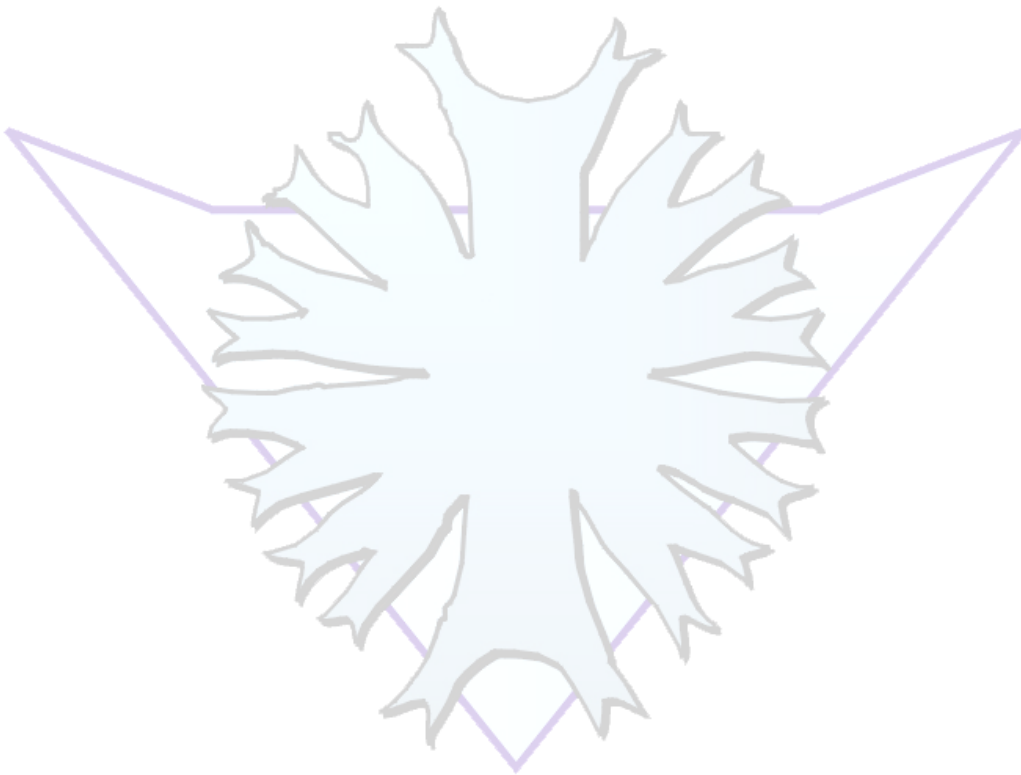


**Aquatics Assessment**  
**(Vlakkeland, Paarl, Western Province)**

**Dr William R Harding**

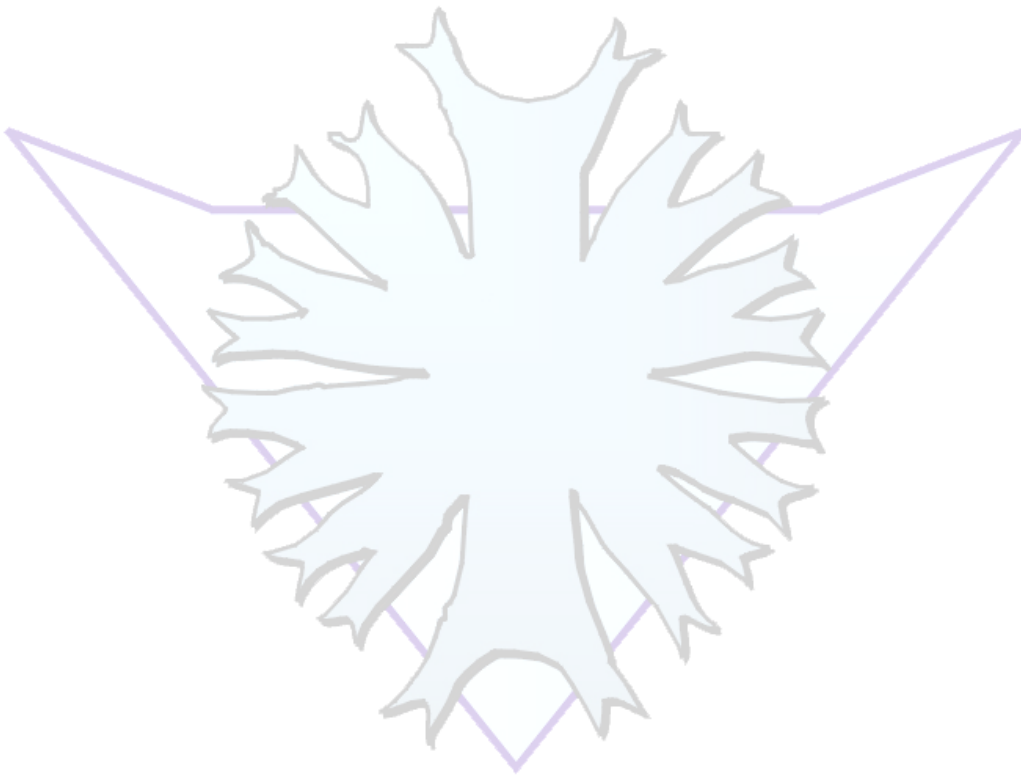


**Report to Guillaume Nel Environmental Consulting**

**by**

**DH Environmental Consulting  
South Africa**

**DHEC Report 622/2013**



# AQUATICS ASSESSMENT – VLAKKELAND, PAARL, WESTERN PROVINCE

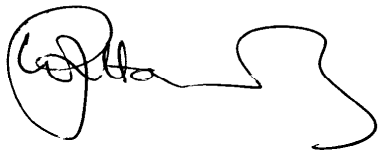
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## EXECUTIVE SUMMARY

DH Environmental Consulting (DHEC) was appointed as independent aquatics specialist, by Guillaume Nel Environmental Consultants (GNEC), to provide input to an Environmental Impact Assessment (EIA) for the proposed housing Development on Erven 8359, 8378, 8399, Rem 8370, 8400, 12628, 12633, and 33027 (108 ha), known as 'Vlakkeland', Paarl.

The site encompasses a short reach of a severely-degraded streamline. There are no wetlands on the property.

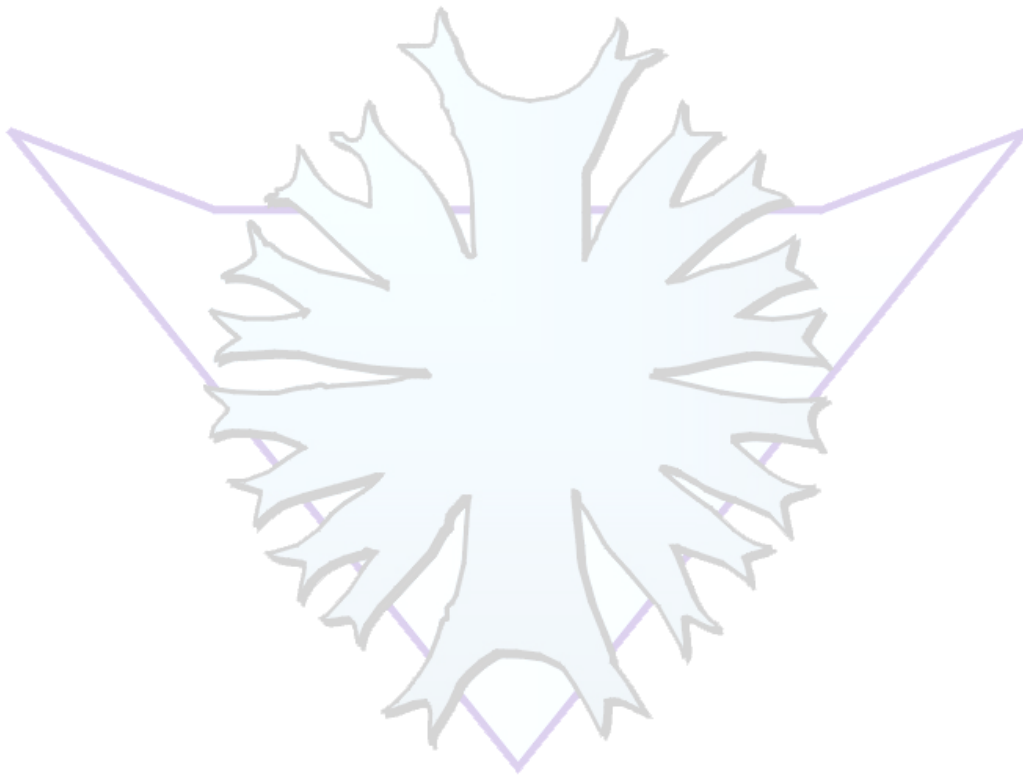
Various options for the streamline exist. These include its retention and future use as a stormwater conveyance, alternately its diversion upstream of this property to flow to the nearby Dal River. A third option would be to divert the streamline at the southern property boundary to the proposed stormwater management area. Insofar as conservation of least-damaged environments is concerned, diversion to the Dal River is considered to be the ecological best option but would be dependent on the ability of the Dal River to accommodate the stream hydraulics.



**Dr WR Harding**  
**Professional Limnologist and Certified Lake Manager (USA)**  
**Registered Professional Natural Scientist (Ecological Sciences) (South Africa)**  
**May 2013**

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## **SPECIALIST DECLARATION**

The aquatic assessment performed for this project was conducted by Dr William R Harding, BSc (Chemistry/Microbiology); BSc (Hons) (Microbiology); MSc (Zoology – Freshwater Biology) and PhD (Zoology – Freshwater Biology). Dr Harding is registered as a Professional Natural Scientist (Pr Sci Nat) as an Ecological Scientist with the South African Council for Natural Scientific Professions (SACNASP), Registration No. 400059/97). Dr Harding is also a USA-certified Lake Manager, accredited by the North American Lake Management Society (NALMS, 98/04/M). Dr Harding is also registered as an Ecologist with the Southern African Society of Ecologists and Environmental Scientists (SAIEES). He recently served on the Minister of Science and Technology's advisory council of the South African Council for Natural Scientific Professions (SACNASP).

Dr Harding has been active in the field of hydrobiology and aquatic ecology for 25 years.

The views expressed in the report are the objective, independent views of Dr Harding and the survey was carried out under the aegis of his registered Close Corporation, DH Environmental Consulting CC, established in 1995. Neither Dr Harding, nor DH Environmental Consulting CC, has any business, personal, financial or other interest in the proposed development, apart from fair remuneration for the work performed.

# AQUATICS ASSESSMENT – VLAKKELAND, PAARL, WESTERN PROVINCE

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## BACKGROUND

DH Environmental Consulting (DHEC) was appointed as independent aquatics specialist, by Guillaume Nel Environmental Consultants (GNEC), to provide input to an Environmental Impact Assessment (EIA) for the proposed housing Development on Erven 8359, 8378, 8399, Rem 8370, 8400, 12628, 12633, and 33027 (108 ha), known as 'Vlakkeland', Paarl.

The Terms of Reference for the DHEC assessment were as follows:

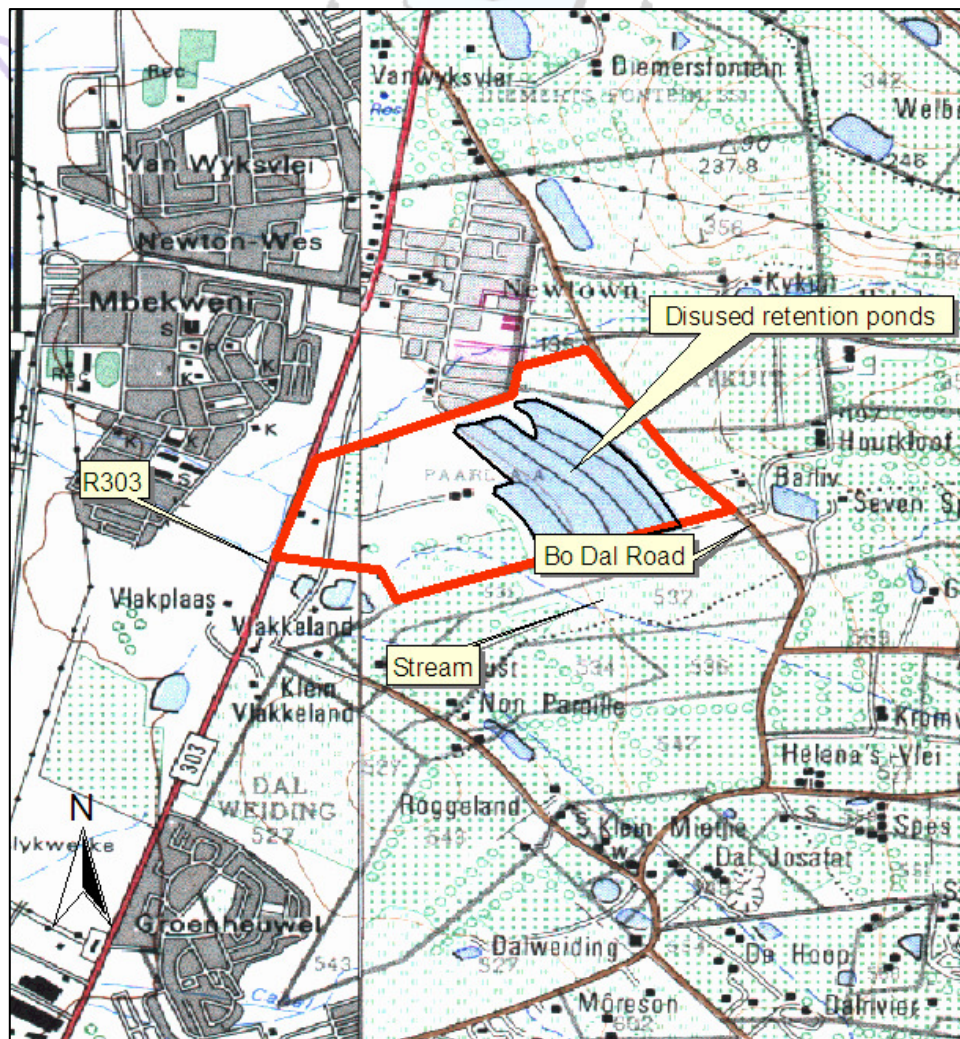
- Determine the extent, nature of, ecological function and importance of the existing wetlands and streamline on site - using extant information and primary data gleaned from a site visit. Contextualize same with the Municipal EMF, SANBI data, aerial photographic history and, where relevant, seek consensus with the Municipality;
- Undertake a desktop assessment to review, compile and map all available information, including historical conditions;
- Undertake a site visit to determine the extant conditions, with specific attention to issues raised in the Belcher aquatics assessment;
- Undertake, if necessary, excavation of trial pits to determine the edge of the main watercourse and/or presence of any residual baseflow (this was not deemed to be necessary following site inspection);
- Liaise with the botanical specialist and Drakenstein Municipality regarding any issues of importance (Mr Cedric Morkel);
- With respect to possible intact wetlands/watercourses, identify areas of mitigation and trade-off for development whilst retaining (possible) wetland function and value in a sustainable manner;
- Provide options to augment and strengthen existing intact wetlands;
- Produce a constraints map indicating areas of development (no issues), possible development (freshwater issues which can be worked with to some extent) and No- Go areas; and
- Produce a report detailing the findings and Mitigation Measures;

- Attend an inception meeting and one project meeting.

A prior assessment of this site (see **Appendix A**) concluded that there might be areas of wetland on the eastern boundary, i.e. in the easternmost of the five pans. Accordingly, this assessment was required to contribute additional information for the EIA process.

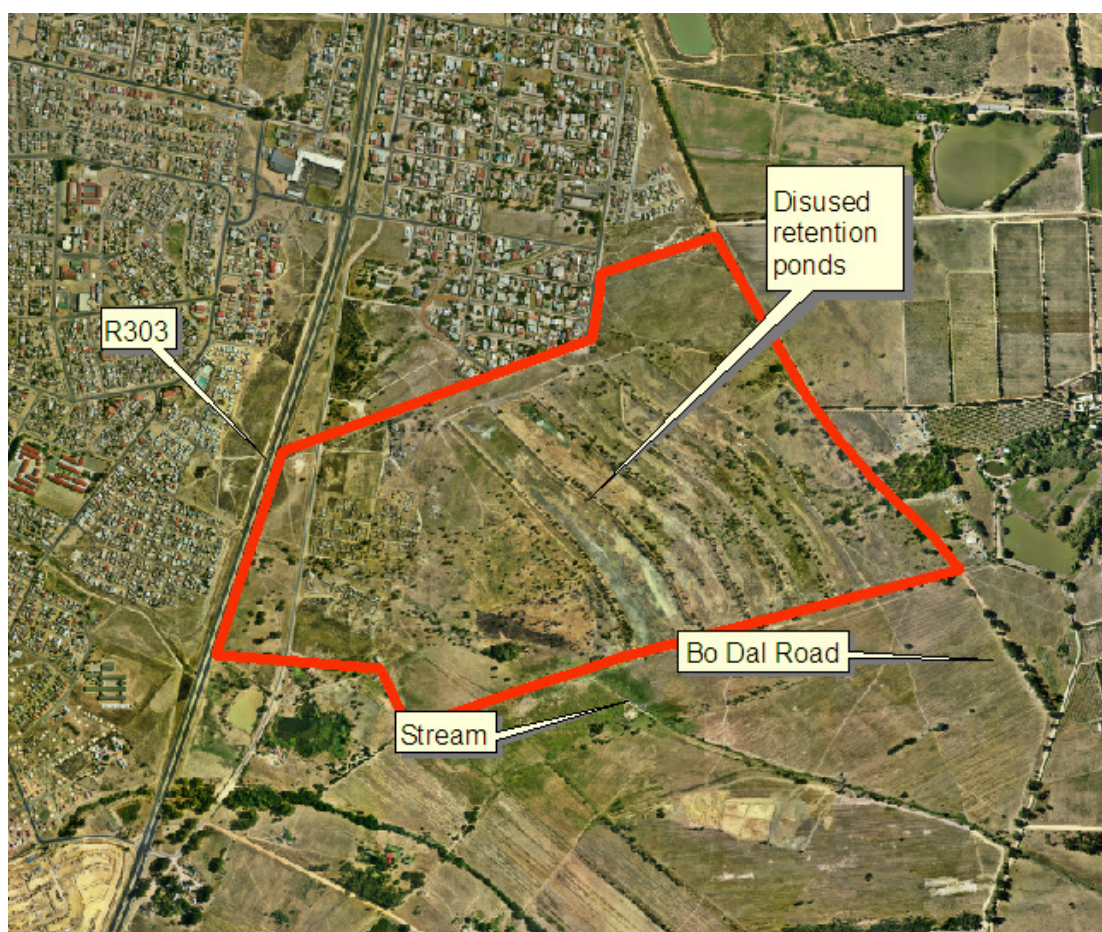
## SITE DESCRIPTION

The site is an area of former farmland, bordered by the R303 to the west, the Paarl township of Newtown to the north, the Bo Dal road to the east, and vacant farmland and the Klein Vlakkeland property to the south (see **Figures 1 & 2**).



**Figure 1:** Map extract showing location of the Vlakkeland site and key features described in this report.

The site slopes steeply down from the Do Bal Road and the gently from the east to the west (**Appendix B, Figures 1 and 2**). The greater portion of the site is taken up by a series of wastewater effluent retention ponds utilized by the Paarl Municipality for several decades until circa 1997 (Mr Cedric Morkel, pers. comm.). Effluent was pumped to the ponds and chlorinated. Overflow from the ponds was conveyed via a pipeline from the south-western corner of the ponds to the Berg River. When use of the ponds was terminated, the pond walls were breached and the site vacated (**Appendix B, Figure 8**).



**Figure 2:** The Vlakkeland site (2009 image) (Source: Drakenstein Municipality).

The western boundary of the site is occupied by an informal settlement.

A small, degraded streamline enters the site from the south via an indistinct drainage line that has been variously manipulated to direct flows along the property boundary towards the west (**Appendix B, Figures 3 - 5**). The bulk of the flow conveyed by this streamline appears to discharge over a broad area on the adjoining property.



An examination of aerial photography for the years 1938 and 1966, prior to the construction of the retention pond system, reveals farmlands and the small stream (see **Figures 3 and 4**), with the stream being very indistinct and becoming more apparent with development of the upstream catchment.



**Figure 3:** The Vlakkeland site (approximate outline in red) as in 1938. The streamline, entering the site towards the south-western corner, appears as little more than a field (tile) drain.



**Figure 4:** The Vlakkeland site (approximate outline in red) as in 1966. The streamline is now more obvious as a result of upstream development.

## ASSESSMENT

The site was assessed on 29 April 2013, on foot and by vehicle. A photographic record of key features is appended to this report (**Appendix B**).

### Stream

The Kleinbosch Stream that passes through the site rises in the foothill slopes to the southwest and by the time it reaches the Bo Dal Road it is already severely degraded and lacking in any formal management (**Appendix B, Figure 3**). The stream was not flowing at the time of this site visit. The stream becomes a severely-degraded urban drainage line when it passes through the informal settlement alongside the R303 and thence to the Berg River ((**Appendix B, Figures 6 & 7**). The informal settlement contains a number of pens and shelters for pigs and other farm animals, these

roaming freely in the local area. These conditions have worsened considerably since (year) when DHEC assessed the adjoining Klein Vlakkeland site.

At the point of intersection with the southern boundary of the property, as well as up- and downstream thereof, the streamline is notional at best and occurs as little more than a boggy, man-modified ditch. There is no residual stream integrity and the ecological importance of the drainage line is considered to be extremely low.

The Bo Dal Road, along the eastern boundary of the site, has been recently embanked and surfaced. This upgrade has included a number of culverts beneath the road that currently discharging in an uncontrolled fashion on the site, principally into the bed of the easternmost pond.

### **Wetlands**

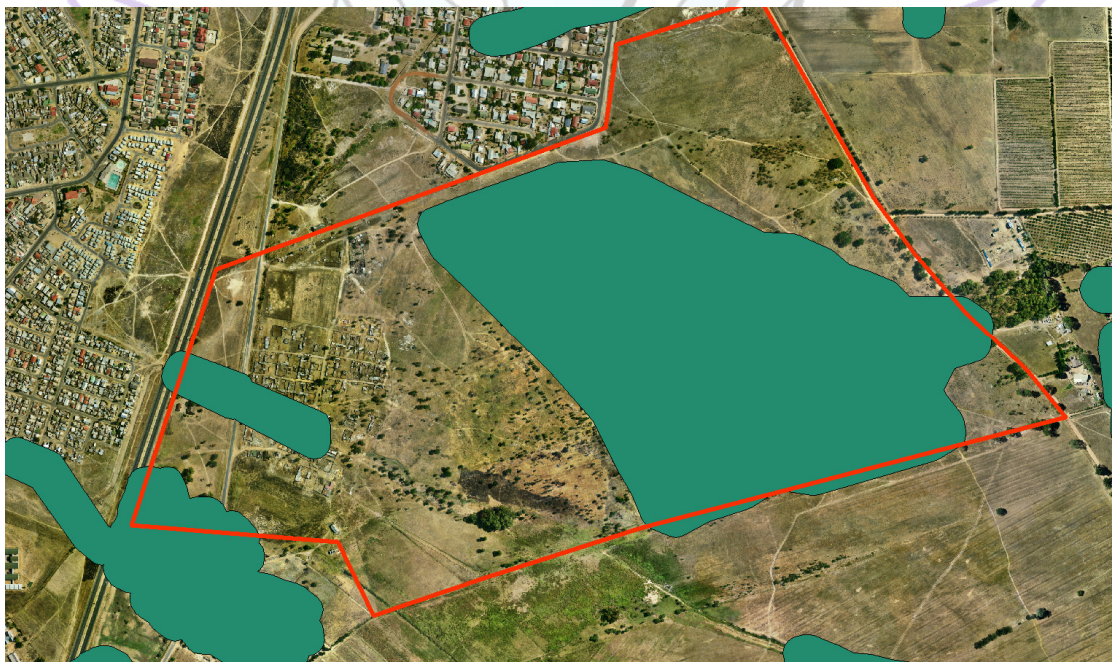
There is a tiny area of highly-disturbed wetland in the extreme south-western corner of the property, this being part of a series of excavated dams and ponds, i.e. man-made, on the adjoining Klein Vlakkeland property. This area has degraded almost beyond recognition since it was previously assessed by DHEC (see **Appendix C**).

### **Other features**

As mentioned above, the site contains a large area of five longitudinal retention ponds (aligned north-south) on the middle to eastern portion of the property. These ponds are no longer in use and have been breached to preclude them from retaining rainwater. Some boggy areas supporting wetland vegetation have developed in the easternmost and adjacent pan, these having possibly given rise to the previous noting of possible wetland presence (see **Appendix A**). These areas have arisen as a consequence of the construction of the pans and their retention of shallow water levels, either directlyly rainfed or from the culverts installed under the upgraded Bo Dal Road (**Appendix B, Figures 9 & 10**).

Accordingly, and as is confirmed from the historical record (**Figures 3 and 4**), there are no natural wetlands on the site. In this regard, the following definition of 'wetlands' is subscribed to by DHEC when evaluating such areas:

**“Wetland”** means an area that is inundated or saturated by surface water and/or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically-adapted (obligate) for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do **not** include those artificial wetlands intentionally-created from non-wetland sites, including but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm dams or ponds, and landscape amenities, or those wetlands that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may, however, include those artificial wetlands intentionally-created from non-wetland areas to mitigate the conversion of wetlands and/or any man-made areas that have, over time, developed especial, rare or irreplaceable ecosystem functional value(s) and services.



**Figure 5:** Extract from Drakenstein EMF GIS wetlands layer showing the areas deemed by the DEMF to be wetlands. The wetland areas are completely artificial and dysfunctional as aquatic environments.

## EXISTING PROTECTIONS

Per the Drakenstein Environmental Management Framework (DEMF), the pans and the disused dam to the south-west (Klein Vlakkeland) have been mapped as wetlands (see **Figure 5**). This classification is clearly incorrect and is not considered further in this report. The DEMF further maps the western end of the streamline where it passes through the informal settlement. A possible option for the streamline is provided hereunder.

There are no NFEPA (National Freshwater Ecosystem Priority Areas) wetlands mapped for this site.

## SUMMARY

### Streamline

The site encompasses a reach of highly degraded streamline passing through the south-western portion of the property. It is understood that the proposal for future development of the site has included re-aligning the streamline along the western boundary. Given that the streamline is already so degraded, from both recent and historical abuse, it is my opinion that this is an option well-worth considering. It would, however, require that the rehabilitation and re-alignment of the streamline be extended upstream towards the Bo Dal Road and also be dependent on the future planning and drainage needs of the adjacent site. These do not appear to be insurmountable issues.

An alternative, and in my opinion superior option, would be to divert the streamline towards the southwest as soon as possible after it crosses the Bo Dal Road and allow it to confluence with the immediately adjacent stream that ultimately confluences with the Dal River flowing along the northern side of the Dal Road (see **Figure 6**). This would allow the stream to connect with a watercourse of good condition, rather than allowing it to simply discharge into the degraded environments alongside the R303.

A third option would be to rehabilitate the streamline through the proposed development. However, given there appears to be an option to not condemn the stream to the further abuse of an urban drainage line, it is my opinion that this option not be considered.

### Stormwater Detention

It is understood that the proposed development will locate its stormwater retention ponds in the south-western corner of the site, i.e. in the degraded area where a small dam once existed. A managed stormwater ponding system would serve to offset the loss of the ponds in the local area between the Vlakkeland and Klein Vlakkeland properties.



**Figure 6:** Proposed diversion option for the Kleinbosch Stream (Red Arrow), southwest to an adjacent, good condition drainage line flowing to the Dal River.

## **AMENDMENT NOTE TO REPORT DHEC 622 (2013): VLAKKELAND (PAARL)**

This amendment provides additional clarification to my report DHEC622 of 2013, in particular with respect to the issues raised by Mr J Knaggs (Drakenstein), in his letter to Guillaume Nel Environmental Consultants dd 31 March 2014. The following serves to provide additional background regarding the apparent existence of wetlands in the southwestern corner of the property (Points 1-8, hereunder). Other issues are addressed thereafter (Points 9 – 10, hereunder):

### **Section A**

This section addresses Pts 21, 22, 24, 26, 28 & 31 of the aforementioned letter:

1. When I first visited the Vlakkeland area in the late 2000s (for assessments of the adjacent TopPrime property), I found no evidence of wetland conditions on the northern and eastern boundaries thereof. My impressions of the site led me to believe that the water that drained off the adjacent farming areas was captured in earth drains (tiledrains) leading to and dug around the TopPrime property, leading the runoff to the Dal River and/or to the culvert on the boundary between this site and the Vlakkeland property that we are now concerned with. My report for same included photographic details of said drains and the general dryness of the surrounding lands. The existence and direction of the aforementioned drains are clearly evident in aerial photography (e.g. *GoogleEarth*).

2. When I first assessed the Vlakkeland site (early 2013, reported on in DHEC622), I noted that there was evidence of recent wetland character in the SW corner. At the time I considered this to be as a result of the field drains, flowing in a general north-westerly direction, no longer being managed, leading to blocking and overflowing in a broad, spread-out fashion. This type of occurrence creates conditions for hardy pioneer wetland vegetation to establish in response to the availability of water. Similar scenarios are common in the ditches and road verges alongside highways. I also noted that the Kleinbosch River terminated on the surface of the SAHRA property and, although dry at the time, was clearly flowing south of the shallow berm between the SAHRA and Vlakkeland properties, i.e. towards the TopPrime site. I assumed that this berm had been created during the excavation and maintenance of the channel leading from the outflow of the now-disused evaporation pans – an alignment parallel to the Vlakkeland/SAHRA boundary.

A hydrological assessment recently conducted by Graeme McGill has confirmed my argument concerning the irregular spatial distribution of flows due to the absence of management of field drains and berms. As such, should these unmanaged flows be appropriately routed, the wetland characteristics will disappear.

3. At the same time as (2) I found the area west of the evaporation ponds to be hardset (impossible to dig or core below 4-5 cm) and minimally vegetated. There were no wetland indicators. As recently as 2003 this flat area was covered with rooikrans (as discerned from *GoogleEarth* historical imagery; see Note 1).

4. During my 2014 resurvey, I found the Kleinbosch River to indeed be spreading on the adjacent SAHRA property, as well as passing through a single breach in the berm between the two sites, spreading on the Vlakkeland site before being captured by the shallow channel of the Kleinbosch River flowing towards the piggery.

5. During 2014 I became aware of the existence of a geotechnical report prepared in 2008 (R Bradshaw) which, although not providing any direct evidence of wetlands *sensu strictu*, reported on alluvial substrates west and southwest of the evaporation ponds. As a result, and in consultation with Professor Cornie Van Huyssteen of Free State University, I undertook a further soils investigation (see accompanying report). This revealed that the aforementioned area west of the evaporation ponds was found to be a shallow perched aquifer of approximately 0.4 m in depth, too wet and too fluidized (sand filter consistency) to support anything other than very stunted wetland-associated plants. A greater level of aquatic macrophyte appearance existed in the shallow depressions towards the SW corner, in which eroded topsoil has accumulated and allowed the invasive *Pennisetum macrourum* to establish. The latter vegetation attribute has led to the presumption of wetland existence in the area as described.

The same soil characteristics persist into the adjacent TopPrime site, an area that is currently being developed for housing.

6. The alluvial perched aquifer presumably flows SW towards the excavated (sump) ponds on the TopPrime site. While alluvial layers are classified as wetlands, this area will be covered by fill for the development and its hydraulic linkage to the SW will not be altered. It should, however, be borne in mind that the flow through the



alluvial layer towards the Berg River has long been intersected by two main roads (Beets and Jan Van Riebeek), i.e. any presumed support of riparian wetlands along the Berg River has long since been terminated.

7. I originally and independently suggested that the Kleinbosch be connected to the Dal River on the SAHRA site (see Note 2, below). This was in accordance with the proposed ecological corridor extending to the northeast. The letter from Mr Knaggs indicates that diversion is a non-option and that the Kleinbosch must be restored to its original path through Vlakkeland. Two conflicting issues arise here: (a) historical aerial photography does not support the notion that the Kleinbosch ever flowed through Vlakkeland but rather to the southwest thereof; (b) I subsequently discovered that both the 2010 Drakenstein Urban Development Framework and the Drakenstein CBA mapping published on SANBI website, show the Kleinbosch River directed to the Dal River on the SAHRA property – i.e. not passing through Vlakkeland as is now indicated as a requirement. These municipal planning statements conflict with the opinion expressed by Mr Knaggs.

8. Should the Kleinbosch River be properly connected in a channel from the SAHRA site to the outlet from Vlakkeland, the overland spillage will no longer occur and the wetland characteristics will disappear. Similarly, if it is diverted to the Dal River, the same end result will accrue. As such, my original conclusion that the nature of the SW corner did not reflect a wetland, *sensu strictu*, remains valid.

Other issues raised by Mr Knaggs:

9. Pt 20 (Climate change): This is being addressed by the engineering hydrologist.

10. Pt 23 (Belcher Report, wetlands): I have not seen the mentioned Belcher report but understand that it refers to wetlands east of the evaporation ponds and possibly in the beds of the now disused ponds. While there is indeed wetland vegetation forming in the shallow pools (small vlei) east of the pans, this is deemed to be in response to the unmanaged flow of runoff from the upslope Seven Springs catchment. The environments currently extant will, if their current hydrology is not deliberately sustained, disappear once the Vlakkeland stormwater management system is created.

**Note 1:** Woody alien vegetation on the alluvial plain. The soils survey conducted during 2014 revealed a very wet sub-surface layer, almost entirely absent in plant roots. However, as recently as 2003, aerial imagery indicates relatively dense woody alien growth over much of the area, now presumably all removed as firewood. The growth of woody species such as rooikrans is contra-indicated in very wet soils, additionally no stumps were found, above or below ground.

**Note 2:** Reasons behind my recommending the diversion of the Kleinbosch River on the SAHRA property.

It is my understanding that development of the SAHRA property for housing or similar is unlikely. As such, I strongly felt that rehabilitation of the Kleinbosch River on said property and its linkage to the Dal River – the latter in fair ecological condition upstream of Beets Road but severely degraded downstream thereof, would maximize the ecological corridor services that the Kleinbosch could contribute to. The value of the alternative, i.e. passage through the Vlakkeland property, pales in comparative value: in the latter case the river would either (a) be discharged into the stormwater management system proposed for the southern boundary of Vlakkeland or (b) need to cross this management system and be conveyed in an engineered environment, through a high-density development, to Beets Road, at which point it would enter a hard engineered stormwater channel. There are no evident ecological arguments that support (b), while (a) has some merit if the Kleinbosch River is conveyed via a wetland environment on the SAHRA property into the stormwater management system, i.e. the created wetland environment would augment the paucity of this environment type in the local area. Few if any ecosystem services pertain west of Beets Road, either to the Dal River or the drain that is presumed to be the Kleinbosch River. As such, expenditure to extend the Kleinbosch through a development, a distance of a few hundred meters to Beets Road, are arguably lacking merit.

I trust that this additional information serves to clarify the understanding of the site and that the information will be useful for the continued planning for the development of the site.

Dr WR Harding, Pr Sci Nat.

Xx August 2014

Cornie van Huyssteen Consulting  
PO Box 25122  
Langenhovenpark 9330

082 781 2029

30 June 2014

Bill Harding  
DH Environmental Consulting (Pty) Ltd  
PO Box 5429  
Helderberg 7135

info@dhec.co.za

Dear Sir,

### **Vlakkeland Soil investigation**

#### **1. INTRODUCTION**

I was contacted by you to interpret soil photographs of the proposed Vlakkeland development for indications of wetland conditions.

#### **2. MATERIAL AND METHODS**

The photographs used in this evaluation was taken on 25 June 2014 by Bill Harding and supplied to me as file "TP profiles 25062014.pdf". This represented eight soil profiles marked Hole 1 to Hole 8. The photographs are attached as Appendix A and the map with locations of the profiles as Appendix B. All holes were between 0.4 and 0.5 m deep, except for holes 6 and 7 which were 0.7 m deep. The opinion expressed here must therefore be seen as a crude estimation of reality.

#### **3. RESULTS AND DISCUSSION**

All the holes had water or signs of water saturation. All profiles have, as far as is evident from a photograph, an orthic A topsoil, underlain by an E horizon. It was not possible to conclusively classify the third horizon. But my opinion is that it might be anything from a yellow brown apedal B, soft plinthic B, or G horizon – most probably the latter. It appeared that this layer started at 0.4 m. The soil forms (Soil Classification Working Group, 1991) of the eight profiles can therefore be Pinedene, Longlands, or Kroonstad – most probably the latter.

I interpret all eight profiles as being wetland soils, irrespective of the subsoil. My interpretation is based on the presence of the E horizon. E horizons are interpreted as representing zones of preferential flow in a landscape and are therefore prone to excessive wetness. [E horizons are identified by the grey colour, with or without mottling.] A further indication of excessive wetness is the dark, organic matter-rich, topsoil. This typically develops only in rather wet conditions. The wetland delineation guidelines (DWAF, 2005) also list E horizons as indicators of wetlands.

Other indicators pointing to excessive wetness are the presence of drains, used in agriculture to rid the soil of water, and the mottling observed in most of the photographs.

#### 4. CONCLUSIONS

I interpret all eight profiles as being temporary or seasonal wetland soils. This interpretation is based primarily on the presence of the grey layer in the soils that was classified as an E horizon. Other indicators of wetness are the presence of water in most of the profiles, mottling, and the fact that the area was drained for agricultural purposes.

#### 5. REFERENCES

DWAF, 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry, Pretoria.

SOIL CLASSIFICATION WORKING GROUP. 1991. Soil classification – A taxonomic system for South Africa. Mem. agric. nat. Resour. S. Afr. No. 15. Dept. Agric. Dev., Pretoria.

Kind Regards,



---

C.W. van Huyssteen  
Soil Scientist  
Ph.D.; Pr.Sci.Nat.: 400115/07

## Appendix A: Photographs of the soil profiles



Hole 5 (005)



Hole 5 (005)



Hole 6 (006)



Hole 6 (Hole 002)

<b>TRIAL PIT NO: TP26</b>		<b>METHOD OF INVESTIGATION : Digger/loader</b>	
		<b>COORDINATES: X: 3728450</b>	
		<b>Y: -500</b>	
: o : : o :		GRAVELLY SILTY SAND Dry, brownish grey, very dense, slightly pinholed, slightly clayey and fine gravelly silty medium to coarse sand. Alluvial wash. Fine roots to 0.1m.	
: : o : : :			
: o : : o :			
: : o : : :			
: o : : o :	0.45		
O : O : O		SILTY SANDY GRAVEL Dry, orange brown, very dense, layered, very	
: O   O :	0.70	slightly clayey silty medium to coarse gravel. Alluvial wash.	
O/:O/:O		CLAYEY SANDY GRAVEL Slightly moist, dark orange brown, very stiff,	
:/O/:O/:		slightly fissured, clayey medium to coarse sandy fine gravel. Colluvium.	
O/:O/:O			
:/O/:O/:	1.10		
/ / / / /		CLAYEY SILT Moist, dark khaki, very stiff, fissured, clayey silt.	
/ / / / /	1.30	Alluvial wash.	
/ / / / /		CLAYEY SILT Slightly moist, grey and mottled brown, very stiff/hard/	
/ / / / /	1.50	weakly cemented, slightly fissured, clayey silt. Colluvium/[edogenic.	
NOTE: Machine excavating very slowly throughout pit and beginning to refuse at 1.5m.			



Hole 7 (007)



Hole 7 (007)

TRIAL PIT NO: TP27

METHOD OF INVESTIGATION : Digger/loader

COORDINATES: X: 3728350

Y: -400

: o : : o :	0.45	GRAVELLY SILTY SAND Dry, brownish grey, very dense, slightly pinholed, slightly clayey and fine gravelly silty medium to coarse sand. Alluvial wash. Fine roots to 0.1m.
: : o : : :		
: o : : o :		
: : o : : :		
: o : : o :		
O : O : O	1.00	SILTY SANDY GRAVEL Dry, orange brown, very dense, layered, very slightly clayey silty medium to coarse gravel. Alluvial wash.
: O   O :		
O : O : O		
: O   O :		
O : O : O		
o / b / o	1.50	GRAVELLY CLAYEY SILT Slightly moist, grey and mottled brown, very stiff/hard/weakly cemented, slightly fissured, gravelly clayey silt. Colluvium/Pedogenic.
/ o / o /		
o / b / o		
/ o / o /		
o / b / o		
: : o : : :	2.50	GRAVELLY SILTY SAND Dry to slightly moist, light grey brown, very dense (locally weakly cemented), layered, gravelly silty sand with minor irregular thin layers of clayey silt. Alluvial wash/pedogenic.
: o : : o :		
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TRIAL PIT NO: TP28

METHOD OF INVESTIGATION : Digger/loader

COORDINATES: X: 3728250

Y: -300

: o : : o :	0.75	SILTY GRAVELLY SAND Dry, brownish grey, very dense to loose, slightly pinholed, slightly clayey and fine silty gravelly medium to coarse sand. High concentrations of gravel, in places, near basal contact. Alluvial wash. Fine roots to 0.1m.
: : o : : :		
: o : : o :		
: : o : : :		
: o : : o :		
o / b / o	1.25	GRAVELLY SANDY CLAY Moist, red brown becoming yellow brown with depth, firm to stiff, fissured, gravelly sandy clay. Alluvial wash.
/ o / o /		
o / b / o		
/ o / o /		
o / b / o		
/ / / / /	1.40	CLAYEY SILT Slightly moist, khaki grey, fissured, weakly cemented, sandy clayey silt with more sandy patches. Transported.
/ / / / /		

NOTE: Machine refused at 1.4m depth.



TP33 (Hole 002)



TP33 (Hole 002)



TP33 (Site 2)



TRIAL PIT NO: TP33

METHOD OF INVESTIGATION : Digger/loader  
COORDINATES: X: 3728350  
Y: -200

o : o :	GRAVELLY SILTY SAND Slightly moist, brownish grey, very loose, slightly pinholed, slightly clayey and fine silty gravelly medium to coarse sand. Coarser grained towards basal contact. Alluvial wash. Fine roots to 0.1m.
: : o :	
o : o :	
: : o :	
o : o :	
: : o :	
o : o :	
: : o :	
o : o :	
: : o :	
o / b / o	0.70 GRAVELLY CLAYEY SILT Moist, light khaki, blotched light brown, stiff to very stiff, fissured clayey silt with fine and scattered medium gravel. Alluvial wash.
/ o / o /	
o / b / o	
/ o / o /	
o / b / o	1.40 GREYWACKE Light khaki, stained and mottled red brown, highly weathered, very fine grained, very closely to closely jointed (sub vertical foliation and joints), very soft rock to generally soft rock greywacke, and very soft rock to very stiff soil.
/ o / o /	
o / b / o	
/ o / o /	
o / b / o	
/ o / o /	
o / b / o	
/ o / o /	
o / b / o	
/ o / o /	
o / b / o	3.05



TP34 (Hole 003)



TP34 (Hole 003)

TRIAL PIT NO: TP34

METHOD OF INVESTIGATION : Digger/loader  
COORDINATES: X: 3728450  
Y: -300



Hole 8 (008)



Hole 8 (008)

o : o :	0.35 GRAVELLY SILTY SAND Dry, greyish brown, very dense, layered and locally slightly pinholed, slightly clayey medium to coarse sand with a fine gravel component. Numerous fine roots to 0.1m.
: : o :	
o : o :	
: : o :	
O : O : O	0.75 SILTY SANDY GRAVEL Dry, brownish grey, dense, layered, very slightly clayey and silty sandy fine gravel. Alluvium.
: O   O :	
O : O : O	
: O   O :	
o : : : o :	2.45 GRAVELLY CLAYEY SILTY SAND Slightly moist becoming moist with depth, khaki to 1.3m then light khaki grey, stiff to very stiff, fissured, clayey silty medium sand with scattered fine and medium gravel. Locally patches of clayey silt or weakly cemented soil. Alluvium.
f : o : f :	
o : : : o :	
f : o : f :	
o : : : o :	
f : o : f :	
o : : : o :	
f : o : f :	
o : : : o :	
f : o : f :	
o : : : o :	
f : o : f :	
o : : : o :	
f : o : f :	
o : : : o :	

NOTE: Machine excavating very slowly at 2.45m.



TP35 (Hole 004)



TP35 (Hole 004)

<b>TRIAL PIT NO:</b> TP35		<b>METHOD OF INVESTIGATION :</b> Digger/loader	
		<b>COORDINATES: X:</b> 3728546	
		<b>Y:</b> -387	
: o : : o :		GRAVELLY SILTY SAND Dry, greyish brown, dense, layered and	
: : : o : : :	0.15	locally slightly pinholed, slightly clayey medium to coarse sand	
: o : : o :		with a fine gravel component. Numerous fine roots to 0.1m.	
/ : o : : :		GRAVELLY CLAYEY SILTY SAND Dry, orange brown, very dense,	
: o : : o :		layered, clayey silty fine to coarse sand with a very minor fine	
/ : o : : :		gravel component. Alluvium.	
: o : : o :	0.65		
O : O : O		SILTY SANDY GRAVEL Dry, brownish grey, very dense/hard (weakly	
: O   O :		cemented), intact, sandy fine gravel with a minor slightly clayey and	
O : O : O	1.00	silty coarse sandy matrix. Alluvium/pedogenic.	
NOTE: Machine refused at 1m depth.			

<b>TRIAL PIT NO:</b> TP36		<b>METHOD OF INVESTIGATION :</b> Digger/loader	
		<b>COORDINATES: X:</b> 3728650	
		<b>Y:</b> -300	
: o : : o :		GRAVELLY SILTY SAND Dry, greyish brown, medium dense, layered	
: : : o : : :		and locally slightly pinholed, slightly clayey medium to coarse sand	
: o : : o :		with a fine gravel component. Numerous fine roots to 0.1m.	
: : : o : : :			
: o : : o :	0.50		
: o : : o :		GRAVELLY CLAYEY SILTY SAND Dry, orange brown, very dense,	
/ : o : : :		layered, clayey silty fine to coarse sand with a very minor fine	
: o : : o :		gravel component. Weakly cemented towards 1m depth. Alluvium.	
/ : o : : :			
: o : : o :			
/ : o : : :	1.05		
NOTE: Machine refused at 1.05m depth.			

<b>TRIAL PIT NO:</b> TP37		<b>METHOD OF INVESTIGATION :</b> Digger/loader	
		<b>COORDINATES: X:</b> 3728550	
		<b>Y:</b> -200	
: : : : : : :		SILTY SAND Dry to slightly moist, brownish grey becoming greyish	
: : : : : : :		brown, medium dense, slightly pinholed, very slightly clayey,	
: : : : : : :		silty medium sand. Alluvial wash.	
: : : : : : :	0.40		
□ □ □		FERRICRETE Moist, dark orange brown and brownish grey,	
□ □ □		very dense/medium dense, layered, coarse gravel-size blocks of	
□ □ □		hardpan ferricrete in a minor coarse sandy matrix. Pedogenic.	
□ □ □	0.90		
: o : : o :		GRAVELLY CLAYEY SILTY SAND Slightly moist becoming moist with	
/ : o : : :		depth, khaki, blotched orange brown, black and white, firm to very stiff,	
: o : : o :		fissured, clayey silty medium sand with scattered fine and medium gravel.	
/ : o : : :		Locally patches of clayey silt or weakly cemented soil. Alluvium.	
: o : : o :			
/ : o : : :			
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: o : : o :			
/ : o : : :			
: o : : o :			
/ : o : : :	2.50		



TP38 (Hole 001)



Appendix B: Map of the soil profiles

