- Upstream of the Tutuka Power Station at DWA gauging station C11_177960, which is situated downstream of the New Denmark Colliery and upstream of the confluence of the tributary of the Leeuspruit, and
- Downstream of the Tutuka Power Station at DWA gauging station C11_90587 at Welbedacht 382 upstream of the Grootdraai Dam (**Figure 6.21**).

These monitoring stations provide minimum, maximum, median and 90th percentile values for the variables (**Table 6.10**) measured between the periods 1999 to 2007 (C11_177960) and 1974 to 2007 (C11_90587). The water quality at DWA site C11_90587 (downstream of the Tutuka Power Station) shows a decrease in quality compared to the upstream site. Constituents of concern are noted as: pH, electrical conductivity (EC), sodium, chloride, fluoride and sulphate (**Table 6.10**).

Table 6.10: Historical water quality for two DWA monitoring sites on the Leeuspruit (C11K)

Variable	**Abbreviation**	**Unit**	**C11_177960**			**C11_90587**		
			Min	90th percentile		Min	90th percentile	
			Max	Median		Max	Median	
Position in relation to Tutuka Power Station			Upstream			Downstream		
pH		H^{1+} ions	8.6	8.25		10.39	8.65	
			6.5	7.7	n=65	6.07	8.1	n=1240
Electrical Conductivity	EC	mS/m	239	46		491	159	
			17	33	n=65	10.8	44.2	n=1307
Total Dissolved Solids	TDS	ppm	-	-		3711	1072	
			-	-	n= -	73	340	n=1181
Calcium	Ca	mg/l	240	35.19		161	38.25	
			5.1	19.1	n=41	5.2	23.14	n=1212
Magnesium	Mg	mg/l	211	26.82		79.3	33.94	
			8.2	16.2	n=41	3.6	18.18	n=1212
Potassium	K	mg/l	-	-		13.45	7.83	
			-	-	n= -	0.43	5.3	n=1212
Sodium	Na	mg/l	57.8	34.65		983	252	
			3	20.5	n=27	5.41	33.23	n=1210
T Alkalinity	Tal	mg/l	182	180		496	289	
			170	176	n=2	20.7	138	n=1211
Chloride	Cl	mg/l	85	29.2		639	203	
			3	18	n=59	1.5	25.34	n=1217
Fluoride	F	mg/l	0.5	0.4		4.66	1.76	
			0.05	0.3	n=49	0.05	0.34	n=1211
Silica	Si	mg/l	-	-		12.82	9.62	
			-	-	n= -	0.2	6.42	n=1213

Variable	Abbreviation	Unit	C11_177960			C11_90587		
			Min	90th percentile		Min	90th percentile	
			Max	Median		Max	Median	
Position in relation to Tutuka Power Station			Upstream			Downstream		
Sulphate	SO4	mg/l	1360	86.5		1501	175	
			5	38	n=65	2	44.5	n=1215
Ammonia	NH4(N)	mg/l	7.5	0.55		10	0.1	
			0.05	0.3	n=65	0.015	0.04	n=1213
Nitrate	NO3(N)	mg/l	1.6	0.59		5	0.27	
			0.05	0.1	n=65	0.005	0.04	n=1237
Phosphate	PO4(P)	mg/l	3.4	0.3		2.6	0.15	
			0.05	0.05	n=64	0.003	0.05	n=1237
Total Phosphate	TP	mg/l	-	-		3.56	0.34	
			-	-	n= -	0.015	0.16	n=860

- ***Expected Macroinvertebrate Species***

A list of macroinvertebrates expected to occur in the study area or indicating the possibility of occurrence was determined for the major drainage lines (**Table 6.11; Figure 6.24**). Each taxon was allocated a rating score of either 1, 3 or 5: a rating of 5 indicates that the specific taxon has been sampled within that sub-quaternary (SQ) reach and is likely to be sampled; a rating of 3 indicates that the taxon has not been sampled in the SQ reach but has been sampled in a similar SQ reach and the probability of occurrence has been extrapolated; a rating of 1 indicates that the taxon has not been sampled in the SQ reach or any other similar SQ reach but is thought to be potentially present taking into account the available habitat, water quality and associated land use activities. Only one relatively sensitive taxon is expected to occur within the study area, namely Leptophlebiidae, which has a sensitivity score of 9 out of a possible 15 (Gerber & Gabriel, 2002), representing a taxon that is moderately intolerant to alterations in water quality (pollution).

Table 6.11: Macroinvertebrate species expected to occur, or indicating the possibility of occurrence, in the different sub-quaternary reaches located within the study area. Taxa in red are considered sensitive taxa

ID		A	B	C
	SS	Leeuspruit	Tributary of Leeuspruit	Tributary of Vaal
Turbellaria	3	1	1	1
Oligochaeta	1	1	1	1
Hirudinea	3	1	1	1
Potamonautidae	3	1	1	1
Atyidae	8	1	1	1
Hydracarina	8	1	1	1
Baetidae > 2 Sp.	12	1	1	1
Caenidae	6	1	1	1
Leptophlebiidae	**9**	**1**	**1**	**1**
Coenagrionidae	4	1	1	1
Aeshnidae	8	1	1	1
Gomphidae	6	1	1	1
Libellulidae	4	1	1	1
Belostomatidae	3	1	1	1
Corixidae	3	1	1	1
Gerridae	5	1	1	1
Hydrometridae	6	1	1	1
Naucoridae	7	1	1	1
Nepidae	3	1	1	1
Notonectidae	3	1	1	1
Pleidae	4	1	1	1
Veliidae/Mesoveliidae	5	1	1	1
Hydropsychidae 1 Sp.	4	1	1	1
Hydroptilidae	6	1	1	1
Leptoceridae	6	1	1	1
Dytiscidae	5	1	1	1
Elmidae/Dryopidae	8	1	1	1
Gyrinidae	5	1	1	1
Hydrophilidae	5	1	1	1
Ceratopogonidae	5	1	1	1
Chironomidae	2	1	1	1
Culicidae	1	1	1	1
Muscidae	1	1	1	1
Simuliidae	5	1	1	1
Tabanidae	5	1	1	1
Ancylidae	6	1	1	1
Physidae	3	1	1	1
Planorbinae	3	1	1	1
Corbiculidae	5	1	1	1
Sphaeriidae	3	1	1	1

SS = Sensitivity Score (Dickens & Graham, 2001)

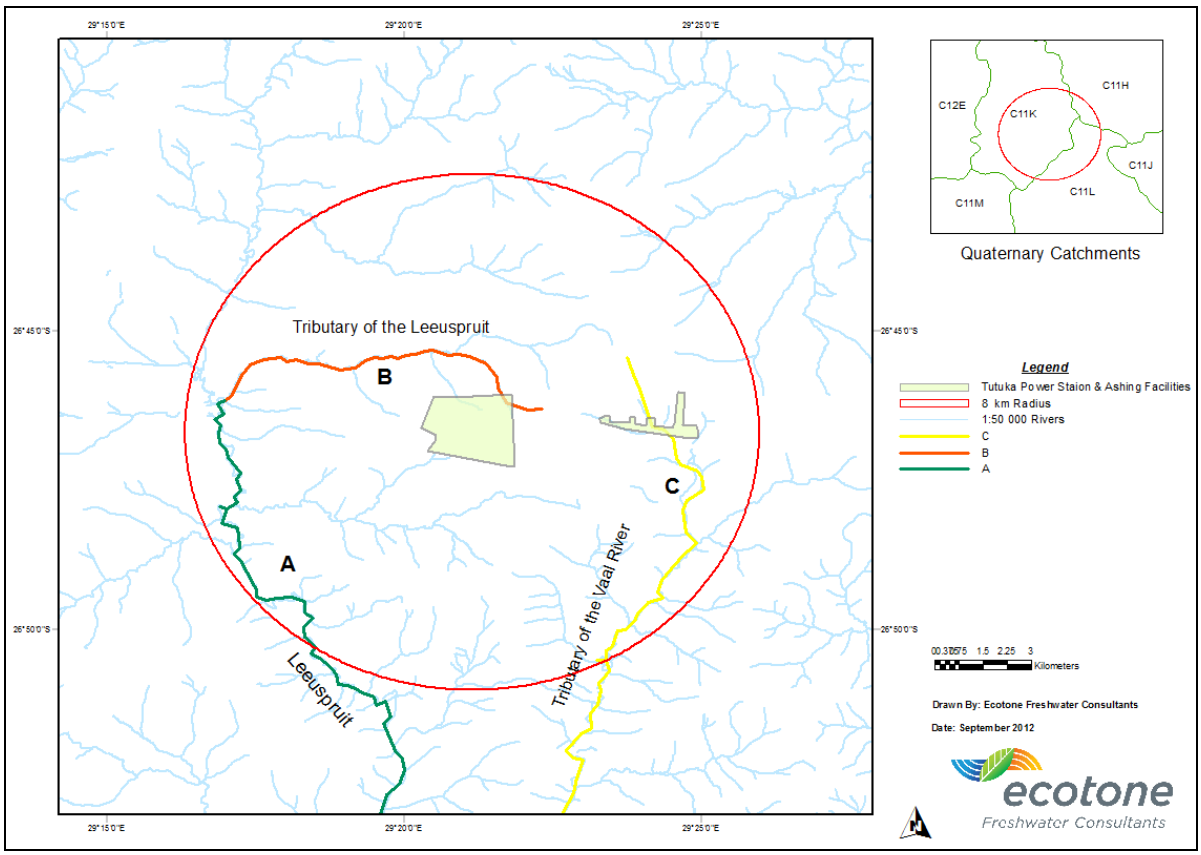

Figure 6.24: Sub-quaternary catchments related to the expected macroinvertebrate species list (Chief Directorate – Surveys and Mapping, 2629; Pers.Comm. Mrs. Christa Thirion, 2012).

- ***Expected Fish Species***

A summary of the expected fish families, species and IUCN conservation status is provided in **Table 6.12**. The study area provides potential refuge for four fish families represented by approximately 12 species (Kleynhans et al., 2007; IUCN, 2012), none of which have conservation status and are listed as Least Concern (LC) by the IUCN (2012). Barbus neefi (Kleynhans et al., 2007) and Barbus pallidus (IUCN, 2012) are expected to occur in the study area and both species are moderately intolerant to alterations in water quality making them good indicators of ecosystem health.

Table 6.12: Fish species expected to occur, or indicating the possibility of occurrence, in the river systems located within the 8 km radius

Family	Genus and Species	Common Name	IUCN Status
Austroglanididae	*Austroglanis sclateri*	Rock Catfish	LC
Cyprinidae	*Barbus anoplus*	Chubbyhead Barb	LC
Cyprinidae	*Barbus neefi*	Sidespot Barb	LC
Cyprinidae	*Barbus pallidus*	Goldie Barb	LC
Cyprinidae	*Barbus paludinosus*	Straightfin Barb	LC
Clariidae	*Clarias gariepinus*	Sharptooth Catfish	LC

Family	Genus and Species	Common Name	IUCN Status
Cyprinidae	*Cyprinus carpio*	Common Carp	EX
Cyprinidae	*Labeobarbus aeneus*	Smallmouth Yellowfish	LC
Cyprinidae	*Labeo capensis*	Orange River Labeo	LC
Cyprinidae	*Labeo umbratus*	Moggel	LC
Cichlidae	*Pseudocrenilabrus philander*	Southern Mouthbrooder	LC
Cichlidae	*Tilapia sparrmanii*	Banded Tilapia	LC
LC: Least Concern; EX: Exotic			

- ***Expected Odonata (dragonflies) Species***

Approximately 60 Odonata species are expected to occur in the study area. All species are listed as LC according to the IUCN database (IUCN, 2012).

- ***Expected Mollusca (snails, limpets) Species***

A total of 10 mollusc species are expected to occur in the study area, of which nine species are listed as LC. Only one species, namely *Burnupia caffra, is listed as Data Deficient (DD)* due to taxonomic uncertainty. Burnupia caffra are frequently unobserved during sampling surveys due to their extremely small size (2 - 4 mm). The genus Burnupia needs taxonomic revision as the numbers of species are extremely uncertain (Appleton et al., 2010).

Further detail can be obtained from the Surface Water Specialist Report in **Appendix K**.

6.3.10 Groundwater

The Department of Water Affairs (DWA) have produced a series of 1:500 000 scale hydrogeology maps (General Hydrogeology Map Series), that cover the whole of South Africa. Analysis of median borehole yields and aquifer types has allowed DWA to classify the aquifers of the country according to an alphanumeric code incorporating aquifer type and borehole yield, as presented in **Table 6.13** below.

Table 6.13: General Hydrogeology Map classification of South Africa

Aquifer Type	Borehole Yield Class (L/s)				
	Class "1" 0 - 0.1	Class "2" 0.1 - 0.5	Class "3" 0.5 - 2.0	Class "4" 2.0 - 5.0	Class "5" >5.0
Type "a": Inter-granular	A1	A2	A3	A4	A5
Type "b": Fractured	B1	B2	B3	B4	B5
Type "c": Karst	C1	C2	C3	C4	C5
Type "d": Inter-granular and fractured	D1	D2	D3	D4	D5

The DWA 1:500 000 scale hydrogeology map of the area (Sheet 2526 Johannesburg) shows that the area within an 8 km radius of the Tutuka power station is entirely classified

as "D2", suggesting the underlying aquifer is inter-granular and fractured and the average borehole yield ranges between 0.1 and 0.5 litres per second (L/s). There are no major groundwater abstractions shown on the hydrogeological map within 8 km of the site.

An extract of the hydrogeological map is presented in **Figure 6.25**.

- ***Quaternary Catchment Area***

The area within an 8km radius of the Tutuka power station is located in quaternary catchment C11K (GRA2), within the Upper Vaal Water Management Area. The GRA2 data for the quaternary catchment C11K is summarized in **Table 6.14** below.

Table 6.14: Summary of the GRA2 Data

QUATERNARY CATCHMENT	C11K
Area (km^2)	340
Average water level (meters below ground level)	7.61
Volume of water in aquifer storage (Mm^3/km^2)	258.96
Specific Yield	0.003
Harvest Potential (Mm^3/a)	7.41
Contribution to river base flow (Mm^3/a)	1.82
Utilizable groundwater exploitation potential in a wet season (Mm^3/a)	2.44
Utilizable groundwater exploitation potential in a dry season (Mm^3/a)	1.58

The Groundwater Harvest Potential Map of South Africa (Baron et al, 1998) classifies the study area as having an estimated groundwater harvest potential of 15 000 to 25 000 m^3/km^2/year (i.e. relatively low). It also suggests that the average borehole yield is > 0.4 litres per second (L/s), and the total dissolved solids concentration of the (unpolluted) groundwater is between 200 and 300 mg/l (i.e. relatively fresh).

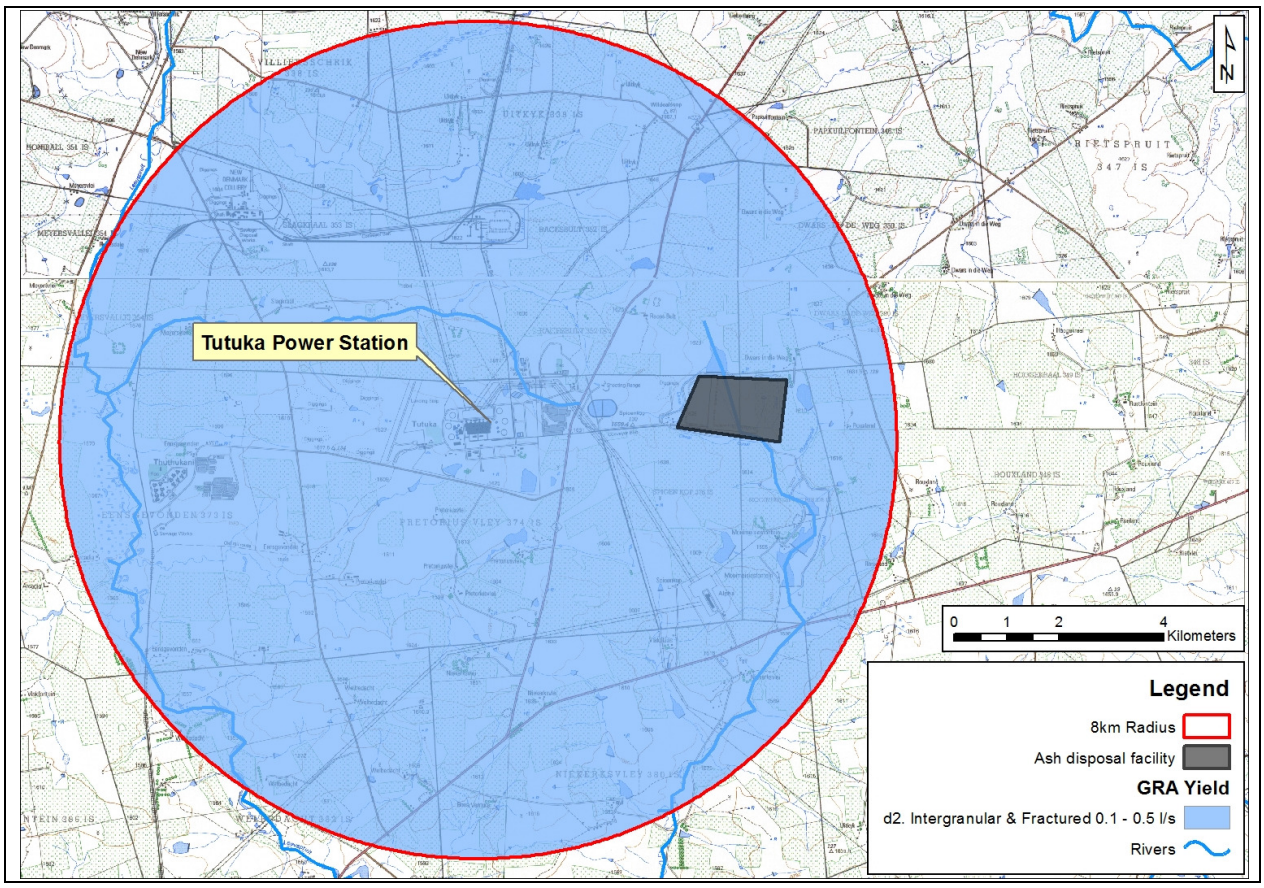

Figure 6.25: An overview of the hydrogeology of the study area.

Further detail can be obtained from the Groundwater Specialist Report in **Appendix L**.

6.3.11 Sites of Archaeological, Historical and Cultural Interest

The cultural landscape qualities of the region essentially consist of a rural setup. In this the human occupation is made up of a pre-colonial element consisting of limited Stone Age occupation and a Late Iron Age occupation, as well as a much later colonial (farmer) component.

- ***Stone Age***

No information about Stone Age habitation of the area is available. There might be two reasons for this. Firstly, it is unlikely that Stone Age people would have occupied the area specific, as it would have been too cold and no shelters or caves exists locally that could be used to shelter in. Secondly, no systematic survey of the area has been done and, as a result, no sites have been reported.

- ***Iron Age***

Iron Age people started to settle in Southern Africa AD 300, with one of the oldest known sites at Silver Leaves, south east of Tzaneen dating to AD 270. However, Iron Age occupation of the eastern highveld area (including the study area) did not start much

before the 1500s. Some sites dating to the Late Iron Age is known to exist to the north, south and west of the study area.

- ***Historic period***

The historical period in this area starts with the arrival of early missionaries, hunters and traders, followed later by the Voortrekkers, who settled permanently and started to farm in the area and developed a number of towns. The town of Standerton was founded in 1878 and attained municipal status in 1903 (Raper 2004). During the Anglo Boer War (1899-1902), some skirmishes took place in the region (Cloete 2000).

Building of the Tutuka Power Station commenced in 1980 and the first unit was put in commercial use on 1 June 1985 and the last unit on 4 June 1990 (www.eskom.co.za).

The farm, Pretorius Vley 374IS on which the power station was developed, was first granted to a certain Mr Pretorius in 1875. A house and farm buildings, approximately in the vicinity of the current farmstead to the southwest of the power station, is indicated on this map

- *Farmsteads*
  Farmsteads are complex features in the landscape, being made up of different yet interconnected elements. Typically these consist of a main house, gardens, outbuildings, sheds and barns, with some distance from that labourer housing and various cemeteries. In addition roads and tracks, stock pens and wind mills complete the setup. An impact on one element therefore impacts on the whole.

  By the early 19th century white settlers took up farms. An investigation of the Title Deeds of most of the farms in the region indicates that they were surveyed as early as the 1860s, implying that they would have been occupied by colonists since then.

  Many farmsteads in the region were destroyed during the Anglo Boer War. As a result most structures date to the period after that. The architecture of these farmsteads can be described as eclectic as they were built and added to as required over a period of time. In some cases outbuildings would be in the same style as the main house, if they date to the same period. However, they tend to vary considerably in style and materials used.

- *Cemeteries*
  Apart from the formal cemeteries that occur in municipal areas (towns or villages), a number of these, some quite informal, i.e. without fencing, occur sporadically all over. Many also seem to have been forgotten, making it very difficult to trace the descendants in a case where the graves are to be relocated.

  Most of these cemeteries, irrespective of the fact that they are for land owner or farm labourers (with a few exceptions where they were integrated), are family orientated.

They therefore serve as important 'documents' linking people directly by name to the land.

- *Infrastructure and industrial heritage*
  In many cases this aspect of heritage is left out of surveys, largely due to the fact that it is taken for granted. However, the land and its resources could not be accessed and exploited without the development of features such as roads, bridges, railway lines, electricity lines and telephone lines. A variety of bridges (**Figure 6.26**), railway lines and other features that can be included in this category occur near the study area.

Figure 6.26: An old bridge across the Leeuspuit.

Further detail can be obtained from the Heritage Specialist Report in **Appendix M**.

6.3.12 Visual Aspects

The study area for the visual assessment is focused to a 8 km radius from the Tutuka Power Station within the Lekwa Local Municipality.

There are no major towns in the immediate area. Standerton lies approximately 20 km to the south. A number of farms and homesteads occur throughout the study area, and in close proximity to the power station.

The visual character of Tutuka Power Station and its surroundings is shaped by a unique combination of the following features:

- An undulating topography with low lying ridges to the east;
- Non-Perennial streams and isolated dams;
- Cultivated land;
- The Tutuka Power Station (being a visually dominant feature in the area);
- An ash dump situated secluded from and east of the power station;
- Coal mines (situated 5 km and 10 km north of the power station);
- A substation;

- Dispersed farmsteads, and
- Roads - arterial routes (R30, R38, R546) and a number of access roads to farms in the region.

The closest towns are Standerton (20 km south west) and Charl Cilliers (20 km north west), both of which are situated beyond the zone of visual influence of the Ash Dump.

Cultivated land, coal mines and the Tutuka Power Station are the main form giving elements in the landscape, together with farmsteads dispersed through the region. The visual quality of the landscape is described as medium to low. The Tutuka Power Station and associated infrastructure has generally been accepted as a feature within the landscape, with its own inherent visual qualities.

Visibility of an object is one of the primary attributes by which visual impact can be concluded. This is determined by a line of sight where nothing obscures the view of an object. Exposure is defined by the degree of visibility, in other words "how much" or "which part" of an object is visible to the observer. This is influenced by topography and the incidence of objects such as trees and buildings that obscure the view partially or in total. Visibility can be modelled by making use of a digital terrain model (DTM), created from contour data, and performing a viewshed analysis using GIS software. It must be noted that the viewshed analysis only accounts for topographical influences, and that the screening effect of vegetation is not included. This indicates a worst-case scenario, where the possibility of visual exposure is mapped, from which possible sensitive viewer locations can be identified.

In addition to viewshed analyses as described above, a proximity analysis is required to incorporate the effect of reduced visibility over distance. By integrating the two types of analyses, an index of possible visual impact is generated, as shown on the map in **Figure 6.27**.

The map indicates a core area of high visibility and a high degree of visual exposure within 6 km from the ash disposal facility. The continuous ashing in an eastern direction is expected to increase its visibility and possibly impact on a number of sensitive receptors within 3 km from the site. Permanent residents within this 3 km radius need to be identified and requirements with regard to mitigation measures investigated during the EIA phase.