. Following which they may need to undertake that process of remediation. In addition to these aforementioned processes, future prospective clients may wish to develop the remainder of the site and depending on the activity, a listed activity under the National Environmental Management Waste Act (Act No. 59 of 1998) could be triggered.

3.3.3.3 National Heritage Resources Act (Act No. 25 of 1999)

The South African Heritage Resources Agency (SAHRA) and their provincial offices aim to conserve and control the management, research, alteration and destruction of cultural resources of South Africa. It is therefore vitally important to adhere to heritage resource legislation at all times. The National Heritage Resources Act (Act No. 25 of 1999, section 38) proceeds to outline when a heritage specialist should be consulted and conduct an Archaeological Impact Assessment (AIA) of the site. Should prospective clients wish to develop an area greater than 5000 m^2 of the property the respective heritage authority will need to be notified. In addition to which, should it be determined that any of the current buildings on site be older than 60 years, a permit of destruction will need to be applied for with the heritage resource authority. However it is likely that developing the site and destroying the building only triggers ECHRA notification. The following is an abstract from the NHRA (Act 25 of 1999) relating to when they require notification:

Heritage resources management

38. *(1) Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as—*

> *(a) the construction of a road, wall, powerline, pipeline, canal or other similarform of linear development or barrier exceeding 300m in length;*
>
> *(b) the construction of a bridge or similar structure exceeding 50 m in length;*
>
> *(c) any development or other activity which will change the character of a site—*
>
> > *(i) exceeding 5 000 m^2 in extent; or*
> >
> > *(ii) involving three or more existing erven or subdivisions thereof; or*
> >
> > *(iii) involving three or more erven or divisions thereof which have been consolidated within the past five years; or*
> >
> > *(iv) the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority;*
>
> *(d) the re-zoning of a site exceeding 10 000 m2 in extent; or*
>
> *(e) any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority,*

3.3.3.4 National Environmental Management: Integrated Coastal Management (Act 24 of 2008)

The National Environmental Management Integrated Coastal Management Act (NEM: ICMA) (Act 24 of 2008) was composed to protect sensitive coastal regions from irresponsible development:

"Implicit in the above purposes is the need to ensure that the development and use of natural resources in the coastal zone is socially and economically justifiable, as well as being ecologically sustainable."

The act defined several regions within the vicinity of the South African coastline. This study area falls within 100m of the estuary; therefore can be defined as falling within the Coastal Protection Zone. This zone was designed to protect coastal ecosystems and therefore it is likely that environmental authorisation from the relevant competent authority will be required prior to additional development taking place on the property outside of the HFO compound.

3.3.3.5 National Environmental Management Act (Act No. 107 of 1998)

NEMA (Act 207 0f 1998) has a significant chapter (Chapter 7), dealing with Compliance, Enforcement and Protection of the Environment Duty of Care Principals outlined in Chapter 7 Section 28 (1) of the Act which states:

> *"Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonable be avoided or stopped, to minimise and rectify such pollution or degradation of the environment."*

In addition to TNPA having to comply with the Duty of Care Principals regarding the property, According to the ECBCP (Figure 2), the study area falls within a CBA 2 region. Given the prospect of a client developing the site, the National Environmental Management Act (NEMA Act No. 107 of 1998) Environmental Impact Assessment (EIA) Regulations (December 2014) indicates that the proposed activity is a listed activity in terms of Government Notice R 983, of 2010. The following listed activity can possibly be triggered:

GNR 983 – Listing Notice 1

- **Activity 19 –**The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 5 cubic metres from

  (i) a watercourse;

  (iii) the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater.
- **Activity 34 –**The expansion or changes to existing facilities for any process or activity where such expansion or changes will result in the need for a permit or licence or an amended permit or licence in terms of national or provincial legislation governing the release of emissions or pollution, excluding-

  where the facility, process or activity is included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the National Environmental Management: Waste Act, 2008 applies;

GNR 984 – Listing Notice 2

- **Activity 5 –** The development and related operation of facilities or infrastructure for the refining, extraction or processing of gas, oil or petroleum products with an installed capacity of 50 cubic metres or more per day, excluding -
  - (i) facilities for the refining, extraction or processing of gas from landfill sites; or
  - (ii) the primary processing of a petroleum resource in which case activity 22 in this Notice applies.
- **Activity 22 –** Any activity including the operation of that activity associated with the primary processing of a petroleum resource including winning, extraction, classifying, concentrating, water removal, but excluding the refining of gas, oil or petroleum products in which case activity 5 in this Notice applies.

GNR 985 – Listing Notice 3

- **Activity 10 –** The development of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of 30 but not exceeding 80 cubic metres.
  - b) In Eastern Cape:
    - iii. In urban areas:
      - (cc) Within 500 metres of an estuarine functional zone.

- **Activity 12–** The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan.
  - a) In Eastern Cape,
    - ii. Within critical biodiversity areas identified in bioregional plans;
    - iii. Within the littoral active zone or 100 metres inland from high water mark of the sea or an estuarine functional zone, whichever distance is the greater, excluding where such removal will occur behind the development setback line on erven in urban areas;

- **Activity 22–** The expansion of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage facilities or infrastructure will be expanded by 30 cubic metres or more but no more than 80 cubic metres.
  - (b) In Eastern Cape:
    - iii. In urban areas:
      - (dd) Within 500 metres of an estuarine functional zone

Therefore according to NEMA developing the site is likely to trigger a Scoping and Environmental Impact Assessment or a Basic Assessment Report. However, this will need to be confirmed following liaison with the prospective client and the nature of the proposed development. In addition to which any potential land contamination falls under the NEMA Duty of Care Principal. Therefore according to NEMA, should the Geotechnical and Groundwater specialist studies confirm contamination, remediation measures will need to be implanted by TNPA.

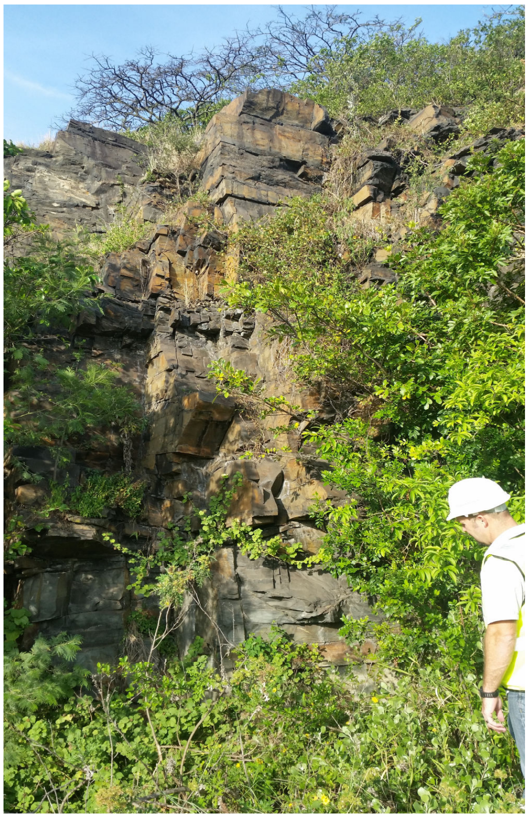
4 RESULTS

4.1 General

The AGES team followed an integrated geo-environmental approach during the assessment and specialists conducted studies and field visits together to ensure that all aspects that need to be covered in the investigation are included and integrated. (Photos 3 & 4).

Results are reported based on the different specialist inputs that were given for the following four different geo-environmental disciplines:

- *Hydrogeological Site Characterisation*
- *Geotechnical Site Characterisation*
- *Environmental Site Characterisation*
- *Socio-Economical Site Characterisation*

	
Photo 3: Groundwater level measurement at BP HFO2	Photo 4: Structural geological assessment

4.2 Hydrogeological Site Characterisation

4.2.1 Structural Geology

Evaluation of rock outcrops west, north and north-east of the TFO tank site was possible due to historical excavations associated with the harbour port development. Not only could the geology type be verified, but also dip and strike directions of sedimentary layers and joints.

According to the published geological map, the dolerite sill contact (depicted by the orange line in Figure 12) should occur approximately 170m south-east of the HFO site. Site surveys have shown that this contact is not present where the map indicates and is more probably located 570m away as indicated by the red line in Figure 12. Taking an expected northerly dip angle of 15º into account, it is unlikely for the dolerite sill to occur at shallow depths below the HFO site as was reported in earlier studies.

Observations and measurements of strike and dip directions in rock exposures around the site have indicated that the general strike direction of the main joint set that occurs is parallel to the ENE line on which the dolerite outcrop is found. This suggests that there is possible faulting present closer to the dolerite sill contact as well as within the sandstone host rock. Such structures could be preferential flow paths for groundwater. The main ENE strike direction of joints and possible secondary faults is indicated in Figure 3 as yellow lines.

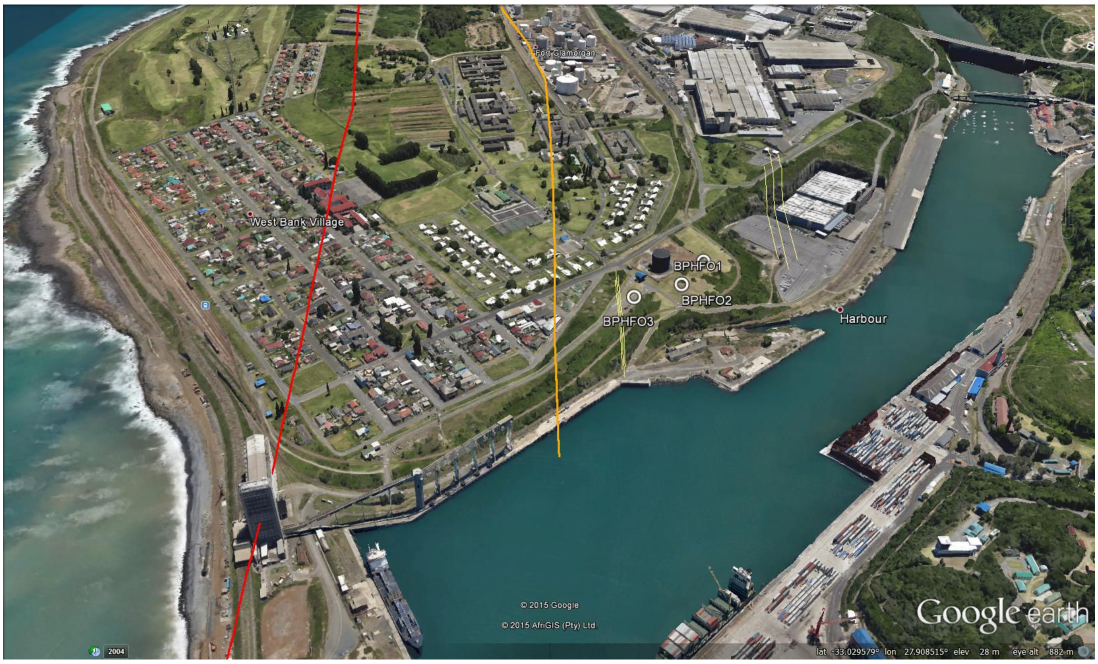


Figure 3: Predicted vs actual Dolerite sheet contact and joint directions

	
Photo 5: ENE striking joints and faulting near the site	Photo 6: ENE striking joints and faulting near the site

Outcrops 200m east of the site show the character of vertical joint sets that can be fault related and which can form preferential flow paths for groundwater. (Photos 5 & 6).

4.2.2 Conceptual Groundwater Flow & Contaminant Transport Model

A conceptual groundwater model was constructed from geological maps, site mapping and historical reports.

A section NNW section drawn as indicated in Figure 15 - perpendicular to the strike direction of the underlying geology and expected dolerite outcrop. The sharp drop towards the harbour excavations can be seen in the northern part of the section.

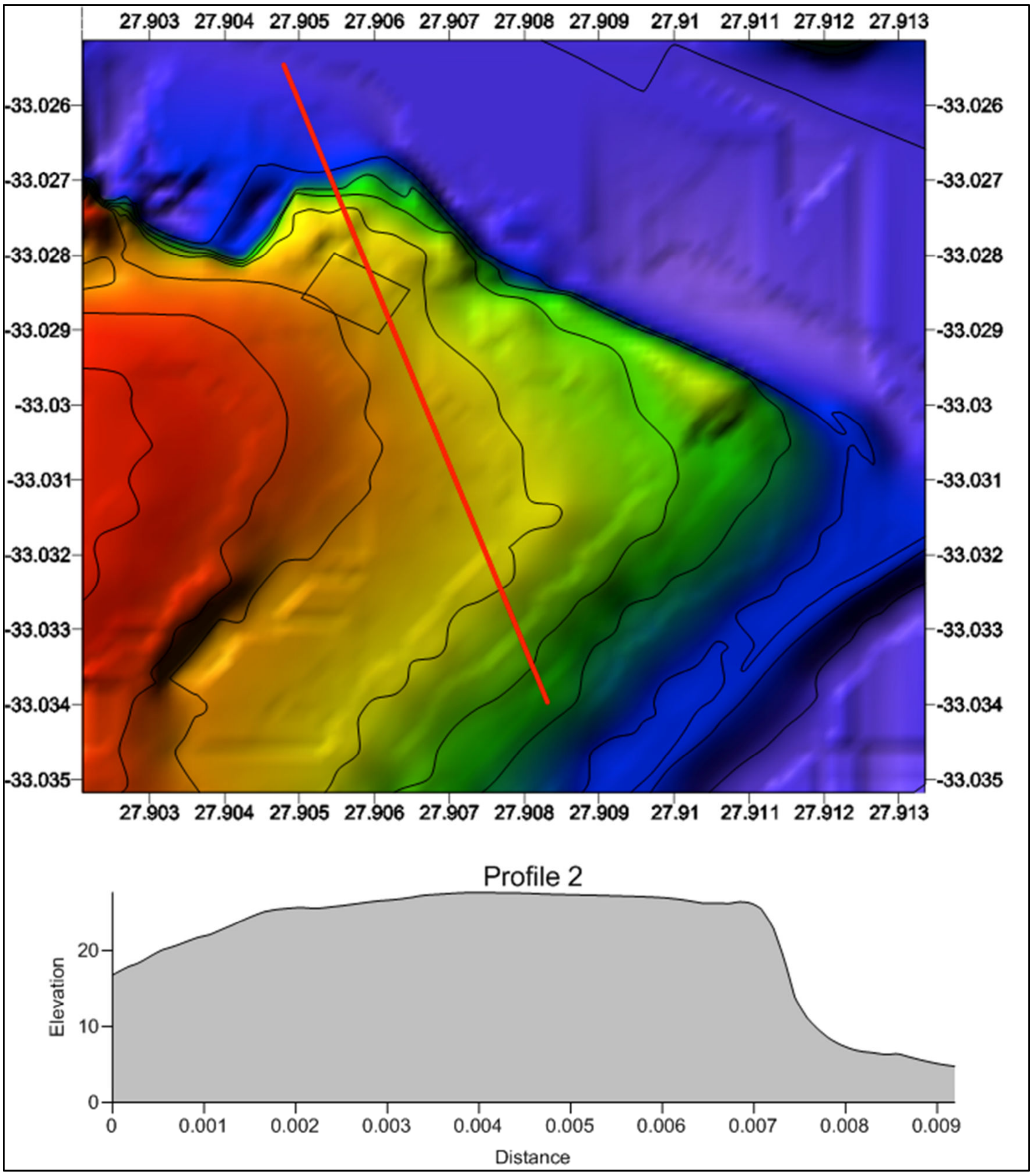


Figure 4: Orientation of conceptual model

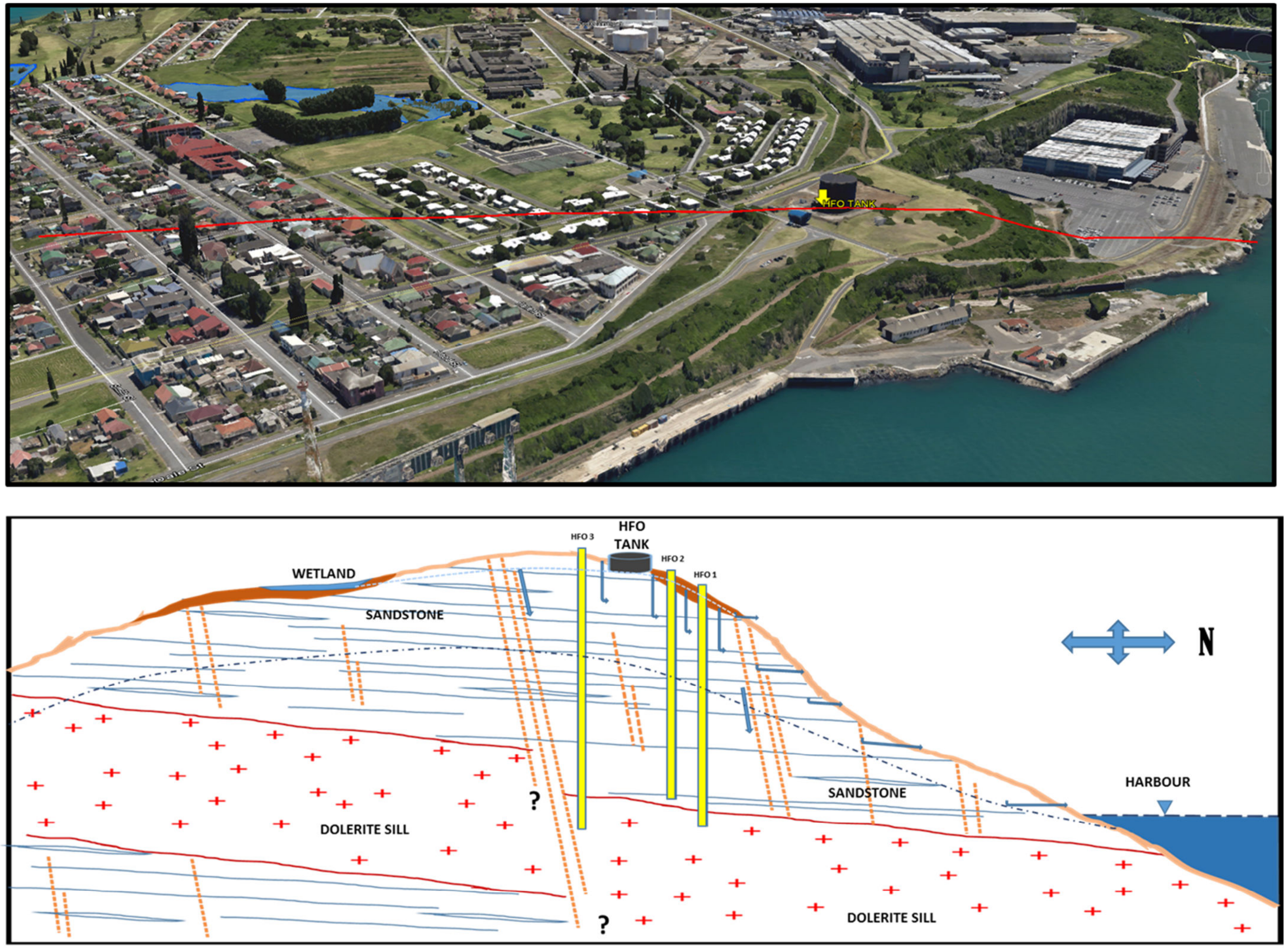


Figure 5: Conceptual hydrogeology (*Not to scale – Vertical scale exaggerated*)

In the conceptual model it is indicated that although it was reported in previous studies that some boreholes penetrated dolerite as shallow as 3m, it is impossible for dolerite to be present within the first 30 m. Baked and altered dark grey quartzitic sandstone was most probably difficult to distinguish from dolerite during the drilling process. It is however likely that dolerite was intersected in depth and it is indicated as such in the conceptual model. (Figure 5).

Perched groundwater within the sandy topsoil and weathered sandstone can be expected at 1.7 mbgl. This perched groundwater level is expected to be associated with the wetland that is found approximately 400m south of the site where it has probably developed within unconsolidated weathered Nanaga Formation sediments. It is assumed that sandy soils found directly north of the HFO tank are also associated with these unconsolidated weathered Nanaga Formation sediments.

The static groundwater level within the fractured bedrock is expected at 8.8 mbgl as indicated in the conceptual model. As indicated earlier in the report, this groundwater level is expected to mimic the surface topography, with flow being in a northerly direction towards the harbour. As indicated, the HFO site is located very close to the crest of the groundwater table. This means that should excessive groundwater abstraction take place south of the site, groundwater gradients may change and flow can be towards the south. The hydrocensus has however not shown any boreholes to be present in this area and flow is therefore expected to remain natural and towards the Buffalo River and harbour.

Illustrated in the model is the expected groundwater flow within the perched shallow aquifer as well as vertical flow along joint sets that were observed on site. It is expected that most of this flow will be from the perched shallow aquifer along vertical joints until it intersects resistive horizontal bedding planes. This is clearly visible in outcrops as reported earlier and repeated here in Photo 7.

Photo 7: Visual indication of groundwater flow and seepage from horizontal bedding planes

4.2.3 Geophysical Survey

A total of five geophysical profiles were conducted on site as indicated in Figure 6 in order to identify possible geological structures in the underlying formations below the HFO tank site and its surrounds. The profiles 1, 4 & 5 were conducted utilising an EM34 frequency domain electromagnetic instrument and a magnetometer and profiles 2 and 3 were conducted using only a magnetometer.

Figure 6: Geophysical surveys conducted on site

Geophysical profile HFO1 starts at HFO 1a and ends at HFO 1b. The EM 34 profile indicates shallow weathering associated with fractures at 167m and 205m from the start of the profile. (Figure 7) The weathering is in association with a less weathered geological structure at 185m from the start of the profile. There is a strong correlation between the magnetometer and EM 34 geophysical data at 185m from the start of the profile, indicative of fractured rocks on either side of a geological structure. Borehole BP HFO 03 that could not be found on site, was probably drilled in close proximity to the fracturing in profile 1 but will need to be verified if its location can be confirmed. The fracturing is expected to be further east of this unidentified borehole.

Shallow weathering was noted in profile HFO 4 at approximately 32m from the start of the profile. (Figure 10). The weathering does not correlate to a magnetic anomaly and is expected to be in the unconsolidated sandy material above the bedrock.

Profile HFO 5 indicates the presence of sand as encountered and described in the geotechnical section of the report as well as deeper fracturing noted in the sedimentary outcrops north of the tank. (Figure 11).

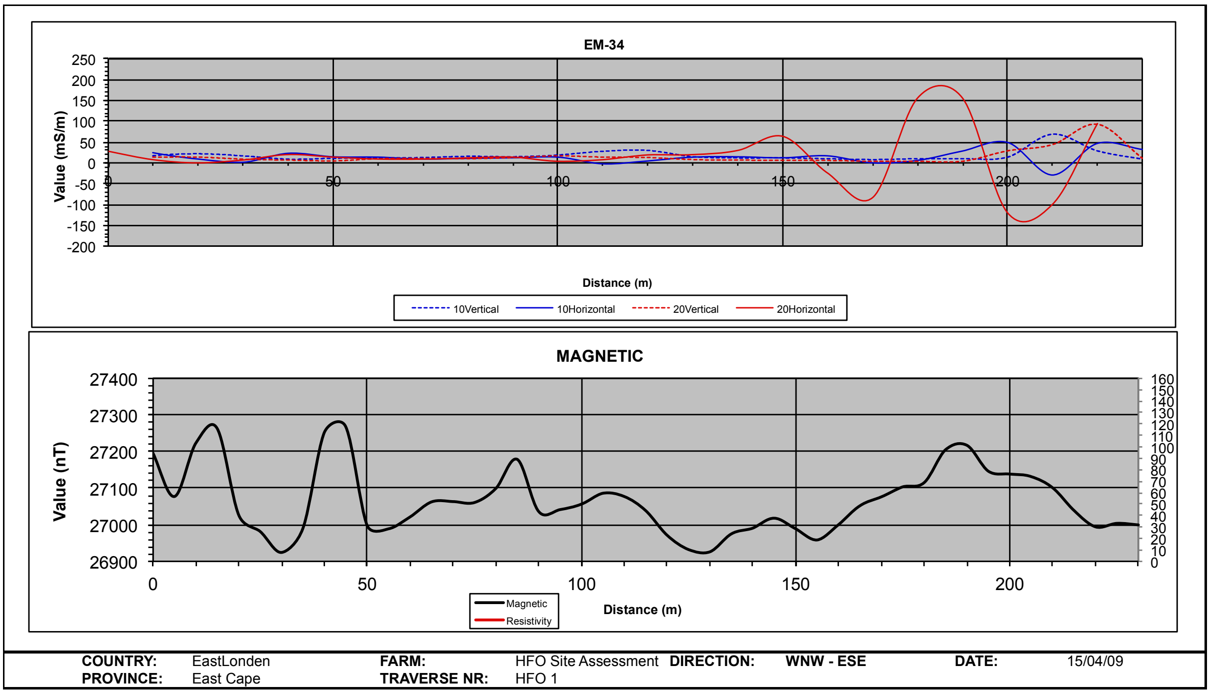


Figure 7: Geophysical profile HFO 1 – EM 34 & Magnetometer

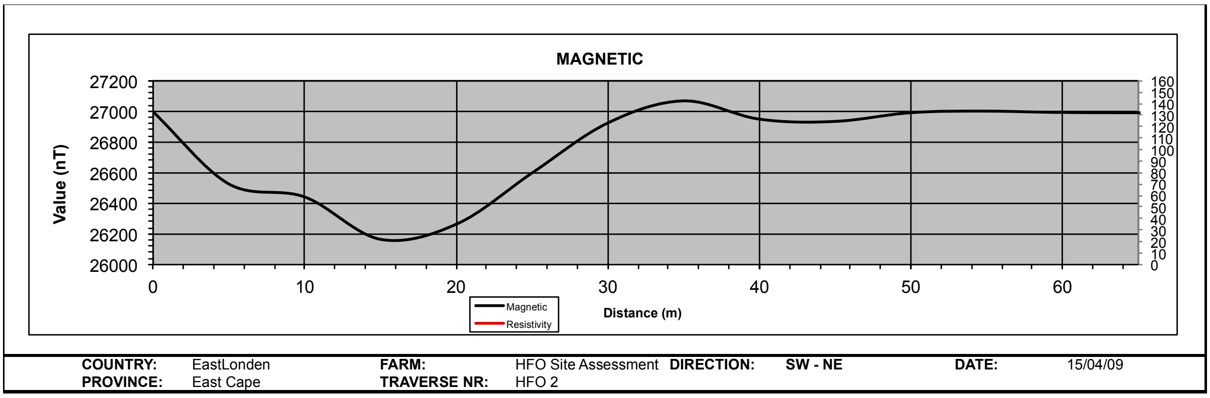
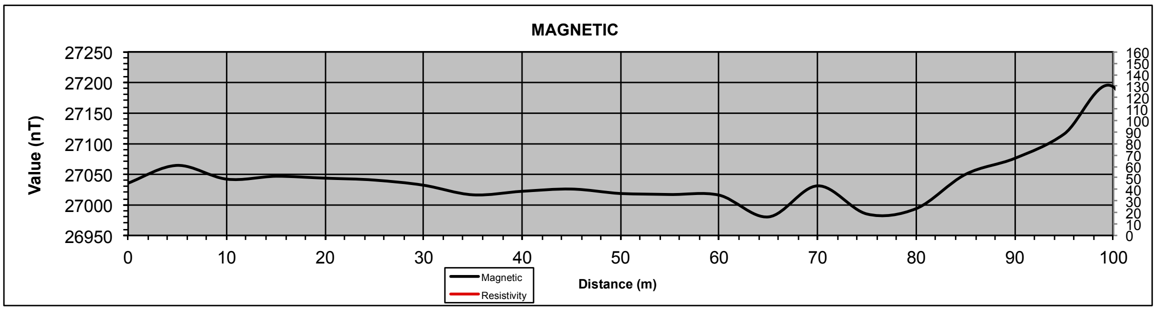
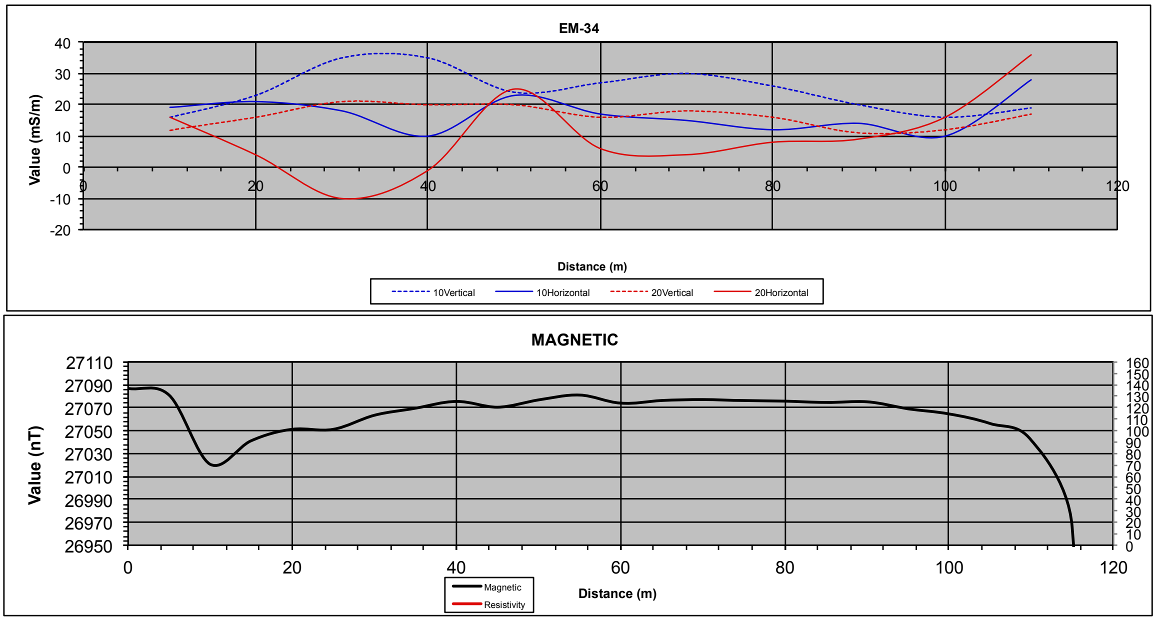


Figure 8: Geophysical profile HFO 2 - Magnetometer



COUNTRY:	EastLonden	FARM:	HFO Site Assessment	DIRECTION:	ENE - WSW	DATE:	15/04/09
PROVINCE:	East Cape	TRAVERSE NR:	HFO 3				

Figure 9: Geophysical profile HFO 3 - Magnetometer



COUNTRY:	EastLonden	FARM:	HFO Site Assessment	DIRECTION:	NE - SW	DATE:	15/04/09
PROVINCE:	East Cape	TRAVERSE NR:	HFO 4				

Figure 10: Geophysical profile HFO 4 - EM34 & Magnetometer

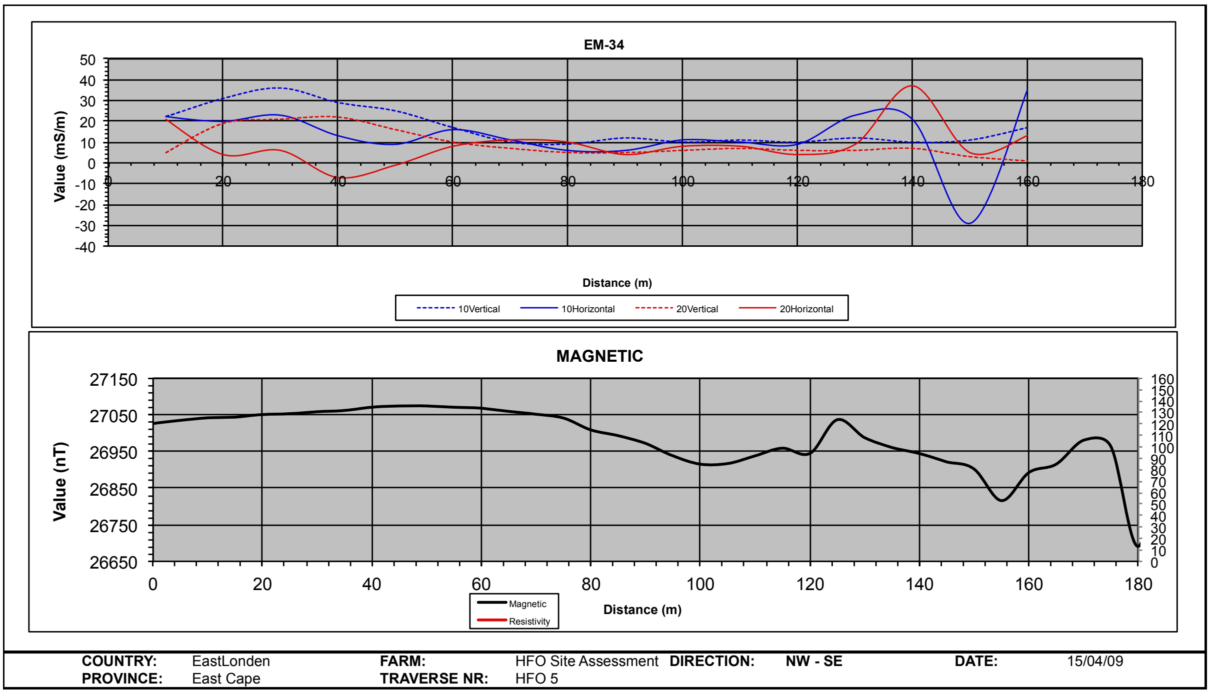


Figure 11: Geophysical profile HFO 5 - EM34 & Magnetometer

4.2.4 Hydrocensus

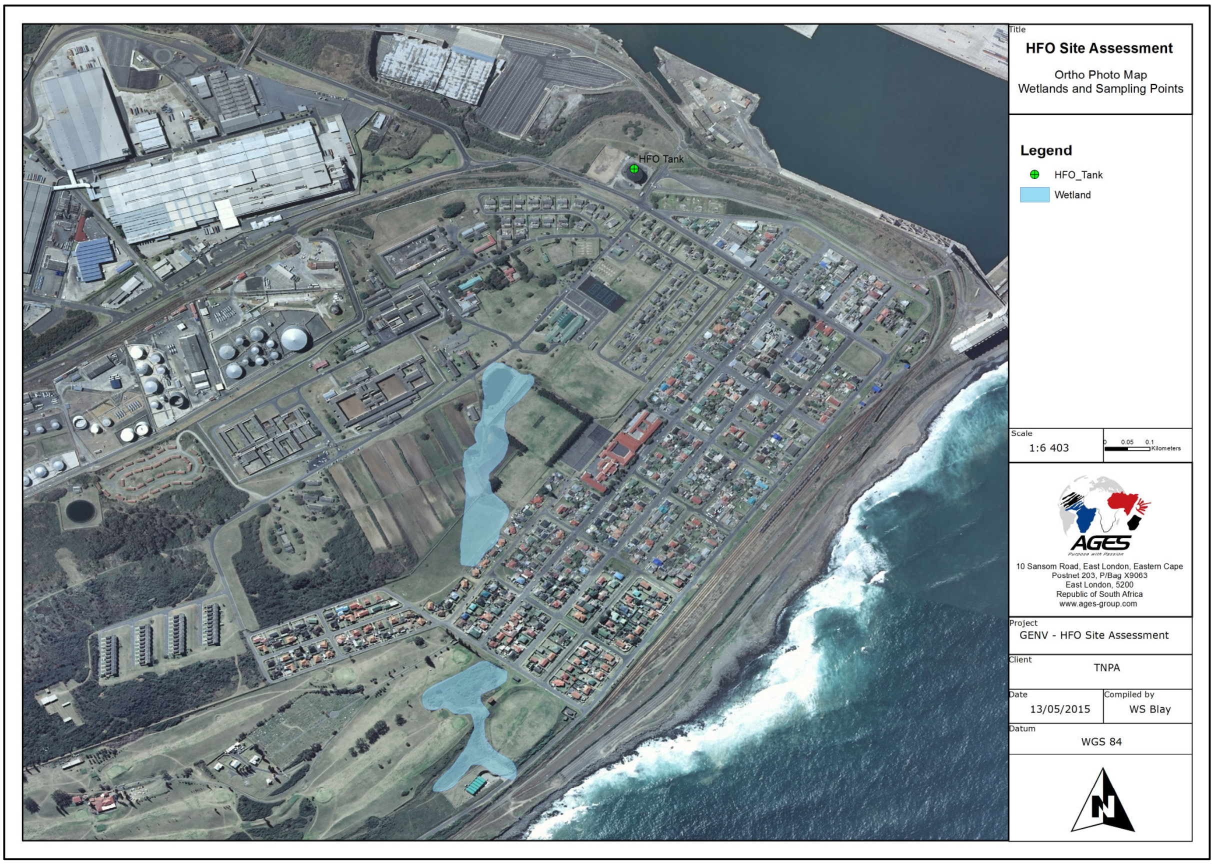
During the assessment a hydrocensus was conducted within a 1km radius of the site to see if any groundwater sites that were not reported in the SRK report could be found. No geosites could be identified during the hydrocensus except for the existing monitoring boreholes located in the direct vicinity of the site. Perched groundwater flow was noted below the site next to the railway line where water flows from the shallow aquifer and along the railway line into the harbour. (Photo 8). A water sample was taken here.

Two potential wetlands were identified approximately 400m south of the site as indicated in MAP 8. Water samples were taken from the seepage site and borehole BP HFO 02. Borehole BP HFO 03 could not be found on site where it was reported in earlier reports. TNPA was requested to clear the vegetation that has overgrown the area where this borehole should be located but the borehole still could not be found for sampling. It is assumed that the borehole has been destroyed by grading that took place in the area since it's development.

Table 2 summarises all boreholes and hand auger holes that have been developed in the past for monitoring purposes. It is also shown in the table which sites have been destroyed or could not be located on site at the time of site surveys. Seven of the shallow auger holes could not be sampled due to too little water being present at the bottom of the holes. The distribution of all holes in and around the site is indicated in MAP 9. In the map it is indicated which holes could not be found on site.

Table 2: Hydrocensus Summary

BH ID	Latitude	Longitude	Historical Well Depth (m)	Status	Measured Water Level (mbgl)	Sampled	Comments
AH1	-33.028349°	27.906006°	1.6	Identified	1.59	NO	Insufficient water for sampling - perched groundwater
AH2	-33.028378°	27.906089°	2.6	Unidentified	-	NO	Could not be identified
AH3	-33.028478°	27.906242°	2	Unidentified	-	NO	Could not be identified
AH4	-33.028600°	27.906300°	3.8	Unidentified	-	NO	Could not be identified
AH5	-33.028750°	27.906204°	2.95	Identified	2.9	NO	Insufficient water for sampling
AH6	-33.028576°	27.905881°	2.2	Identified	1.78	NO	Insufficient water for sampling - perched groundwater
AH8	-33.028189°	27.905760°	-	Identified	1.6	NO	Insufficient water for sampling - perched groundwater
BPHFO1	-33.027932°	27.905882°	34.5	Identified	1.68	NO	Not sampled, no smell noticed
BPHFO2	-33.028115°	27.906714°	33.5	Identified	8.77	YES	Sampled, Diesel smell noticed
BPHFO3	-33.028647°	27.907329°	38	Unidentified	-	NO	Could not be identified
BPHFO4	-33.028154°	27.905640°	2	Identified	1.49	NO	Perched groundwater
BPHFO5	-33.028398°	27.905478°	1.5	Identified	Dry	NO	Dry Borehole
BPHFO6	-33.028454°	27.905721°	0.8	Unidentified	-	NO	Could not be identified
BPHFO7	-33.028380°	27.905715°	2.1	Identified	1.73	NO	Perched groundwater
BPHFO8	-33.028521°	27.904925°	2.2	Unidentified	-	NO	Could not be identified
BPHFO9	-33.028348°	27.905211°	2.4	Identified	Dry	NO	Dry Borehole
BPHFO10	-33.028434°	27.906242°	2.1	Unidentified	-	NO	Could not be identified
BPHFO11	-33.028329°	27.906053°	2.6	Identified	2.59	NO	Insufficient water for sampling - perched groundwater
Seepage	-33.027428°	27.907089°	-	-	-	YES	Seepage sampled



Map 8: Possible Wetlands and perched groundwater seepage zones

Map 9: Hydrocensus & Sampling Map

Photo 8: Seepage below the site near railway line

4.2.5 Groundwater Sampling

A total of 3 groundwater samples were taken based on localities where elevated hydrocarbons were detected in soils as reported in the SRK report. The original budget allowed only for the analyses of 2 water samples at two existing boreholes. As one of these boreholes could not be found (BP HFO 03), samples were eventually taken from monitoring borehole BP HFO 02 and another one from the seepage that was noted from bedrock downstream of the tank site where it flows into the harbour. Most of the shallow monitoring boreholes at the HFO site did not have sufficient water to allow sampling. It was further decided that seepage found in Trial pit 1 should also be sampled. The localities of the three sampling sites are indicated in MAP 9. All of the samples were submitted to an accredited laboratory - Talbot & Talbot laboratories in Pietermaritzburg - for analyses. The chemical analyses of BP HFO 02 and Seep S1 consisted of BTEX, TPH (GRO & DRO) while the trial pit sample had an additional analysis of Aliphatics and Aromatics conducted on it. This was done to identify possible tracers that could indicate historical pollution.

During the sampling procedure of BP HFO 02 a strong diesel odour was noticed and pollution was visible in the sample. The water sample was taken just below the static water level of 8.77 meters below ground level (mbgl) to get as much as possible of the polluted water that should float on top of the cleaner water. Sample BP HFO2 has a DRO concentration of 89 mg/l as well as a GRO concentration of 1800 µg/l that correlates to the strong diesel odour noticed during sampling.

The second sample named “SEEP S1” was taken where groundwater seepage was noted below the railway line northeast of the site as indicated in MAP 9 and photo 8. All of the parameters analysed for in SEEP S1 were however below the laboratory detection limits.

A third water sample was taken from Trial pit 1 as part of the geotechnical investigation. This third sample was analysed for BTEX, TPH (GRO & DRO) including aliphatics and aromatics. The results were also below the detection limit of the laboratory. A summary of the analytical results is indicated in Table 3 and given in APPENDIX A for reference. The results of the water sampled during the SRK study is indicated in Table 4 and 5.

Table 3: Water chemistry results BTEX TPH(GRO & DRO), Aliphatics and Aromatics.

Sample Number		SEEP S1	BP HFO2	TP 1
Sample Date		10-Mar	10-Mar	13-Apr
Determinand	**LOD / Units**			
BTEX	ug/l	<10	<10	<10
Benzene	ug/l	<1	<1	<1
Ethylbenzene	ug/l	<2	<2	<2
Naphthalene	ug/l	<2	<2	<2
Toluene	ug/l	<10	<10	<10
Xylenes	ug/l	<2	<2	<2
m+p Xylene	ug/l	<2	<2	<2
o-Xylene	ug/l			<0.4
TPH Range C10-C28 (DRO)	mg/l	<380	89.00	<380
TPH Range C6-C10 (GRO)	ug/l	<10	1800.00	<10
GRO Surrogate & recovery	%			79
GRO >C5-C12	<50 ug/l	-	-	<50
Methyl tertiary butyl ether (MTBE)	<3 ug/l	-	-	<3
Benzene	<7 ug/l	-	-	<7
Toluene	<4 ug/l	-	-	<4
Ethylbenzene	<5 ug/l	-	-	<5
m+p Xylene	<8 ug/l	-	-	<8
o-Xylene	<3 ug/l	-	-	<3
Sum of detected Xylenes	<11 ug/l	-	-	<11
Sum of detected BTEX	<28 ug/l	-	-	<28
Aliphatics >C5-C6	<10 ug/l	-	-	<10
Aliphatics >C6-C8	<10 ug/l	-	-	<10
Aliphatics >C8-C10	<10 ug/l	-	-	<10
Aliphatics >C10-C12	<10 ug/l	-	-	<10
Aliphatics >C12-C16 (aq)	<10 ug/l	-	-	<10
Aliphatics >C16-C21 (aq)	<10 ug/l	-	-	<10
Aliphatics >C21-C35 (aq)	<10 ug/l	-	-	<10
Total Aliphatics >C12-C35 (aq)	<10 ug/l	-	-	<10
Aromatics >EC5-EC7	<10 ug/l	-	-	<10
Aromatics >EC7-EC8	<10 ug/l	-	-	<10
Aromatics >EC8-EC10	<10 ug/l	-	-	<10
Aromatics >EC10-EC12	<10 ug/l	-	-	<10
Aromatics >EC12-EC16 (aq)	<10 ug/l	-	-	<10
Aromatics >EC16-EC21 (aq)	<10 ug/l	-	-	<10
Aromatics >EC21-EC35 (aq)	<10 ug/l	-	-	<10
Total Aromatics >EC12-EC35 (aq)	<10 ug/l	-	-	<10
Total Aliphatics & Aromatics >C5-35 (aq)	<10 ug/l	-	-	<10

Table 4: SRK water chemistry results for BTEX & MTBE (SRK, April 2013)

Sample ID			AH2	AH3	AH6	AH8	AH9	BPHFO7	BPHFO4	BPHFO5	BPHFO9	BPHFO3	BPHFO2	BPHFO1
Depth														
Sample Type			GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sampled Date			10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012	10/12/2012
Sample Received Date			14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012	14/12/2012
Test	**Units**	**LOD**												
Methyl Tertiary Butyl Ether#	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzene#	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene#	ug/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene#	ug/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
p/m-Xylene#	ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
o-Xylene#	ug/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Surrogate Recovery Toluene D8	%	<0	96	93	94	90	96	94	95	95	94	94	94	96
Surrogate Recovery 4-Bromofluorobenzene	%	<0	94	93	93	89	94	95	94	95	94	92	93	95

Table 5: SRK water chemistry results for TPH-CWG analyses (SRK, April 2013)

Sample ID	Unit	LOD	AH2	AH3	AH6	AH8	AH9	BPHFO7	BPHFO4	BPHFO5	BPHFO9	BPHFO3	BPHFO2	BPHFO1
Aliphatics														
>C5-C6#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>C6-C8#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>C8-C10#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>C10-C12#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>C12-C16#	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>C16-C21#	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>C21-C35#	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>C35-C44	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total aliphatics C5-44	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aromatics														
>C5-EC7#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>EC7-EC8#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>EC8-EC10#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>EC10-EC12#	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
>EC12-EC16#	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>EC16-EC21#	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>EC21-EC35#	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>EC35-EC44	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total aromatics C5-44	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total aliphatics and aromatics(C5-44)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

4.2.6 Summary and Conclusion

No groundwater pollution was detected and reported in the April 2013 SRK study. The only pollution that was detected at that stage was elevated TPH levels noted within soils at BP HF010 (where a strong odour was reported), AH3 and BP HFO3.

TPH groundwater pollution was encountered during this 2015 study at borehole BP HFO2. The contamination is of a Diesel Range Organics origin. As this is the only borehole where this kind of pollution was encountered it will need to be investigated in order to determine the origin and extent of the pollution source. The exact history of activities at the HFO tank since the 2013 survey need to be confirmed.

The possibility of a diesel spill associated with the AGO pipeline or any related pumping infrastructure need to be investigated as a matter of urgency. The location of the AGO pipeline is indicated in MAP 9 but no information could be obtained from TNPA regarding any other pipelines that occur on site. This will need to be obtained and reviewed in relation to the site where TPH pollution was noted at borehole BP HFO2.

4.3 Geotechnical Site Characterisation

4.3.1 Results from previous investigations

Data was utilised from the following previous investigation:

- BP HFO East London, Soil and Grondwater Investigation; Perpared for BP SA by SRK Consulting in April 2013; Report Number 449168.

A total of 11 shallow and deep wells were constructed during the pervious investigation as indicated in the figure below. Data that could be utilised from this previous investigation was limited to the following:

- Borehole and dug well positions
- Limited geological logs

Figure 12: Layout of existing / historic boreholes and dug wells (Google Earth Pro)

4.3.2 Placement of test pits

A total of 4 test pits, HFO TP1 to HFO TP4, were excavated by hand (pick & shovel) and profiled on the 8th of April 2015 utilising local labour. Hand excavation was utilised to prevent any possible damage to existing infrastructure on site, as no detailed layouts of the subsurface services could be obtained. The locality of the trial pits are indicated in Figure 13 with detailed logs and photos attached in Appendix B.

It must be noted that test pit excavation was conducted after a prolonged period of heavy precipitation. Soil moisture conditions and perched groundwater levels are therefore expected to be more elevated.

Figure 13: Layout of soil test pits (Google Earth Pro)

The placement of the test pits were determined as follow:

- HFO TP1 – this test pit was placed inside the perimeter of the HFO tank in the position where surface drainage water collects as well as in the vicinity of the existing grease trap where maximum soil contamination is expected in the case of a spillage.

Photo 9: Position of test pit HFO – TP1

- HFO TP2 and TP3 – These test pits were placed in deeper sandy material in order to verify reported TPH pollution at borehole BP HFO 2 which is located slightly up gradient. The positions of these test pits were therefore to assess if TPH pollution was limited to groundwater or if it is encountered in the surrounding soil material as well.

Photo 10: Position of test pit HFO – TP2

- HFO TP4 – This test pit was placed at the beginning of the small drainage in which one of the metal pipelines that transport fuel from the harbour to the HFO tank and back is located. Any possible pollution from the pipeline would most likely be identified in this test pit.

Photo 11: Position of test pit HFO – TP4

4.3.3 Excavatability

It was possible to excavate test pits to the following depths:

- HFO TP1 – Siltstone bedrock was encountered at 0.85 mbgl and excavation refused on 1.05 mbgl.
- HFO TP2 – Siltstone bedrock was encountered at 0.90 mbgl and excavation refused on 0.95 mbgl.
- HFO TP3 – No bedrock was encountered. Excavation was stopped in aeolian sand / residual sand at 1.80 mbgl as the maximum safe excavation depth was reached.
- HFO TP4 – No bedrock was encountered. Excavation was stopped in residual nanaga soil material at 1.65 mbgl as the maximum safe excavation depth was reached.

4.3.4 Sidewall stability

The sidewalls of the trial pits remained moderately stable during profiling with partial sidewall collapse or overbreak occurring. These trial pits were only left open for a very short duration of 2 to 3 hours from excavation to backfilling.

4.3.5 Groundwater occurrences

Slight to moderate seepage was encountered in test pits HFO TP1, HFO TP2 and HFO TP4 at a depth of 1.00; 0.90 and 0.75 mbgl respectively. The seepage in HFO TP1 and HFO TP2 occurred in the exposed siltstone bedrock material as indicated in the photo below. Seepage in HFO TP4 occurred in the residual siltstone / hillwash material.

No pedogenic soil material, such as ferricrete, was encountered in any of the soil profiles. Pedocretes are believed to form mainly in seasonally or perennially water-deficient climates. Local drainage conditions must also be suitable, as a supply of shallow ground water, charged with potentially pedocrete-forming salts, must be available to be evaporated for the salts to precipitate in the soil. These type of conditions are normally provided by seasonally dry water-courses, pans or depressions that may contain water in the rainy season, but dry out in the dry season.

The absence of pedogenic soil material is therefore potentially indicative of the following:

- that there is a lack of potentially pedocrete-forming salts
- the drainages are not seasonally dry due to the local rainfall trends
- there is no evaporation of shallow ground water for salts to precipitate in the soils
- the soils are well drained

Photo 12: Groundwater seepage encountered in test pits

4.3.6 Generalised soil profile

Note: this description is based on field observations, and does not reflect the results of any laboratory tests.

Based on the site observations of this investigation, and the previous investigation, the soils encountered on site are highly variable. The site is expected to have been reworked and changed over the years from the construction of the harbour and the associated infrastructure. The following generalised soil conditions were encountered in the excavated test pits.

The site is expected to have been covered to partially covered by sandy deposits, that might be related to completely weathered Nanaga formation lithologies or aeolian sand deposits, as encountered in HFO TP3. The material is generally composed of sand that exhibits a dense consistency and intact structure, extending to a depth up to and in excess of 1.80 mbgl.

The quaternary sand deposits are underlain by, and portions of the project area covered by fill material that is composed of sandy clay with scattered to abundant rubble (bricks, concrete etc) that is expected to be of hillwash in origin. This material was encountered in test pits HFO TP1, TP2 and TP4. The site was most likely stripped of topsoil for construction and mixed with building rubble and later backfilled or spread across the site.

The transpoted materials are generally underlain by residual siltstone material as encountered in test pits HFO TP1 and TP4. The material is composed of sandy clay with scattered to frequent siltstone gravel. The material exhibits a firm consistency and micro-shattered to inherent structure.

Siltstone bedrock was encountered in test pits HFO TP1 and TP2 at a depth from 0.85 to 0.90 mbgl respectively. The material is highly to moderately weathered, fine grained and thinly jointed, with a moderately hard rock hardness.

4.3.7 Conceptual soil profile model

Based on the results of the investigation and previous investigations, a preliminary conceptual model of soil conditions on site was compiled. No accurate elevations were available to refine the topographical profile. Due to the nature of profiling of the previous investigation, only the soil colors could be utilised as a possible reference to the origin of the material. The model of profile AB is indicated in the figure below.

In the model it is shown that deeper sand occur in the zone directly north east of the HFO tank. This zone can act as a preferential pathway for shallow groundwater flow towards the Buffalo River and harbour.

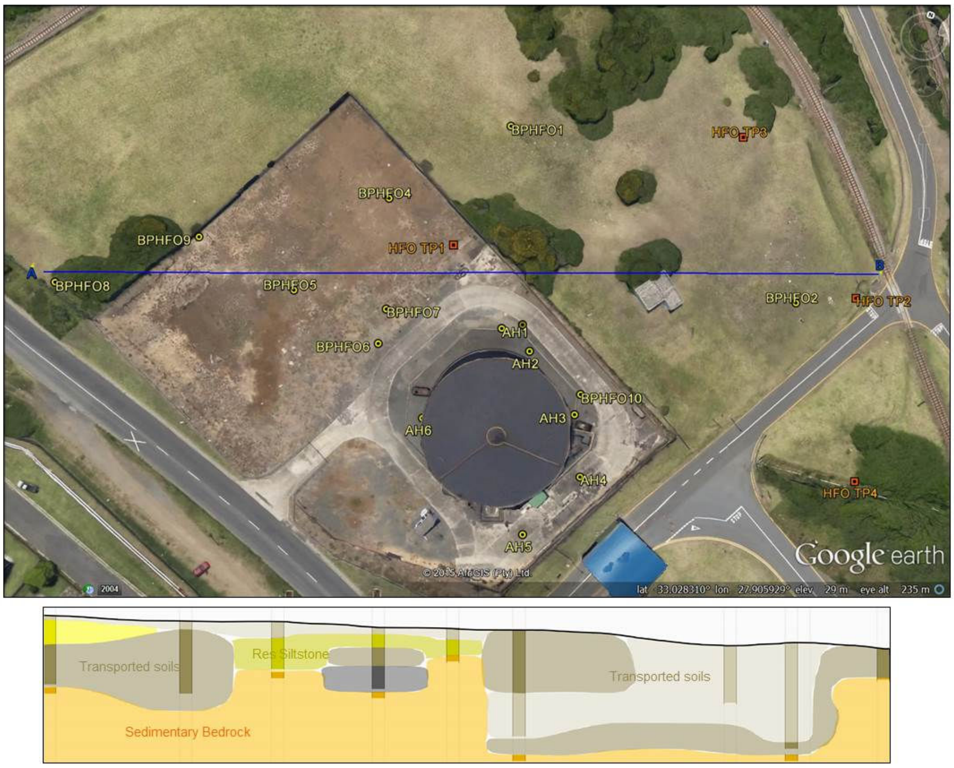


Figure 14: Preliminary conceptual model of soils (Google Earth Pro)

4.3.8 Soil material properties

A total of 3 disturbed soil samples were taken during the site investigation and submitted for detailed laboratory analysis of the physical properties of the soils. Processed and interpreted results are discussed in the paragraphs below and summarized in Table 1. Laboratory certificates are attached in Appendix C for reference.

4.3.8.1 Sand material

The sand deposit material is generally composed of approximately 91% sand, 8 % silt and 1 % clay with no gravel. The fines fraction of the material is non plastic, with a liquid limit of CBD, a plasticity index of NP and a linear shrinkage of 0.0 %.

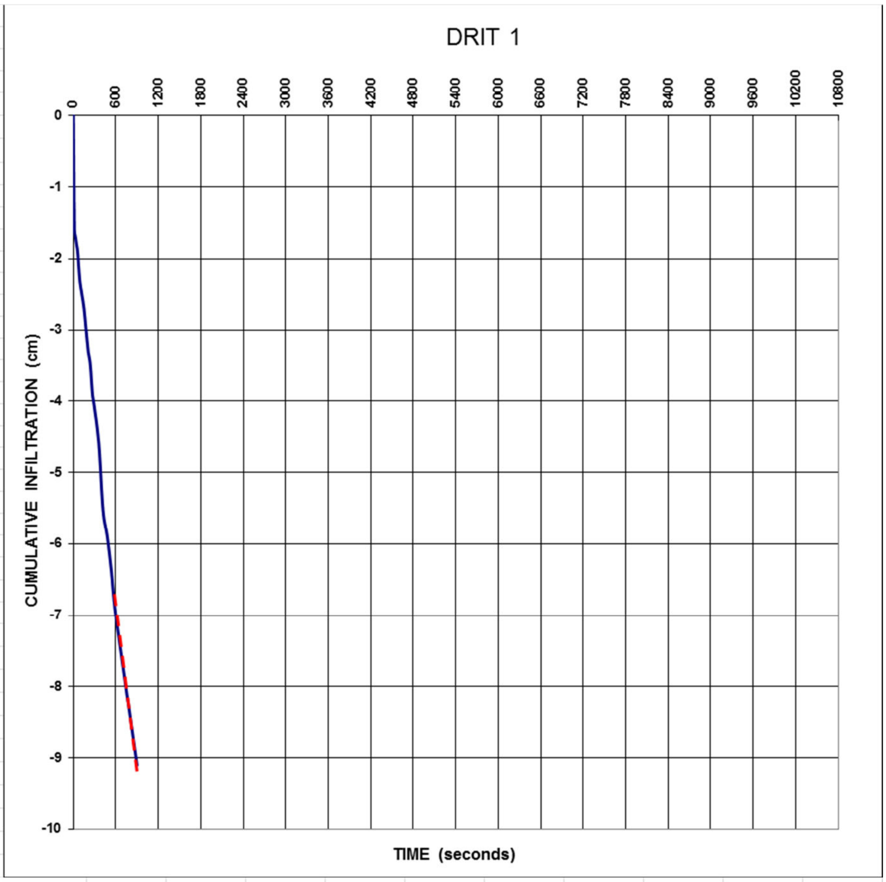
The moisture content of the material at the time of investigation is 3.9 %. The material has a measured pH of 8.90 that is classified as strongly alkaline, and a conductivity of 4.60 mS/m.

The calculated permeability of the material, based on the grading analysis and Hazen's formula, is 6.0 x 10^{-3} cm/sec. This equates to a calculated permeability of 4.86 m per day.

An in-situ permeability test was conducted on the material to measure the permeability. This was done utilising the double-ring infiltrometer method. Results from the in-situ field test are presented in the figure below and indicates that the material has a measured permeability of 7.0 x 10^{-3} cm/s which related well with laboratory analyses results.

Inner Ring Dia.:	29	cm
Ring Height:	15	cm
Test No.:	DRIT 1	
Position:	0.15 mbgl	
Material:	Aeolian Sand	

Time (sec)	Cum. Infilt	
0	0.0	
15	-1.6	
30	-1.7	
45	-1.8	
60	-1.9	1 min
90	-2.3	
120	-2.5	2 min
150	-2.7	
180	-3.0	3 min
210	-3.3	
240	-3.5	4 min
270	-3.9	
300	-4.1	5 min
360	-4.6	6 min
420	-5.5	7 min
480	-5.9	8 min
540	-6.4	9 min
600	-7.0	10 min
900	-9.1	15 min
1200		20 min
1500		25 min
1800		30 min
2700		45 min
3600		1 HOUR
4500		1 hr 15 min
5400		1 hr 30 min
6300		1 hr 45 min
7200		2 HOURS
8100		2 hr 15 min
9000		2 hr 30 min
9900		2 hr 45 min
10800		3 HOURS



h_1 =	7.0	initial height (cm)
h_2 =	9.1	final height (cm)
Δ_t =	300	time difference (sec)

k_m =	7.0E-03 $cm.s^{-1}$

Figure 15: Double ring infiltrometer test results – Aeolian sand

4.3.8.2 Hillwash / Residual Siltstone material

The hillwash / residual siltstone material (dark brown) is generally composed of approximately 49 % sand, 43 % silt and 6 % clay with little to no gravel. The fines fraction of the material has low plasticity with a liquid limit of 17, a plasticity index of 5 and a linear shrinkage of 2.5 %.

The moisture content of the material at the time of investigation is 20.3 %. The material has a measured pH of 8.66 that is classified as strongly alkaline, and a conductivity of 14.50 mS/m.

The calculated permeability of the material, based on the grading analysis and Hazen's formula, is 6.0 x 10^{-5} cm/sec. This equates to a calculated permeability of 0.048 m per day.

4.3.8.3 Residual Siltstone material

The residual siltstone material (yellowish brown) is generally composed of approximately 46 % sand, 30 % silt and 20 % clay with little to no gravel. The fines fraction of the material has high plasticity with a liquid limit of 26, a plasticity index of 14 and a linear shrinkage of 2.5 %.

The moisture content of the material at the time of investigation is 27.3 %. The material has a measured pH of 8.42 that is classified as slightly alkaline, and a conductivity of 14.70 mS/m.

The calculated permeability of the material, based on the grading analysis and Hazen's formula, is 4.0 x 10^{-7} cm/sec. This equates to a calculated permeability of <0.001 m per day.

4.3.9 Chemical soil properties

No sign of soil contamination was noted during the profiling of the 4 excavated test pits. There were no odours or decolouration of the soil material in any of the test pits. No samples were taken of the soil materials for specific chemical analysis.

A sample was taken at test pit HFO TP1 of the perched groundwater seepage that entered the test pit at a depth of 1.0 mbgl. Any possible recent pollution would most likely be identified from the analysis of this sample, as this is the most likely position of pollution to accumulate and possible fuels and chemicals being transported within and on-top of the water.

The results of the analysis on this perched groundwater sample, labelled "Water Sample", is discussed under the water chemistry section of the report.

4.3.10 Conclusion

Soil descriptions and results from the previous investigation could not really be utilised as part of the geotechnical soils characterisation as limited soil profiling descriptions and parameters were recorded in the previous investigation. No profiles or data of the auger holes were available.

Results from this investigation indicate that the project area is generally underlain by shallow sedimentary bedrock material, with the exception of a deep sandy soil zone of unknown origin and extent that cross the site in a basic east west direction in the direct vicinity of old boreholes BPHFO10, AH3, BPHFO2 and new test pit HFO TP3. There is a very high possibility that all the soils on site were disturbed historically during the construction of the harbour and HFO tank.

At the time of investigation no strong odours or free phase was encountered in any of the 4 excavated test pits. No decolouration of the soils were noted and no signs of obvious pollution. Most likely as the result of heavy precipitation prior to site investigation, perched ground water, particularly seepage in test pits, were encountered in 3 of the test pits. Seepage was mainly limited to the fractured bedrock material in the vicinity of the HFO tank.

Based on the results and site observations, it was decided to take a sample of the perched ground water that seeped into the test pit HFO TP1, situated adjacent to the grease trap, as this was the most likely mode of transport for the possible contaminant. This sample was analysed for BTEX, TPH (GRO & DRO) including aliphatics and aromatics. The results were also below the detection limit of the laboratory. A summary of the analytical results is indicated in Table 3 and given in APPENDIX B for reference.

Table 6: Summarised processed disturbed soil test results

SAMPLE INFORMATION			GRADING ANALYSES				ATTERBERG LIMITS			LS	SOIl CHEMISTRY			POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS				CALCULATED
Number	Depth (m - m)	Origin	Gravel %	Sand %	Silt %	Clay %	LL %	PI	PI'	%	pH	Conductivity (mS/m)	% Water Saturation	Expansiveness	Collapse / Compressibility	Corrosiveness (Conductivity)	Dispersivity	PERMEABILITY (cm/sec)
HFO 4/2	0.65 - 1.65	Hillwash / Residual Siltstone	2	49	43	6	17	5	4.7	2.5	8.66	14.50	20.3	Low Risk	Very High Risk	Strongly Alkaline / Mildly Corrosive	High Risk	6E-05
HFO 3/1	0.30 - 1.75	Dune Sand	0	90.6	8.4	1	CBD	NP	CBD	0.0	8.90	4.60	3.9	Low Risk	Very High Risk	Strongly Alkaline / Generally not corrosive	High Risk	6E-03
HFO 1/2	0.35 - 0.85	Residual Siltstone	4	45.6	30.4	20	26	14	12.3	7.0	8.42	14.70	27.3	Medium Risk	Very High Risk	Slightly Alkaline / Mildly Corrosive	High Risk	4E-07

4.4 Transient Domenico Transport Model

The aquifer and soil properties utilised for the Domenico Transient models were determined based on the geotechnical and geohydrological findings and constants from Kruseman and De Ridder (1991).

A constant hydraulic gradient of 0.079 was utilised for the models assuming the groundwater and surface water flow direction is in a northern direction towards the Buffalo river. The decay coefficient was assumed to be zero for DRO in order to simulate a worst case scenario. The concentration of the Diesel Range Organics (89 mg/l) was used as the contaminant concentration as sample from BP HFO 2 had the diesel contamination. The laboratory limit of detection for DRO is 0.38 mg/l that is used as the cutoff limit for the contaminant transport.

Table 7: Dune sand transient Domenico transport model parameters

Time (**t**)	1	days
Initial Concentration (**C_0**)	89	mg/L
Source Width (**Y**)	30.0	m
Source Depth (**Z**)	8.0	m
Decay Coefficient (**l**)	0.00	
Longitudinal Dispersion (a_x)	7.5	
Transverse Dispersion (a_y)	0.8	
Vertical Dispersion (a_z)	0.2	
Hydraulic Conductivity (**K**)	4.8600	m/d
Hydraulic Gradient (**i**)	0.0790	
Effective Porosity (Q_e)	0.2700	
Retardation Factor (**R**)	0.00	
Seepage Velocity (**v**)	1.43	m/d
Scale Factor (**1=10m**)	0.5	

Based on the geotechnical findings a hydraulic conductivity of 4.86 m/d was calculated for the sieve analyses conducted on the dune sand sample taken from trial pit HFO3. The sand was selected due to its high permeability and it is located downstream of the HFO tank in the vicinity of the monitoring borehole BP HFO 2 that had a strong diesel odour during sampling. The seepage velocity was calculated using Darcy's equation and was determined to be 1.43 m/d.

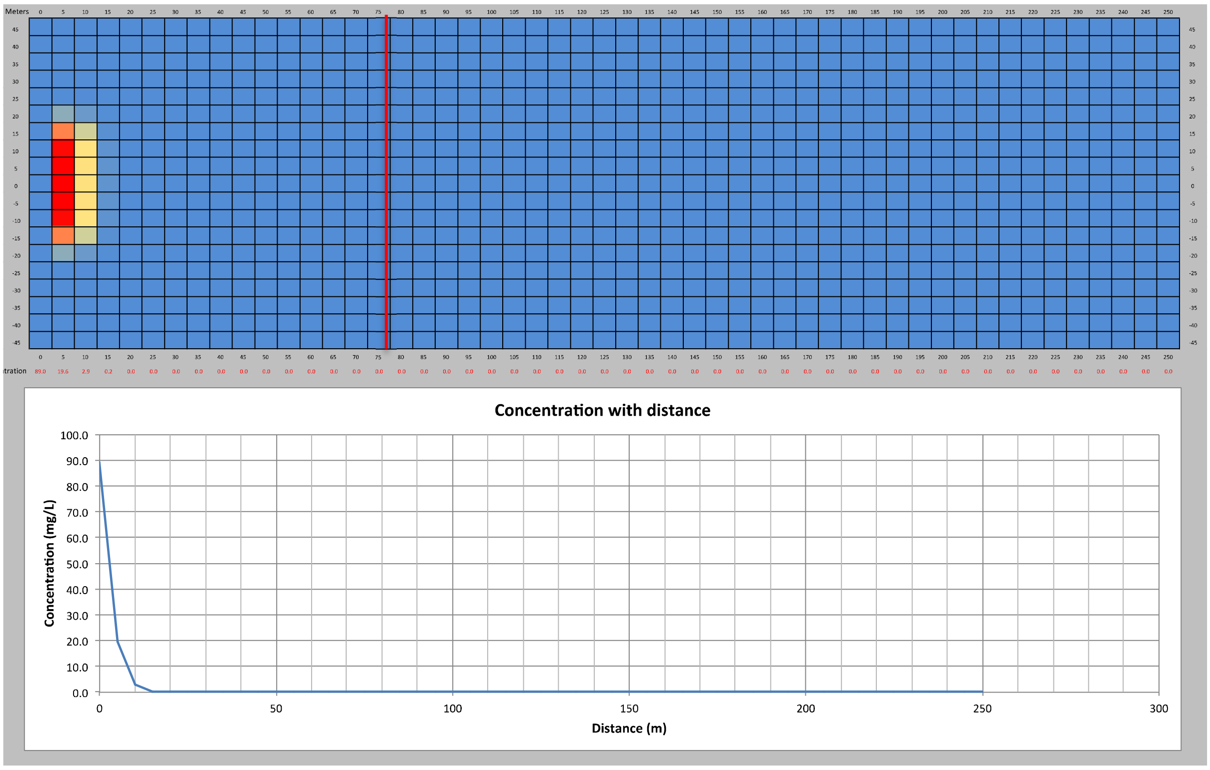


Figure 16: Dune sand transient model 1 day transport

From the dune sand transient model we can conclude that the initial contaminant concentration of 89 mg/l will reduce to less than 0.2 mg/l over a distance of 15m. Rock exposures have indicated that water within the sands and shallow weathering enters vertical joints along which it infiltrates until it reaches resistive horizontal bedding planes on which it flows towards the outcrop after which it enters the harbour as surface water flow.

Based on the geology of the site a second model was drafted in order to simulate flow of contaminants through the underlying fractured rock. The hydraulic conductivity of the fractured rock was estimated to be 300 m/d and a worst case effective porosity of 23% Kruseman and De Ridder (1991). A seepage velocity of 104.02 m/d was calculated.

Table 8: Fractured rock transient Domenico transport model parameters

Time (**t**)	1	days
Initial Concentration (**C_0**)	89	mg/L
Source Width (**Y**)	30.0	m
Source Depth (**Z**)	8.0	m
Decay Coefficient (●)	0.00	
Longitudinal Dispersion (♋$_x$)	7.5	
Transverse Dispersion (♋$_y$)	0.8	
Vertical Dispersion (♋$_z$)	0.2	
Hydraulic Conductivity (**K**)	300.00	m/d
Hydraulic Gradient (**i**)	0.0790	
Effective Porosity (✈$_e$)	0.2300	
Retardation Factor (**R**)	0.00	
Seepage Velocity (**v**)	104.02	m/d
Scale Factor (**1=10m**)	0.5	

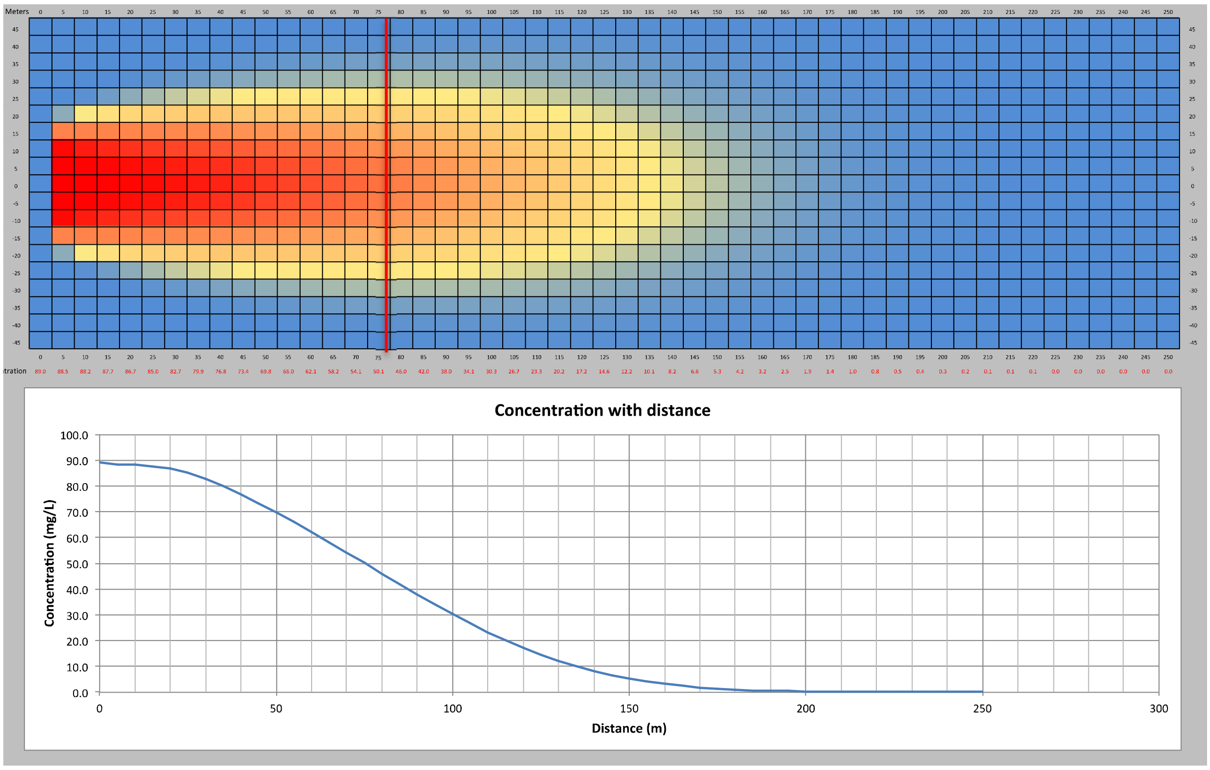


Figure 17: Fractured rock transient model 1 day transport

From the fractured rock Domenico model we can also conclude that the contamination plume would travel approximately 205m before reaching an end concentration of 0.2 mg/l. With the rock outcrop being only 75m downstream of the contaminated borehole it is indicated in Figure 17 that pollution can reach the Buffalo River Estuary before reaching acceptable concentrations.

Conclusion:

It can be concluded that contamination transport through the fractured rock could be orders of magnitude faster and therefore further and wider than in the dune sand. Fractures in the underlying formation strike in a north east direction and are associated with horizontal bedding planes along which groundwater can flow towards the Buffalo River. It is further concluded that any contamination entering the overlying soil layers would most likely enter the fractured rock and flow along the bedding planes and would be discharged along the Buffalo River. Once contamination has entered the fractures it can be transported up to 104m in a single day under ideal conditions.

4.5 Environmental Site Characterisation

Following the conclusion of the environmental literature review a field trip was conducted for verification purposes.

4.5.1 Ecological Status and Sensitivity Assessment

A large portion of the site is an existing development which is cleared and fenced containing a 1.7ml HFO tank with associated infrastructure. The HFO tank site is mostly covered with chipped stone and sand [Figure 21 (a and b)]. This covering, combined with a distinctive herbicide spraying regime has reduced the vegetation coverage to primary weeds such as *Bidens pilosa* and grass species such as *Cynadon dactylon* and *Sporobolus africanus* [Figure 21 (c and d)].

Outside of the HFO compound small portions of indigenous Buffels Thicket (Coastal Thicket) [Figure 22(a)] and coastal grassland vegetation [Figure 22 (b)] dominates the site (Figure 19). A small dam\artificial wetland also being noted (Figure 19). In general the entire site was rated with medium sensitivity due to the levels of anthropogenic influence and high levels of alien plant infestation. Although the dam/artificial wetland region was rated as highly sensitive due to the ecosystem services it provides for the fauna of the region.

The medium rated coastal thicket (Figures 19 and 20), is predominantly dominated by alien vegetation such as *Lantana camara* and *Cestrum laevigatum* [Figure 22 (c and d)]. There are however still sensitive natural coastal vegetation species present such the *Sideroxylon inerme* protected trees [Figure 22 (e)] which resulted in its medium sensitivity rating.

The coastal grassland section of the site is regularly mowed and dominated by *Stenotaphrum secondatum* [Figure 22 (f)]. Following specialist consultation it was concluded that common mole-rats (*Cryptomys hottentotus*) or possibly the Hottentot golden moles (*Amblysomus hottentotus*) are living within this section of the property. These mole-rats are responsible for the large number of mole hills\holes. Both of these species are widespread and not protected under South African legislation. The coastal grassland portion of the site was rated as medium sensitivity due to these high levels of ecological activity.

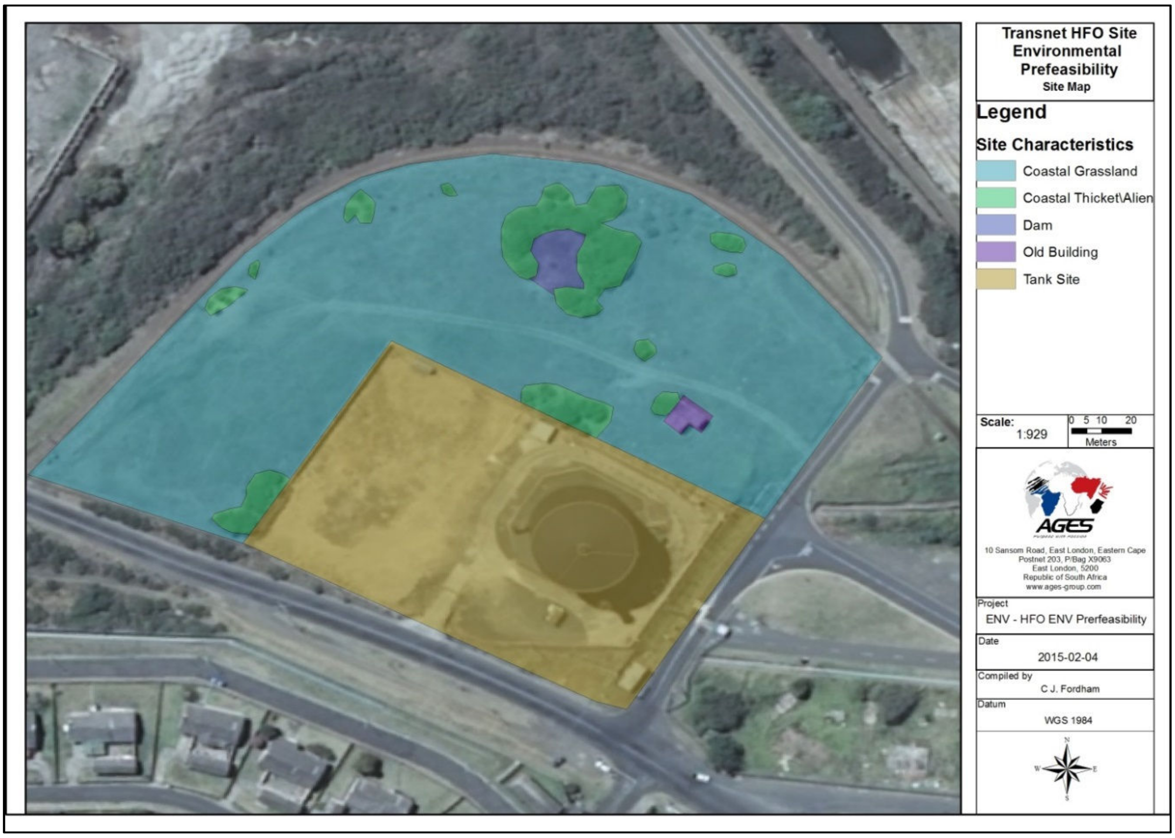


Figure 18: Map illustrating various site characteristics

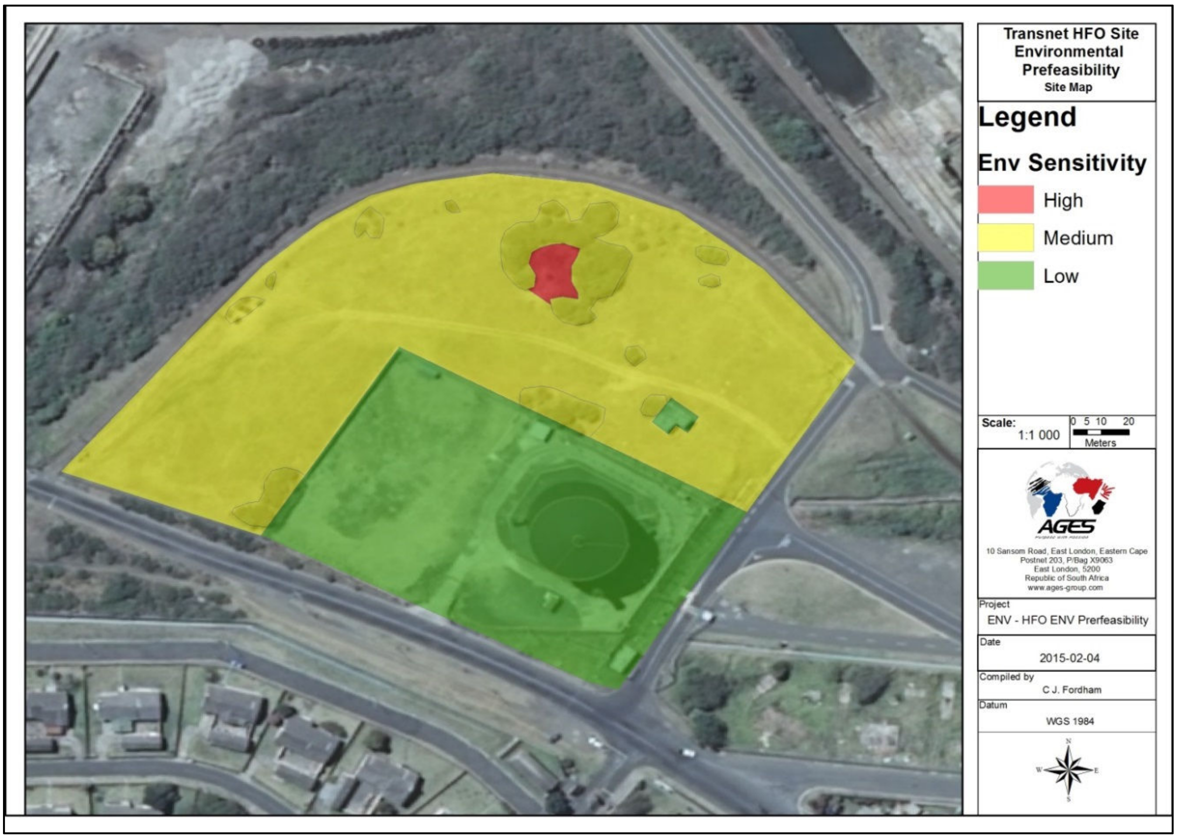


Figure 19: Map illustrating site environmental sensitivity

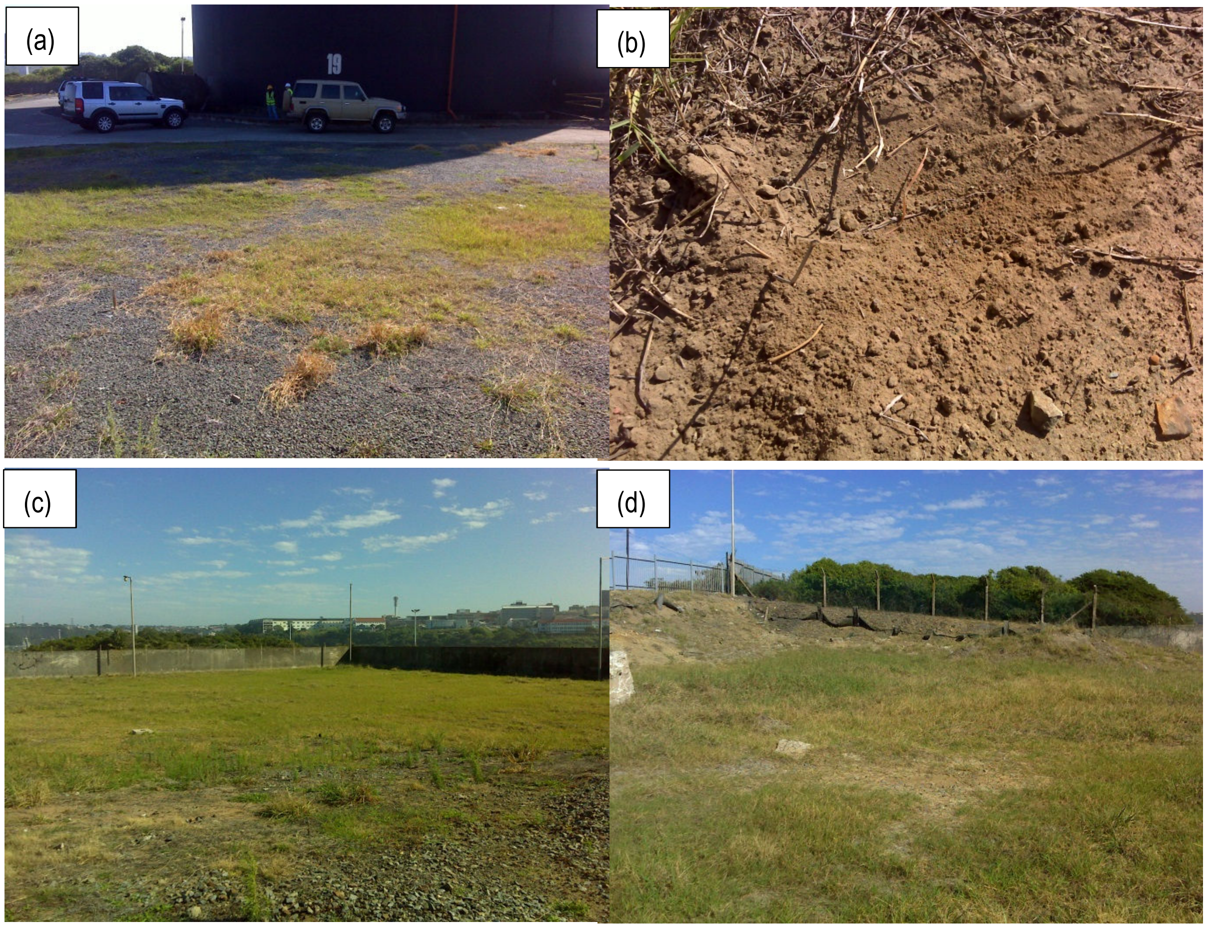


Figure 20:A collection of photos from within the current HFO site

Figure 21:A collection of photos from the remainder of the site outside the HFO compound

4.5.1.1 Heavy Furnace Oil Contamination

It is difficult to quantify the extent of potential contamination based on vegetation\ecological activity alone, especially when levels of contamination do not appear to be excessive. Heavy Fuel Oil (HFO) is a residue from the crude oil refinery process and used to be extensively used in the maritime shipping industry. Being a residue, it is known to be a cheap fuel, but contains significant quantities of contaminants and over the past decades its use over time has decreased mainly due to stricter Air Quality standards of various countries. Generally when spilled HFO is rapidly degraded by soil microbiota, however the rate of which depends on the abiotic factors of the ecosystem. Due to herbicide spraying regime within the HFO compound, vegetation cover cannot be used as a reliable indicator of contamination. Outside of the HFO compound, the site is partially mowed on a regular basis resulting in *Stenotaphrum secondatum* dominating large portions of that region.

According to numerous authors including Marwood *et al.* (2001); Sverdrup *et al.* (2003) and Alkio *et al.* (2005), heavy fuel oil generally affects plant germination, growth and physiological processes such as photosynthesis or mineral update depending on the concentrations of the contaminants. However during this brief site assessment it was difficult to assess if the plants within the HFO compound were impacted by oil contamination or by herbicide spraying regimes or by other anthropogenic influences. Outside of the facility the vegetation did not show distinctive signs of Heavy Fuel Oil contamination, however to be able to fully quantify this, additional in depth investigation would be required. Therefore to better determine the extent of any pollutant contamination and the sites compliance with South African legislation, Groundwater and Geotechnical analysis would provide greater clarity in this regard.

4.6 Socio-Economic Status

The city of East London formed around the only river port in South Africa where the settlement on the West Bank was the nucleus from where development took place. Today the Westbank suburb is an impoverished community with little signs of development in terms of residential living conditions. Several houses in the suburb have been upgraded and refurbished in recent years but there are still numerous reports of crime which leaves local residents negative in terms of the future for this part of the BCM. In contrast, the Daimler Chrysler factory and its associated infrastructure developments adjacent to the East London harbour is of world class standard. A huge part the land is used by the Department of Correctional Services for the West Bank Prison who's main entrance is directly adjacent to the HFO Tank site.

Figure 22:Aerial view of the HFO site and main different land use areas

4.6.1 Desktop Study

The HFO site according to regularity information has been described as "Flammable, Harmful, Irritant and a Danger to the Environment" Of concern from the site is the possible negative effect it could have to neighbouring communities should it not be maintained and managed properly.

According to toxicological information in the report, the site could negatively affect humans in the eye and skin areas. These effects have been described as moderate/minimal 'irritations'. Other effects can be in the event that the toxins were ingested in small quantities or inhaled through vapour or the fumes emitted from the site.

Ecological information suggest that the HFO is biodegradable and therefore, if spillages occur, with decisive efforts, the affected area could be rehabilitated. However, concern should be noted where the oils come into contact with ground or surface water and contaminate it.

4.6.2 Land-use

Land-use around the HFO Tank site can be categorized in the following distinct groups:

- Residential
- Commercial
- Industrial
- Governmental
- Petrochemical Industry
- Recreational
- Educational

These different land-uses are indicated in MAP 10 showing that the largest part of the area surrounding the HFO site is in use by the Department of Correctional Services as well as for Industry, mainly Daimler Chrysler. The third largest land-use component is for residential and recreational purposes, followed by the petro-chemical industry. Commercial and educational facilities are limited in terms its extent but still important role players when it comes to any environmental impacts in the area.

4.6.3 Identified Stakeholders

As agreed with TNPA it was decided not to engage any stakeholders at this stage of the study but rather to identify the most likely and obvious role players based on available information and site observations. With reference to MAP 10 in terms of Land-use, the following stakeholders are preliminary listed:

- Buffalo City Municipality
- Rate payers associations – if in place and active
- Local Councillors and committee members
- Renting and permanent residents of the Wesbank south of the tank site
- Shop owners and light industry owners
- St Andrews Presbyterian Church
- Mercedes-Benz Manufacturing South Africa (Pty) Ltd and associated industries
- South African Department of Correctional Services
- HFO Tank Site and East London Fuel Depot
- Wesbank Golf Club
- Wesbank High School

It is anticipated that more stakeholders could be identified and the community profile better understood if more detailed social site assessments are conducted in future.

4.6.4 Potential Risks

Risks associated with the local communities have been defined based on the current status of the HFO tank site and history related to its use since 1976. As described before under the description of the site, the site is classified as hazardous with the nature and intensity of hazards varying from situation to situation. The following risks were addressed in the Overall Risk Assessment which is summarised in Chapter 4.15.

- Health Risks
- Safety Risks
- Risks to Economy
- Risks to Business

4.6.5 Conclusion

It is well understood that the site is classified as hazardous. The current scope of social inputs was limited to a basic scan of current land-use and potential stakeholders so that a foundation is established from where stakeholders can be engaged once the outcome and way forward of the Environmental and Structural assessments are defined.

Map 10: Land Use around the HFO Tank Site

4.7 RISK ASSESSMENT

4.7.1 Source Pathway Receptor Assessment

The risk of potential pollution to the environment by the HFO tank facility in it's operational and functional state, containing Heavy Furnace Oil, can be gauged with reference to the conceptual model that is presented in chapter 4.2.2. The conceptual model is used to conduct a preliminary risk assessment of the site conditions and entails the identification of:

1. *The source or sources of contamination;*
2. *The possible and likely pathways that the contaminants may migrate through if coming into contact with the surface or subsurface;*
3. *Receptors that may be exposed to the contaminant source;*
4. *Characterisation of the risk associated with the HFO facility.*

The sources, pathways and potential receptors for the operational phase of the HFO facility is summarised in Table 9.

Table 9: Sources pathways and potential receptors for the HFO site

SOURCE	PATHWAYS		RECEPTORS			
	Soils	**Groundwater**	**Environmental**	**Soils**	**Groundwater**	**Social**
HFO Tank leakage **HFO pipeline** **Diesel Transfer Facility** **AGO pipeline**	*Sand deposits* *Residual siltstone*	*Vertical joints* *Bedding planes* *Weathered siltstone* *Residual Nanaga formation* *Dolerite contact*	*Coastal grassland* *Protected trees* *Buffalo River* *Harbour* *Possible Wetlands*	*Sand deposits* *Bedrock contact*	*Perched groundwater at 1.7mbgl* *Fractured aquifer at 8.8mbgl*	*TNPA Tank Site personnel* *TNPA Harbour personnel & facilities* *Wesbank residents& property* *Prison residents & property* *MBSA personnel & facilities*

The most prominent and sensitive receptors identified are the Buffalo River and harbour, soils and groundwater.

4.7.2 Overall risk Assessment

The method used for analysing environmental risks associated with this project is outlined in detail in a document produced by DEAT (2006). It was determined that to calculate the extent of environmental risk for this project a three function risk formulae derived from Germain *et al* (1998) should be used (Table 10).

Table 10: A table illustrating how the three function risk formulae risk score is calculated, Germain et al (1998)

RISK SCORE – LIKELIHOOD X EXPOSURE X CONSEQUENCE	
LIKELIHOOD * (L):	**Value**
Might well be expected (Happens often)	10.0
Quite possible	6.0
Unusual but possible	3.0
Only remotely possible (has happened somewhere)	1.0
Conceivable but very unlikely (hasn't happened yet)	0.5
Practically impossible (one in a million)	0.2
Virtually impossible (Approaches the impossible)	0.1
* The probability of a loss when the hazardous event does occur	
EXPOSURE * (E):	**Value**
Continuous	10.0
Frequently (daily)	6.0
Occasionally (weekly)	3.0
Unusual (monthly)	2.0
Rare (a few per year)	1.0
Very Rare (yearly)	0.5
No exposure	0.0
* How frequently the hazard event occurs	
CONSEQUENCES (C):	**Value**
Catastrophic (Many fatalities, or damage over $ 10 000 000)	100
Disaster (A few fatalities or damage over $ 1 000 000)	40
Very serious (One fatality or damage over $ 100 000)	15
Serious (Serious injury or damage over $ 10 000)	7
Important (Temporary disablement or damage over $ 1 000)	3
Noticeable (Minor first aid or damage over $ 100)	1
R = L x E x C: The risk score (magnitude of the risk) is derived by multiplying the likelihood value times the exposure value times the consequence value	
RISK CLASSIFICATION	**RISK SCORE**
Very high risk: consider discontinuing the operation	Over 400
High risk: Immediate correction required	200 – 400
Substantial risk: Correction needed	70 – 200
Possible risk: Attention is indicated	20 – 70
Low risk: Risk perhaps acceptable as is	Under 20

Table 11 gives the outcome of the overall risk assessment for the HFO tank facility and associated pipelines in its operation stage. In the table it can be seen that the highest risks are associated with surface water, shallow and deep groundwater as well as soil pollution and health risks to humans.

Table 11: A table illustrating the Geo-Environmental Risk Assessment results

Project Phase	Risk type	Risk	Likelihood (L)	Exposure (E)	Consequences (C)	Risk Score = L * E *C	Risk Category
Use of HFO Tank facility and associated infrastructure In OPERATIONAL state	Ecological	Increased surface water chemical\ petroleum contamination	1	10	15	150	Substantial Risk (Correction needed)
	Ecological	Disturbance of indigenous fauna by loud noises	1	2	1	2	Low Risk (Risk perhaps acceptable as is)
	Environmental	Decreased air quality	0.2	10	7	14	Low Risk (Risk perhaps acceptable as is)
	Geohydrological	Groundwater pollution (Shallow perched aquifer)	6	2	15	180	Substantial Risk (Correction needed)
	Geohydrological	Groundwater pollution (Deep fractured aquifer)	6	2	7	84	Substantial Risk (Correction needed)
	Geotechnical	Pollution of soils	6	2	7	84	Substantial Risk (Correction needed)
	Geotechnical	Destabilisation of foundations	0.1	2	3	0.6	Low Risk (Risk perhaps acceptable as is)
	Social	Impacts on Health	3	2	15	90	Substantial Risk (Correction needed)
	Social	Impacts on Safety	3	2	7	42	Possible risk: (Attention is indicated)
	Social	Impacts on local Economy	3	1	3	9	Low Risk (Risk perhaps acceptable as is)

5 CONCLUSION & RECOMMENDATIONS

5.1 Integrated Geo-Environmental Conclusion

No groundwater pollution was detected and reported in the April 2013 SRK study. The only pollution that was detected at that stage was elevated TPH levels noted within soils at BP HF010 (where a strong odour was reported), AH3 and BP HFO3.

TPH groundwater pollution was encountered during this 2015 study at borehole BP HFO2. The contamination is of a Diesel Range Organics origin. As this is the only borehole where this kind of pollution was encountered it will need to be investigated in order to determine the origin and extent of the pollution source. The exact history of activities at the HFO tank since the 2013 survey need to be confirmed.

The possibility of a diesel spill associated with the AGO pipeline or any related pumping infrastructure need to be investigated as a matter of urgency. The location of the AGO pipeline is indicated in MAP 9 but no information could be obtained from TNPA regarding any other pipelines that might occur on site. This will need to be obtained and reviewed in relation to the site where TPH pollution was noted at borehole BP HFO2

The site is underlain by Karoo Sequence lithologies consisting of grey and red mudstone and sandstone of the Middleton Formation. This formation forms part of the Adelaide Subgroup of the Beaufort Group. The geology map indicates the presence of an extensive dolerite sill intrusion directly south and to the west of the HFO tank site. Younger deposits of Quaternary and Tertiary age cover the Karoo-aged rocks and dolerite towards the south of the site. Calcereous sandstone and sandy limestone of the Nanaga Formation of the Algoa Group can therefore be expected at the HFO site in varying thicknesses or where completely weathered, as sandy deposits.

Based on the topography and surface water drainage directions it is expected that groundwater flow will mimic surface topography and is therefore expected to be in a northeast direction, from the HFO site towards the Buffalo River and harbour.

Observations and measurements of strike and dip directions in rock exposures around the site have indicated that the general strike direction of the main joint set that occurs is parallel to the ENE line on which the dolerite outcrop is found. This suggests that there is possible faulting present closer to the dolerite sill contact as well as within the sandstone host rock. Such structures could be preferential flow paths for groundwater.

In the conceptual model it is indicated that although it was reported in previous studies that some boreholes penetrated dolerite as shallow as 3m, it is impossible for dolerite to be present within the first 30 m. Baked and altered dark grey quartzitic sandstone was most probably difficult to distinguish from dolerite during the drilling process. It is however likely that dolerite was intersected in depth and it is indicated as such in the conceptual model.

Perched groundwater within the sandy topsoil and weathered sandstone can be expected at 1.7 mbgl. This perched groundwater level is also expected to be associated with the potential wetland that is found approximately 400m south of the site where it has probably developed within unconsolidated weathered Nanaga Formation sediments.

Illustrated in the model is the expected groundwater flow within the perched shallow aquifer as well as vertical flow along joint sets that were observed on site. It is expected that most of this flow will be from the perched shallow aquifer along vertical joints until it intersects resistive horizontal bedding planes.

The static groundwater level within the fractured bedrock is expected at 8.8 mbgl as indicated in the conceptual model. As indicated earlier in the report, this groundwater level is expected to mimic the surface topography, with flow being in a northerly direction towards the harbour. As indicated, the HFO site is located very close to the crest of the groundwater table. This means that should excessive groundwater abstraction take place south of the site, groundwater gradients may change and flow can be towards the south. The hydrocensus has however shown that no groundwater abstraction is taking place south of the site.

Based on the geotechnical findings a hydraulic conductivity of 4.86 m/d was calculated for the sieve analyses conducted on the dune sand sample taken from trial pit HFO3. The sand was selected due to its high permeability and it is located downstream of the HFO tank in the vicinity of the monitoring borehole BP HFO 2 that had a strong diesel odour during sampling. The seepage velocity was calculated using Darcy's equation and was determined to be 1.43 m/d.

From the dune sand transient model we can conclude that the initial contaminant concentration of 89 mg/l will reduce to less than 0.2 mg/l over a distance of 15m. Rock exposures have indicated that water within the sands and shallow weathering enters vertical joints along which it infiltrates until it reaches resistive horizontal bedding planes on which it flows towards the outcrop after which it enters the harbour as surface water flow.

Based on the geology of the site a second model was drafted in order to simulate flow of contaminants through the underlying fractured rock. The hydraulic conductivity of the fractured rock was estimated to be 300 m/d and a worst case effective porosity of 23% Kruseman and De Ridder (1991). A seepage velocity of 104.02 m/d was calculated.

From the fractured rock Domenico model we can also conclude that the contamination plume would travel approximately 205m before reaching an end concentration of 0.2 mg/l. With the rock outcrop being only 75m downstream of the contaminated borehole it is indicated in Figure 17 that pollution can reach the Buffalo River Estuary before reaching acceptable concentrations

It can be concluded that contamination transport through the fractured rock could be orders of magnitude faster and therefore further and wider than in the dune sand. Fractures in the underlying formation strike in a north east direction and are associated with horizontal bedding planes along which groundwater can flow towards the Buffalo River. It is further concluded that any contamination entering the overlying soil layers would most likely enter the fractured rock and flow along the bedding planes and would be discharged along the Buffalo River. Once contamination has entered the fractures it can be transported up to 104m in a single day under ideal conditions.

It must be noted that the focus of the geotechnical investigation was aimed at defining and understanding potential pathways for pollution and not at the geotechnical character of underlying soils for foundation design purposes. Should the TNPA property north of the HFO tank be considered for development, a detailed geotechnical investigation will be required. From this study it can only be stated that underlying formations vary considerably with deep sand to be expected in places with fluctuation perched groundwater conditions.

No DRO contamination was however noted in the seepage sample that was taken downstream of the HFO tank and borehole BP HFO 2 where pollution was noted. This single sample cannot be used to conclude that pollution has reached the Buffalo River. More samples will have to be taken as there are numerous joint sets and bedding planes along which pollution could migrate.

From an ecological and environmental perspective HFO rapidly biodegrades, so unless there is a significant spill, vegetation is able to regrow. The adjacent property is heavily tunnelled with mole-rats and is well vegetated and does not show obvious signs of contamination from an ecological point of view. Therefore to accurately determine the extent of any pollution geohydrological and geotechnical investigations were required. Should Geotechnical and Geohydrological sections of the report conclude site contamination with HFO, the following competent authorities need to be informed:

- In terms of NEMWA it is recommended that their findings be forwarded to the Minister of Environmental Affairs as well as the MEC.
- In terms of NEMA DEA TNPA will also be complying with the Duty of Care Principals outlined in Chapter 7 Section 28 of NEMA.
- In terms of the NWA as the pollution aquatic orientated, DWA will also need to be informed of the levels of contamination.
- It is also be recommended that BCM be informed to ensure that all relevant authorities are aware of the status of the property.

Regarding future development of the HFO compound and the adjacent property it is likely the potential legislation which triggers is NEMA GNR 983, 984 and 985. General Authorisation from DWA for the dam destruction will also be required as per NWA and any development must comply with the Port of East London Strategic Environmental Assessment (CES 2007). However this is all highly dependent on the nature of the proposed development that the client wishes to implement.

Soil descriptions and results from the previous investigation could not really be utilised as part of the geotechnical soils characterisation as limited soil profiling descriptions and parameters were recorded in the previous investigation. No profiles or data of the auger holes were available.

Results from this investigation indicate that the project area is generally underlain by shallow sedimentary bedrock material, with the exception of a deep sandy soil zone of unknown origin and extent that cross the site in a basic east west direction in the direct vicinity of old boreholes BPHFO10, AH3, BPHFO2 and new test pit HFO TP3. There is a very high possibility that all the soils on site were disturbed historically during the construction of the harbour and HFO tank.

Based on the results of the investigation and previous investigations, a preliminary conceptual model of soil conditions on site was compiled. No accurate elevations were available to refine the topographical profile. Due to the nature of profiling of the previous investigation, only the soil colours could be utilised as a possible reference to the origin of the material. In the model it is shown that deeper sand occur in the zone directly north east of the HFO tank. This zone can act as a preferential pathway for shallow groundwater flow towards the Buffalo River and harbour within unconsolidated permeable sand.

At the time of investigation no strong odours or free phase was encountered in any of the 4 excavated test pits. No decolouration of the soils were noted and no signs of obvious pollution. Most likely as the result of heavy precipitation prior to site investigation, perched ground water, particularly seepage in test pits, were encountered in 3 of the test pits. Seepage was mainly limited to the fractured bedrock material in the vicinity of the HFO tank.

Based on the results and site observations, it was decided to take a sample of the perched ground water that seeped into the test pit HFO TP1, situated adjacent to the grease trap, as this was the most likely mode of transport for the possible contaminant. This sample was analysed for BTEX, TPH (GRO & DRO) including aliphatics and aromatics. The results were also below the detection limit of the laboratory. A summary of the analytical results is indicated in Table 3 and given in APPENDIX A for reference

It is well understood that the site is classified as hazardous. The current scope of social inputs was limited to a basic scan of current land-use and potential stakeholders so that a foundation is established from where stakeholders can be engaged once the outcome and way forward of the Environmental and Structural assessments are defined.

Risks associated with the local communities have been defined based on the current status of the HFO tank site and history related to its use since 1976. As described before under the description of the site, the site is classified as hazardous with the nature and intensity of hazards varying from situation to situation. Applicable risks were addressed in the Overall Risk Assessment which is summarised in Chapter 4.15.

The risk of potential pollution to the environment by the HFO tank facility in its operational and functional state, containing Heavy Furnace Oil, can be gauged with reference to the conceptual model. The conceptual model is used to conduct a preliminary risk assessment of the site conditions and entails the identification of potential sources, pathways and receptors.

The outcome of the overall risk assessment for the HFO tank facility and associated pipelines in its operation stage, indicated that the highest risks are associated with surface water, shallow and deep groundwater as well as soil pollution and health risks to humans.

The following recommendations are given in summary:

1. Immediate action need to be taken to define and contain the DRO pollution that was noted at borehole BP HFO 2. This will have to entail the following steps:

    a. *Obtain detailed layout maps of all piping and related fuel infrastructure within 300m of the site.*

    b. *Report pollution noted to relevant authorities and parties associated with the AGO fuel line to the Fuel Depot to look if is not a re-occurrence of the 2012 spill.*

    c. *Sampling and analyses of additional water samples from seepage downstream of BP HFO 2*

    d. *Sampling and analyses of soils between the AGO fuel line and HFO tank as well as within the sandy sediment channel that was identified in the conceptual soil model, to determine if DRO water pollution has reached the underlying soils around borehole BP HFO 2.*

2. A spill containment plan needs to be defined and quotations need to be obtained from competent service providers for implementation.

3. It should be investigated if the construction of a seepage trench downstream of the HFO tank will be feasible to capture any polluted sub-surface flow within the perched aquifer. This should form part of the recommended oil spill contingency plan.

4. It needs to be verified if an Oil Spill Contingency Plan is in place for the East London Harbour and a HFO Tank Oil Spill Contingency Plan needs to be drafted or updated if available.

5. The exact history of activities at the HFO tank since the 2013 survey need to be confirmed.

6. Appropriate action must be taken based on the approved spill containment and remediation plan.

7. A Tachy survey needs to be conducted to determine exact elevations of all monitoring boreholes and prominent site features for more accurate quantification of aquifer characteristics.

8. Monitoring boreholes that could not be found or has been destroyed need to be re-instated for ongoing groundwater monitoring.

9. Borehole BP HFO 2 must be tested to determine exact hydraulic conductivities and seepage velocities that can be expected in underlying fractures. This can be done with a falling head test.

10. A groundwater and soil monitoring plan must be implemented

11. Risks that have been defined in the report should be measured against outcomes of the engineering report for decision making purposes and prioritisation of immediate actions.

12. Stakeholders need to be formally defined and approached towards establishing an effective and appropriate communication channel between TNPA and relevant stakeholders.

13. Currently the site is well fenced and as long as any spills are contained and immediately remediated, within the existing HFO site, no additional control measures need to be implemented from an ecological

aspect. It has however been reported in the Engineering Structural assessment that Bunding Facilities are not sufficient and would need to be upgraded to be able to contain a worst case scenario spill.

14. Should the undeveloped portion of the site be developed then the relevant environment applications supplied to the competent authorities will result in an appropriate monitoring plan.
15. An ecological sampling plan is not required for the current site, although surface water and groundwater monitoring is recommended. The site however must continue to complies with NEMA “Duty of Care Principals”. Should the undeveloped portion of the site be developed then the relevant environment applications provided to the competent authorities will result in an appropriate monitoring plan. However, due to the sensitive nature of the site it is recommended that an external Environmental Control Officer (ECO) be appointed to ensure that the client complies to conditions of the relevant submitted documents and authorisations.

16. A water sampling plan must be defined and implemented once boreholes that could not be found are re-instated. With reference to MAP 9 - this plan must entail quarterly water sampling at the following sites:

    - BP HFO1
    - BP HFO2
    - BP HFO3 (If not found – to be re-drilled)
    - Seepage below site at railway track (Sampling point to be formalised and marked)
    - BP HFO10 (If not found – to be re-drilled)
    - AH3 (If not found – to be re-drilled)
    - AH5
    - BP HFO6 (If not found – to be re-drilled)

17. Water samples must be tested for the following at an accredited laboratory:
    - BTEX
    - TPH (GRO & DRO)
    - Aliphatics & Aromatics

18. A soil sampling plan must be defined and implemented with three soils samples to be taken bi-annually at the following localities at 0.5 mbgl:

    - Directly north of BP HFO10
    - A point where an AGO fuel spill is most likely to occur
    - Directly north of BP HFO2

19. Soil samples must be tested for the following at an accredited laboratory:
    - BTEX & MTBE
    - TPH-CWG

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7 APPENDIX A – WATER CHEMISTRY DATA

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2015/05/29

ANALYTICAL REPORT

OUR REF:	**AGES 4414/15.R1** **(This amended report replaces report number AGES 4414/15** **(O/N: EL840)**
COMPANY NAME:	**AGES**
CONTACT ADDRESS:	**PRIVATE BAG X9063, POSTNET 203, EAST LONDON**
CONTACT PERSON:	**WILBE BLAY**
SAMPLE TYPE:	**WATER SAMPLES**
DATE SUBMITTED:	**2015/03/16**

Determinand	**Units**	**Results**	
		4414/15	4415/15
		SEEP S1 HFO SITE 10.03.15 11:15	BP HFO 02 10.03.15 11:00
BTEX*	µg/l	<10**	<10**
Benzene*	µg/l	<1**	<1**
Ethylbenzene*	µg/l	<2**	<2**
Naphthalene*	µg/l	<2**	<2**
Toluene*	µg/l	<10**	<10**
m+p-Xylene*	µg/l	<2**	<2**
o-Xylene*	µg/l	<2**	<2**
TPH Range C10-C28 (DRO)*	mg/l	<0.38**	89**
TPH Range C6-C10 (GRO)*	µg/l	<10**	1 800**

Technical Signatory: Chemistry____________ Bacteriology____________

- This report relates only to the samples tested. This report shall not be reproduced, except in full, without the written approval of **TALBOT LABORATORIES.**
- Tests marked with an asterisk (*) in this report are not SANAS accredited and are not included in the Schedule of Accreditation for our laboratory.
- Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
- Note: Results marked with a double asterisk (**) have been sub-contracted to a peer laboratory.
- Note: Estimates of Uncertainty of Measurement may be obtained from the laboratory if required.

Directors: Dr MMU-F Talbot, Mr FD Urbaniak-Hedley (British), Mrs VR Talbot
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2015/05/29

ANALYTICAL REPORT

OUR REF: AGES 6137/15.R1
(This amended report replaces report number AGES 6137/15)
QU102254 (O/N: EL848)

COMPANY NAME: AGES

CONTACT ADDRESS: PRIVATE BAG X9063, POSTNET 203, EAST LONDON

CONTACT PERSON: WILBE BLAY

SAMPLE TYPE: WATER SAMPLE

DATE SUBMITTED: 2015/04/14

Determinand	Units	Results
		6137/15
		WATER SAMPLE 13.04.15 10:00
BTEX*	µg/l	<10**
Benzene*	µg/l	<1**
Ethylbenzene*	µg/l	<2**
Naphthalene*	µg/l	<2**
Toluene*	µg/l	<10**
m+p-Xylene*	µg/l	<2**
o-Xylene*	µg/l	<2**
TPH Range C10-C28 (DRO)*	mg/l	<0.38**
TPH Range C6-C10 (GRO)*	µg/l	<10**

Directors: Dr MMU-F Talbot, Mr FD Urbaniak-Hedley (British), Mrs VR Talbot
Talbot & Talbot (Pty) Ltd - Company Registration Number 2003/021732/07

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TPH CWG (W)**		
Determinand*	LOD/Units	Results
		6137/15
		WATER SAMPLE 13.04.15 10:00
GRO Surrogate % recovery	%	79
GRO >C5-C12	<50 µg/l	<50
Methyl tertiary butyl ether (MTBE)	<3 µg/l	<3
Benzene	<7 µg/l	<7
Toluene	<4 µg/l	<4
Ethylbenzene	<5 µg/l	<5
m,p-Xylene	<8 µg/l	<8
o-Xylene	<3 µg/l	<3
Sum of detected Xylenes	<11 µg/l	<11
Sum of detected BTEX	<28 µg/l	<28
Aliphatics >C5-C6	<10 µg/l	<10
Aliphatics >C6-C8	<10 µg/l	<10
Aliphatics >C8-C10	<10 µg/l	<10
Aliphatics >C10-C12	<10 µg/l	<10
Aliphatics >C12-C16 (aq)	<10 µg/l	<10
Aliphatics >C16-C21 (aq)	<10 µg/l	<10
Aliphatics >C21-C35 (aq)	<10 µg/l	<10
Total Aliphatics >C12-C35(aq)	<10 µg/l	<10
Aromatics >EC5-EC7	<10 µg/l	<10
Aromatics >EC7-EC8	<10 µg/l	<10
Aromatics >EC8-EC10	<10 µg/l	<10
Aromatics >EC10-EC12	<10 µg/l	<10
Aromatics >EC12-EC16 (aq)	<10 µg/l	<10
Aromatics >EC16-EC21 (aq)	<10 µg/l	<10
Aromatics >EC21-EC35 (aq)	<10 µg/l	<10
Total Aromatics >EC12-EC35 (aq)	<10 µg/l	<10
Total Aliphatics & Aromatics >C5-35 (aq)	<10 µg/l	<10

Technical Signatory: Chemistry____________ Bacteriology____________

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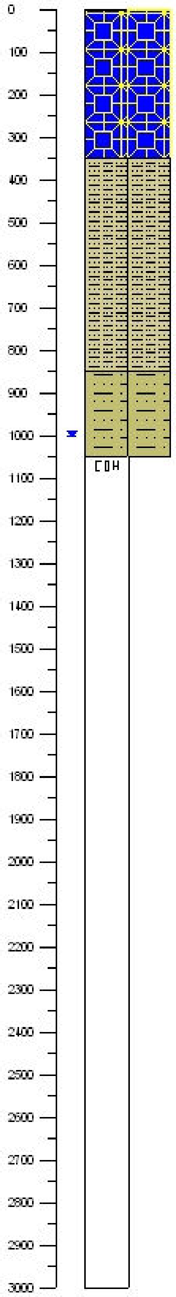
8 APPENDIX B – TRIAL PIT LOGS

PROJECT:	**GTEC HFO Site Assessment**			**TRIAL PIT NO.:**	**HFOTP1**
CLIENT:	TNPA	LATITUDE:	S33.02821		
CONTRACTOR:	Community Labour	LONGITUDE:	E27.90583	DATE EXCAVATED:	08 April 2015
MACHINE TYPE:	Hand Dug	ELEVATION:	32 mamsl	DATE PROFILED:	08 April 2015



Description	Sampling
Moist, dusky yellow brown, soft, micro-shattered, clayey sand. FILL	
Moist to wet, yellow brown, in profile yellow brown, firm, micro-shattered to inherent, sandy clay with few to frequent angular siltstone gravel. RESIDUAL SILTSTONE.	HFO 1/2
Khaki, highly weathered to moderately weathered, fine grained, moderately hard roc. Joints are narrow, satined ans slightly rough. SILTSTONE BEDROCK.	HFO 1/3
Excavation refused on moderately hard SILTSTONE BEDROCK.	

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Notes:

Strong seepage @ 1.00 mbgl

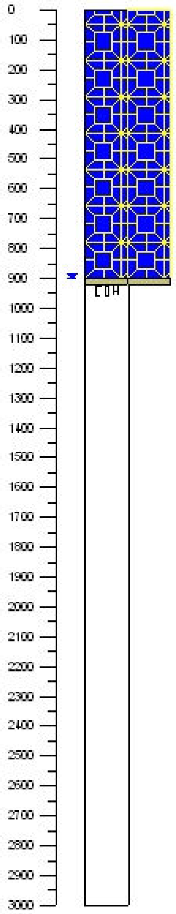
Sidewall stability good

2 Disturbed sample taken

HFOTP1

PROJECT:	**GTEC HFO Site Assessment**			**TRIAL PIT NO.:**	**HFO TP2**
CLIENT:	TNPA	LATITUDE:	S33.02806		
CONTRACTOR:	Community Labour	LONGITUDE:	E27.90687	DATE EXCAVATED:	08 April 2015
MACHINE TYPE:	Hand Dug	ELEVATION:	19 mamsl	DATE PROFILED:	08 April 2015

Depth **Lithology** **Description** **Sampling**



Moist, dark brown, firm, micro-shattered, sandy clay with frequent subrounded gravel and cobbles. FILL

Khaki, highly weathered to moderately weathered, fine grained, moderately hard roc. Joints are narrow, satined ans slightly rough. SILTSTONE BEDROCK.

Excavation refused on moderately hard SILTSTONE BEDROCK.

Sampling: HFO 2/1

AGES EC (PTY) LTD

Notes: Seepage @ 0.90 mbgl
Sidewall stability good
1 Disturbed sample taken

HFO TP2

PROJECT:	**GTEC HFO Site Assessment**			**TRIAL PIT NO.:**	**HFO TP3**
CLIENT:	TNPA	LATITUDE:	S33.02780		
CONTRACTOR:	Community Labour	LONGITUDE:	E27.90654	DATE EXCAVATED:	08 April 2015
MACHINE TYPE:	Hand Dug	ELEVATION:	20 mamsl	DATE PROFILED:	08 April 2015

Depth	Lithology	Description	Sampling
0 – 300		Moist, brown, soft, intact, sand. Roots. DUNE SAND?	
300 – 1800		Moist, light brown, dense, intact, sand. DUNE SAND?	HFO 3/1
1800	EOH	Excavation was stopped on soft DUNE SAND.	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000

AGES Purpose with Passion

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Notes:

No seepage

Sidewall stability good

1 Disturbed sample taken

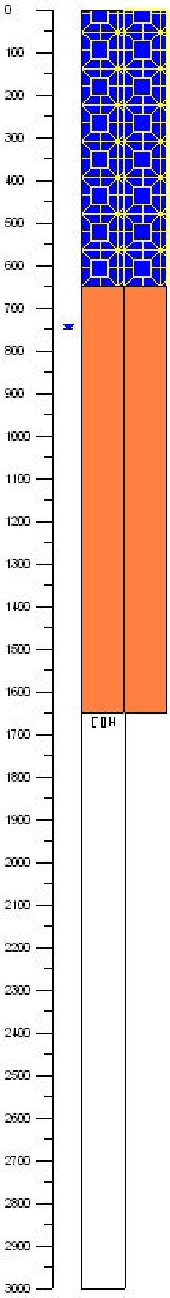
HFO TP3

PROJECT: GTEC HFO Site Assessment

TRIAL PIT NO.: HFO TP4

CLIENT:	TNPA	LATITUDE:	S33.02845		
CONTRACTOR:	Community Labour	LONGITUDE:	E27.90701	DATE EXCAVATED:	08 April 2015
MACHINE TYPE:	Hand Dug	ELEVATION:	16 mamsl	DATE PROFILED:	08 April 2015

Depth **Lithology** **Description** **Sampling**



Moist, brown, firm, micro-shattered, sandy clay with rubble material(brick, concrete etc). FILL

HFO 4/1

Very moist to wet, dark brown, firm, micro-shattered, sandy silty clay. HILLWASH / RESIDUAL SILTSTONE?

HFO 4/2

Excavation was stopped on HILLWSH / RESIDUAL SILTSTONE ? with a firm consistency

AGES EC (PTY) LTD

Notes:

Seepage @ 0.75 mbgl

Sidewall stability good

2 Disturbed sample taken

HFO TP4

9 APPENDIX C – LABORATORY SOIL TEST RESULTS

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

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sanas Testing Laboratory T0308 ISO/IEC 17025:2005 Accredited Laboratory

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT:	AGES EC (Pty) Ltd	PROJECT:	H F O
	Postnet Suite 203	DATE RECEIVED:	2015-04-23
	Private Bag X9063	DATE TESTED:	2015-05-09
	EAST LONDON, 5200	DATE REPORTED:	2015-05-14
ATT :	Mr F de Jager	TEST REPORT NO.:	73651

FOUNDATION INDICATOR REPORT

SAMPLE NO	2909	2910	2911			
POSITION	4 / 2	3 / 1	1 / 2			
DESCRIPTION	dk Br	lt Br	lt Y O			
	Ferr +	sand	Sh +			
	sdy st		cly s			
SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5						
% PASSING 75 mm						
37.5 mm			100			
19 mm	100		99			
9.5 mm	99		97			
4.75 mm	98		96			
2.36 mm	97		95			
1.18 mm	96		93			
0.600 mm	94		90			
0.425 mm	94	100	88			
0.300 mm	94	95	86			
0.150 mm	90	43	68			
0.075 mm	49.0	9.4	50.4			
HYDROMETER ANALYSIS: Method ASTM D422						
0.06 mm	41	7	45			
0.02 mm	17	2	31			
0.006 mm	9	1	23			
0.002 mm	6	1	20			
ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4						
LIQUID LIMIT	17	CBD	26			
PLASTICITY INDEX	5	NP	14			
LINEAR SHRINKAGE	2.5	0.0	7.0			
PREDICTION OF HEAVE (VAN DER MERWE METHOD)						
MOISTURE CONTENT %:	20.3	3.9	27.3			
PI WHOLE SAMPLE	4.0	0.0	12.0			
POTENTIAL EXPANSIVENESS	LOW	LOW	MED			

The above test result are pertinent to the samples received and tested only.
While the tests are carried our according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.

Technical Signatory: J Atterbury

Remarks:

Samples Delivered by Customer: YES

Sampled by Controlab

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

CLIENT:	AGES EC (Pty) Ltd	**PROJECT:**	H F O
	Postnet Suite 203		
	Private Bag X9063		
	EAST LONDON	**DATE:**	2015-05-14
	5200		
ATT:	Mr F de Jager	**REF:**	73651

pH & CONDUCTIVITY

SAMPLE NO.	POSITION	pH	Conductivity (μS/cm) (Micro Siemens / cm)
2909	HFO 4/2	8.66	145
2910	HFO 3/1	8.90	46
2911	HFO 1/2	8.42	147

Technical Signatory:________
J Atterbury