ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR 1') AND ASSOCIATED INFRASTRUCTURE

Agricultural Impact Assessment

September 2015

Prepared by: Golder Associates/ Imani Development (SA) (Pty) Ltd

Prepared for: Arcus GIBB Pty Ltd

On behalf of: Eskom Holdings Ltd

DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE

I, Jonathan Rhodes Howcroft as duly authorised representative of Golder Associates Africa (Pty) Ltd, hereby confirm my independence (as well as that of Golder Associates Africa (Pty) Ltd) as a specialist and declare that neither I nor Golder Associates Africa (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Arcus GIBB was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed conventional nuclear power station ('Nuclear 1'). I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in my attached report.

Full Name: Jonathan Rhodes Howcroft

Title / Position: Mr

Qualification(s): Msc

Experience (years/ months): 24

Registration(s):

DIRECTORS: FR SUTHERLAND, AM VAN NIEKERK, SAP BROWN, L GREYLING, SM MANYAKA

g:\projects\10543 - gaa agric specialist study - nuclear 1 eia\correspondence\10543_declaration of independence_jon howcroft (aug10).docx

EXECUTIVE SUMMARY

1. A survey undertaken within a 16km radius of all three sites showed that agriculture around Thyspunt is based substantially on milk production; fynbos prevails in the Bantamsklip area although there is some dairy as well as beef, sheep and game farming; while the Duynefontein area is based on mixed farming.

2. Given the information gathered in the agricultural study, it was estimated that the current annual value of farm production in 2008 was R150 million in the Thyspunt area, R29 million for Bantamsklip and R75 million for Duynefontein.

3. The major impacts of a nuclear power station on agriculture would be the generation of dust during the construction phase, labour shortages and wage increases, and market effects. The estimated impact on produce markets showed that the gross value of production in the Bantamsklip area ***could potentially*** increase by up to 5% and in the Thyspunt area by 10 to 15%, while no change is anticipated in the Duynefontein area.

4. From an agricultural production perspective Duynefontein is a mature site because grape and wheat production in the area has progressed alongside the construction and operational phases of the existing Koeberg Nuclear Power Station. Dust during construction of the new plant will have little effect on farm lands because the prevailing winds during the dry summer months are in line with the coastal strip.

   In summary, the impacts on agriculture at the three sites are as follows:

   Duynefontein – no significant impact on agriculture during construction and normal operations. No increase in agricultural production during operation.

   Thyspunt – ***short term*** negative impact on agriculture in terms of dust during the construction phase. However, there is potential for a positive impact on production by taking advantage of the increase in demand for agricultural produce on a regional basis (Eastern Cape) as a result of the proposed construction and operation of the power station.

   Bantamsklip – *short term* negative impact on agricultural production with regard to dust during the construction phase. There is an estimated potential of less than 5% to increase the market for local agricultural produce because of water limitations that restrict expansion.

   In terms of the impact on agriculture, there are no fatal flaws in respect of any of the three sites, and all of them would be suitable to accommodate Nuclear-1.

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR-1') AND ASSOCIATED INFRASTRUCTURE

CONTENTS

Chapter	Description		Page
EXECUTIVE SUMMARY			**2**
1	**INTRODUCTION**		**1**
	1.1	Background	1
	1.2	Methodology	2
2	**DESCRIPTION OF AFFECTED ENVIRONMENT**		**3**
	2.1	Description of Land Use (20km radius)	3
	2.1.1	Thyspunt	3
	2.1.2	Bantamsklip	8
	2.1.3	Duynefontein	10
	2.2	Agricultural Survey	13
	2.2.1	Soils	13
	2.2.2	Agricultural Survey of Farm Units within a 16km radius	20
	2.2.3	Thyspunt	20
	2.2.4	Bantamsklip	26
	2.2.5	Duynefontein	30
	2.2.6	Summary of Farming Practices	34
	2.3	Economic Analysis of Agriculture	34
3	**POTENTIAL IMPACTS ON AGRICULTURAL PRODUCTION**		**36**
	3.1	Introduction	36
	3.2	Literature Review and Related Case Studies	36
	3.3	Livestock	37
	3.3.1	Effect of Radionuclides on Livestock	38
	3.3.2	Potential Impacts on Livestock	42
		(1) Construction Phase	43
		(2) Operational Phase	44
		(4) Possibility of a Nuclear Incident	44
	3.4	Crop Production	45
	3.4.1	The Effect of Radionuclides on Crop Production	46
	3.4.2	Potential Impacts on Crop Production	46

	(1)	Construction	47
	(2)	Operational Phase	47
	(4)	Possibility of a Nuclear Incident	48
	3.5	Potential for Water Contamination	48
	3.6	Potential Economic and Marketing Impacts	48
	3.7	Potential Impact of Climate Change	51
	3.8	Impact of Desalination Plant	54
4	**MITIGATION MEASURES**		**55**
	4.1	Construction Phase	55
	4.2	Operational Phase	55
	4.2.1	Phase 1 − Data Gathering and Laboratories	55
	4.2.2	Phase 2 − Protective Measures	56
	4.3	Decommissioning Phase	56
5	**IMPACT ASSESSMENT**		**57**
	5.1	Impact Criteria	57
	5.2	Assessment	57
	(a)	Thyspunt	58
	(b)	Bantamsklip	58
	(c)	Duynefontein	59
6	**CONCLUSIONS AND RECOMMENDATIONS**		**60**
7	**REFERENCES**		**61**

TABLES

Table 2-1: Means and Extremes of Temperature for Cape St. Francis − 2004 (June) to 2007. 20
Table 2-2: Average, Maximum and Minimum Monthly Rainfall (mm) for Cape St. Francis − 2004 (June) to 2007 21
Table 2-3: Means and Extremes of Dry-bulb Temperatures for Hermanus − 2001 to 2007. 26
Table 2-4: Means and Extremes of Temperature for Struisbaai − 2001 to 2007....26
Table 2-5: Average, Maximum and Minimum Monthly Precipitation (mm) for Hermanus and Struisbaai − 2001 to 2007 (South African Weather Service). 27
Table 2-6: Means and Extremes of Dry-Bulb Temperature at the Duynefontein Site (measured 10 m above ground level) − (1980 To 2007) 30
Table 2-7: Monthly Measurements off Precipitation at the Duynefontein Site −1980 to 2007 31
Table 2-8: Farming Practices (number of farms)....34
Table 3-1: Maximum Inhalation and External Effective Dose Predicted In the 40 km by 40 km Study Area for 4 000 MWe nuclear power station 36
Table 3-2 : Estimated Economic Impact on the Markets of Agricultural Produce 51
Table 3-3 : Indicative Summary of Projected Changes in Mean Annual Rainfall at Tableview (Duynefontein)....51
Table 3-4 : Indicative Summary of Projected Changes in Mean Annual Rainfall for Pearly Beach (Bantamsklip) 52
Table 3-5 : Indicative Summary of Projected Changes in Mean Annual Rainfall for Oyster Bay (Thyspunt)....52
Table 3-6 : Indicative Summary of Projected Changes in Temperature for Tableview (Duynefontein)....53
Table 3-7 : Summary of Projected Changes in Temperature for Pearly Beach (Bantamsklip) 53
Table 3-8 : A Summary of Projected Changes in Temperature for Oyster Bay (Thyspunt) ...54
Table 4-1: Guideline Levels for Radionuclides in Foods for Use in International Trade following Accidental Nuclear Contamination....55
Table 5-1: Agricultural Impacts for sites....58

FIGURES

Figure 2-1: Borrow Pit Area 6
Figure 2-2: Woodlands Dairy 6
Figure 2-3: Land Use Map, Thyspunt 7
Figure 2-4: *Fynbos flower picking – The Springs Farm* 8
Figure 2-5: *Typical farmland* 8
Figure 2-6: Land Use Map - Bantamsklip 9
Figure 2-7: Land Use Map - Duynefontein....12
Figure 2-8: Broad Soil Pattern: Thyspunt....14
Figure 2-9: Broad Soil Pattern: Bantamsklip....15
Figure 2-10: Broad Soil Pattern: Duynefontein 16
Figure 2-11: Land Types: Bantamsklip 17
Figure 2-12: Land Types: Thyspunt....18
Figure 2-13: Land Types: Duynefontein....19
Figure 2-14: Dairy cows on a farm....22
Figure 2-15: Extensive silage production on most farms....23
Figure 2-16: Silage bales....23
Figure 2-17: Agricultural survey: Thyspunt 24
Figure 2-18: Types of farming: Thyspunt 25

Figure 2-19: Agricultural Survey: Bantamsklip 28
Figure 2-20: Types of Farming: Bantamsklip 29
Figure 2-21: Agricultural Survey : Duynefontein 32
Figure 2-22: Types of Farming: Duynefontein..33

APPENDICES

Appendix 1: Detailed information on each farm unit
Appendix 2: Soil Sample Results

ABBREVIATIONS

AERMIC	AMS/EPA Regulatory Model Improvement Committee
AERMOD	AERMIC dispersion model
AERMAP	AERMOD terrain pre-processor
AERMET	AERMOD meteorological pre-processor
AGIS	Agricultural Georeferenced Information System
APCS	Air Pollution Control System
AQGs	Air Quality Guidelines
BMP	best management practices
Bq	becquerel(s)
BWR	boiling water reactor
C	Celsius
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
cm	centimetre(s)
CNPP	Chernobyl Nuclear Power Plant
CO	Carbon monoxide
CO_2	Carbon dioxide
d	day
DBA	design-basis accident
DEA	Department of Environmental Affairs (previously Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DWEA	Department of Water and Environmental Affairs
EC	European Community
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
ESE	east-southeast
FAO	Food and Agriculture Organisation
g	gram
GDP	Gross Domestic Product
ha	hectare(s)
HC	Hydrocarbon
HLW	high-level waste
HP	High Pressure
HWR	Heavy Water Reactors
hr	hour(s)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ISCST	Industrial Sources Complex Short-Term Model
IT	Interim Targets
kg	kilogram(s)
km	kilometre(s)
kV	kilovolt(s)
kWh	kilowatt hour(s)
L	litre(s)
m	metre(s)
m/s	metre(s) per second
MSL	mean sea level
mSv	millisievert(s)
µSv	microsievert(s)
MW	megawatt(s)

MWt	megawatt(s)-thermal
MWh	megawatt hour(s)
NA	not applicable
NCDC	National Climatic Data Centre
NCRP	National Council on Radiation Protection and Measurements
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NNE	north-northeast
NOAA	National Oceanographic and Atmospheric Administration
NO	Nitrous oxide
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
OA	Options Analysis
PAH	Polycyclic aromatic hydrocarbons
PAZ	***Proactive Action Zone***
PPC	plant parameter corridor
ppm	parts per million
PM2.5	Particulate matter with diameter of 2.5 µm
PM10	Particulate matter with diameter of 10 µm
PWR	pressurised water reactor
RCIC	reactor core isolation cooling
REMP	radiological environmental monitoring programme
s	Second
SA	South African
SABS	South African Bureau of Standards
SANS	South African National Standards
SAWS	South African Weather Services
SO_2	Sulphur dioxide
SOx	Sulphur oxide(s)
SSR	Site Safety Report
SSE	south-southeast
Sv	sievert(s)
t	metric ton(s) (or tonne[s])
TSP	Total Suspended Particulates
UK	United Kingdom
UPZ	***Urgent Protective Zone***
USA	United States of America
US EPA	United States Environmental Protection Agency
WB	World Bank
WHO	World Health Organisation
yr	year(s)
µ	Micro

1 INTRODUCTION

1.1 Background

Eskom Holdings Limited (Eskom) is responsible for the provision of reliable and affordable power to South Africa. The South African economy is currently experiencing greater than expected economic growth, resulting in a rapidly declining surplus of power. Demand for power in South Africa is expected to grow at around the same pace as that of gross domestic product (GDP), with long-term forecasts putting electricity demand on a growth path of 4.2 %. It is estimated that this will amount to a requirement of more than 40 000 megawatts (MW) of new electricity generating capacity over the next 20 years. This additional generating capacity could come from a variety of energy sources, for example, coal, liquid fuels, gas turbines, natural gas, uranium (nuclear), hydro and pumped storage schemes, wind and solar energy. Eskom's current plant mix includes gas-fired stations (including open cycle), hydropower, pumped storage schemes, nuclear and coal-fired based-load stations, the latter making up the largest portion of the current power mix.

South Africa's existing nuclear power station at Koeberg has been safely supplying electricity for more than 20 years. Eskom has undertaken a number of studies aimed at identifying possible sites for additional nuclear power stations.

This EIA covers the construction and operation of a conventional nuclear power station and its associated infrastructure in the Eastern and Western Cape areas. The sites that are being investigated in this EIA have been identified on the basis of site investigations undertaken in the 1980s. Eskom proposes to construct a nuclear power station of the pressurised water reactor type which in many ways resembles the structure of that of a conventional thermal power plant. The difference between such plants is in the manner in which heat is produced. In a fossil plant, oil, gas or coal is fired in the boiler, which means that the chemical energy of the fuel is converted into heat, whereas in a nuclear power plant the energy from the fission chain reaction is utilised. The water required for cooling purposes within the nuclear power station can be obtained directly from the sea. Although a detailed design still needs to be completed, it is estimated that the entire development will require in the region of 250 - 280 ha as a primary nuclear plant zone, including all auxiliary infrastructure. The proposed Nuclear-1 will include a nuclear reactor, turbine complex, spent fuel, nuclear fuel storage facilities, waste-handling facilities, intake and outfall basin and various elements of auxiliary service infrastructure. ***The proposed Nuclear-1 will include two or three nuclear reactors, depending on the technology used, associated turbine complexes, spent fuel, nuclear fuel storage facilities, waste-handling facilities, intake and outfall pipelines and various elements of auxiliary service infrastructure.***

The primary objective of this study will be to measure the nature and magnitude of the impacts on agriculture emanating from the increased production activities in the Eastern Cape and Western Cape due to the construction of a nuclear power station.

1.2 Methodology

This study considers the agricultural sector at each proposed site for the Nuclear-1 programme and the potential impact thereon of the construction, operation and decommissioning of a nuclear power station.

The proposed sites are:

- Thyspunt;
- Bantamsklip; and
- Duynefontein

This report has three objectives:

- Describe the status quo in terms of the agricultural production in a 16km radius of the proposed sites;
- Determine the potential impacts on agricultural production that would occur as a result of the construction and operation of a nuclear power station;
- Identify and recommend mitigation measures to reduce or offset perceived negative impacts.

Although the proposed sites (EIA corridors) are discussed, the study focuses on the impact of agriculture in the surrounding region as the impact of the actual site where the plant is to be constructed will be negligible in relation to the total agricultural production in the region.

As per the terms of reference the study analyses the general land use within a 20km radius, undertakes an agricultural survey, and identifies all farming units within a 16 km radius and significant agricultural support infrastructure within a 30 km radius of the proposed sites for the nuclear power station. The study examines the general land use around each site, followed by a detailed survey of all agricultural production of the proposed study areas. ***It should be noted that during the study a number of stakeholders, including the farm owners or managers and other related agribusiness representatives such as the dairy factories, were consulted in this process and information obtained from them.*** From this information the value of agricultural production is estimated for each region. This is followed by identifying the potential impacts that a nuclear power station would have on agricultural production. Lastly, mitigation options are considered and the potential sites are compared according to the potential net impacts.

It should be noted that this study does not include the impact on agriculture of the proposed transmission lines related to the nuclear power station as this is being undertaken under a separate study.

2 DESCRIPTION OF AFFECTED ENVIRONMENT

2.1 Description of Land Use (20km radius)

Using aerial photography, satellite imagery and on-site verification, a general land use map was compiled on a 20km radius for each site.

As stated in Section 1.2, the actual proposed site for Nuclear-1 will not have a significant impact on agriculture. However, the EIA ***corridor*** for each site was inspected to ascertain any potential loss to agriculture.

2.1.1 Thyspunt

There is currently no agricultural production on the proposed site (EIA ***corridor***) but given the land use on surrounding farms, there is the potential for agricultural development. This would mainly be the allocations of planted pastures for dairy production. Soil samples from within the EIA corridor were taken, ***and the results of the analysis are given in Appendix 2. No abnormal significant soil characteristics are observed given the site area (i.e. coastal etc)***

There is no agricultural production within the 800m ***"Proactive Action Zone" (PAZ). The 3km "Urgent Protective Zone" (UPZ)*** borders onto a dairy farm on the northern side of the proposed site but will have no impact on agricultural activities.

With regard to the new proposed access roads to the site, the proposed northern access road will pass through cultivated pasture land used for dairy production. The exact extent of the amount of pasture land taken out of production as a result of the road will depend on the final route of the road. This area is considered to be a prime dairy production area, and the estimated value of pasture land is in the region of R 20,000-25,000 per hectare. It should also be noted that dust from the northern access road will have a negative ***short term (as it is planned that the access road be tarred at the beginning of the construction phase)*** impact on surrounding pastures, i.e., dust settling on the leaves and reducing photosynthesis of the pasture. The proposed western and eastern access roads will have no significant impact on agricultural production.

It should be noted that the impacts of the proposed electricity transmission lines on the dairy farms in the region are dealt with in a separate stand-alone report by a different consultant.

The land use within a 20km radius of the Nuclear-1 site is dominated by commercial dairy farming as indicated in Figure 2.3. About 65% of the entire body of land within the radius is used for commercial agriculture. Strandveld (thicket) is found along the coastline together with a larger portion of bare sand in the form of dunes (the Sand River). The residential areas are Humansdorp, St. Francis, Cape St. Francis and Oyster Bay. Humansdorp is the most populated residential area as the other areas consist predominantly of holiday homes, occupied only seasonally. There is a large area of degraded land which is indicated in

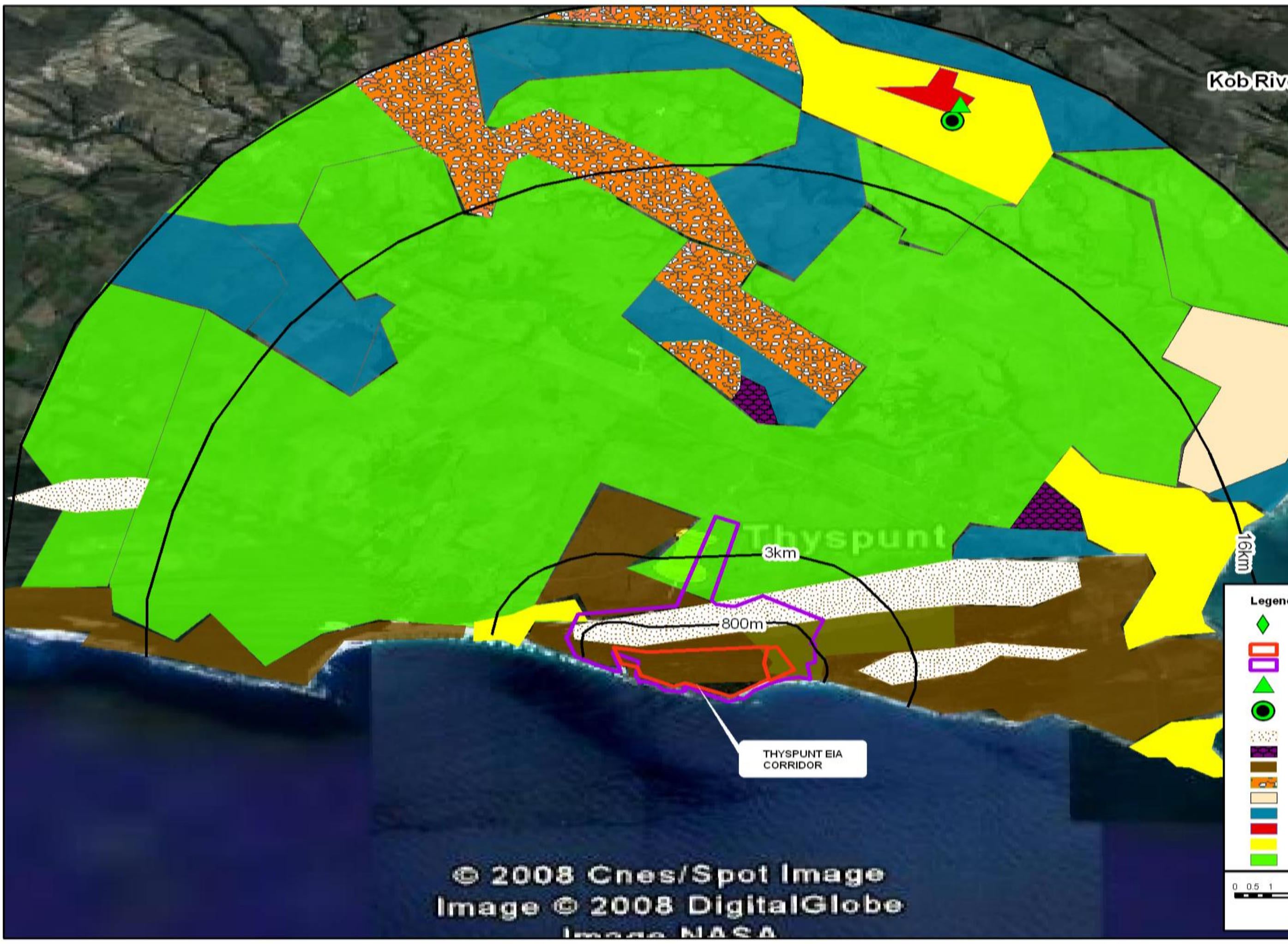

Figure 2-3. The causes of degradation appear to be wind erosion and perhaps overgrazing in the past. The rest of the area is reasonably well vegetated, and no significant degradation was evident. A conservation area runs along the southern part, and other portions of the Sand River dune area are in the process of being registered as a conservancy. There is a borrow pit in this area that was used for road construction and ongoing maintenance work. The only sand mine in the area is next to Cape St. Francis which has also been used for local road-building work. The Krom River catchment is within the 20km radius, and supplies most of the local area's fresh water.

Some of the land close to the shoreline is residential, specifically in Oyster Bay, which is situated about 5km from the proposed Nuclear-1 site. There are holiday residential houses along the Krom River, most of which are unoccupied out of peak holiday season.

Existing agro-industrial developments are the Woodlands Dairy in Humansdorp (which markets its products nationally) and large silos situated near Humansdorp. These silos are used for storing wheat but, due to the changing regional trend from wheat to dairy, are not being fully utilised.

Further afield within a 30km radius (as indicated in

Figure 2-3), other features to note include scattered natural forest outcrops and the Kob River, which is a tourist ttraction in-season for recreational camping and fishing activities close to Jeffrey's Bay. **Figure 2-1** ***shows the borrow pit areas and Figure 2-2 shows Woodlands Dairy.***

Figure 2-1: Borrow Pit Area

Figure 2-2: Woodlands Dairy

Figure 2-3: Land Use Map, Thyspunt

2.1.2 Bantamsklip

There is no agricultural production within the proposed site (EIA corridor) and, in fact, the potential for agricultural production is very limited. This is mainly because of the lack of available irrigation water from surface and ground water sources. As in the case of Thyspunt, soil samples were taken within the EIA ***corridor and are given in Appendix 2. No abnormal significant soil characteristics are observed given the site area (i.e. coastal etc).***

A large majority of the area surrounding the proposed site is land that is currently being used for fynbos harvesting with some commercial agricultural production taking place on a few farms. The main activity in this area is fynbos harvesting. Only farms that have planted pastures with irrigation that can supplement the natural grazing have livestock on their farms. Therefore, for agriculture production to increase in this area, more irrigation and cultivated pastures would need to be established.

The permanent residential areas in this area are relatively small in population size. Pearly Beach, for example, is a holiday location, occupied seasonally during peak tourist times; it has only a small permanent population.

Figure 2-4: ***Fynbos flower picking – The Springs Farm***

Figure 2-5: ***Typical farmland***

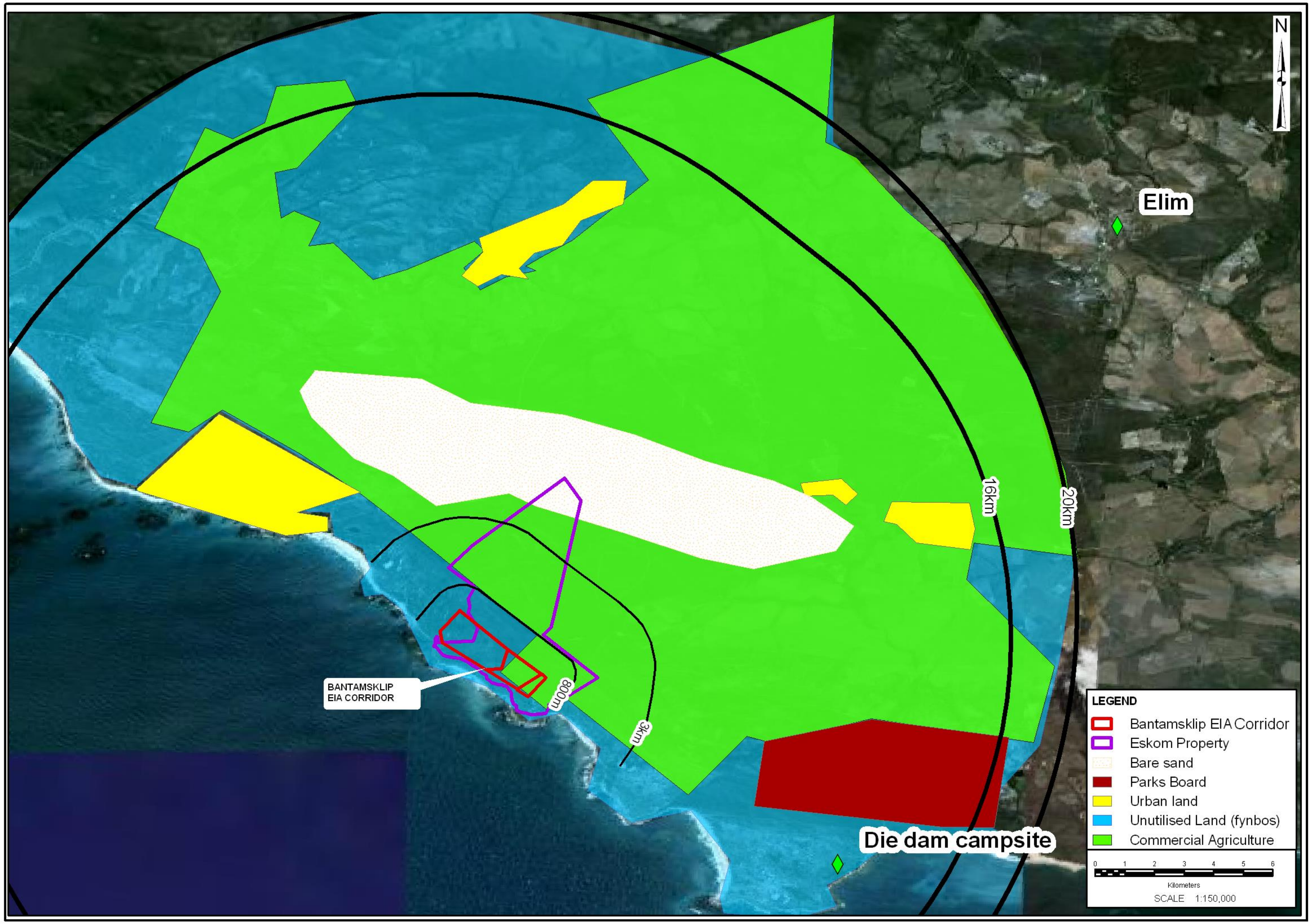

Figure 2-6: Land Use Map - Bantamsklip

2.1.3 Duynefontein

There is no agricultural production within the proposed site (EIA corridor). The potential for agricultural production on the proposed site is very limited, mainly as a result of the soil (sand dunes). As the ***EIA corridor*** only consists of sand dunes no soil samples were taken for this site. There is no commercial cultivation within the ***proposed*** 800 m ***PAZ*** but some mixed farming is being undertaken on the border of the ***proposed*** 3 km ***UPZ .***

There are broad bands of land use around the proposed site, the first being open vegetation close to the coast, the second the farming areas, and then the residential areas in and around Melkbosstrand and Atlantis.

As shown in

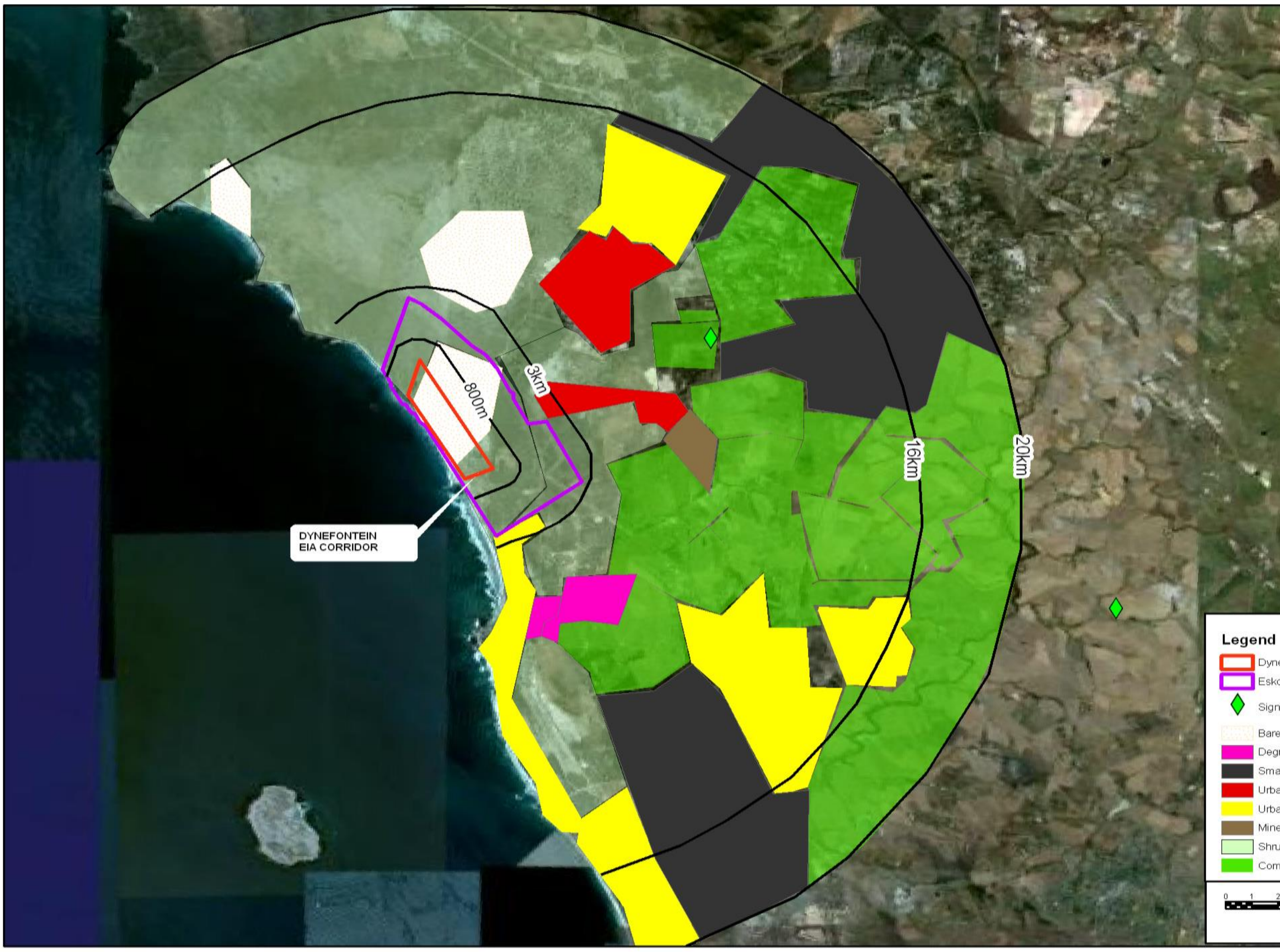

Figure 2-7, the majority (approximately 80%) of the northern area is dominated by shrubland. There is a large urban area in Atlantis with industrial activity around the residential areas. There is an area that has been prepared for residential development, marked on the map as land degraded in preparation for development.

There are two distinct areas that that are dominated by smallholdings ***where*** mainly subsistence farming ***is practiced***. A wide range of enterprises produce agricultural goods but this is mainly for home consumption with very little commercial production taking place.

On one farm (Vaaitjie) there is a sand mine and adjacent brick-making business with excavations for brick-making material. Apollo Brickmakers produce an average of 3,500,000 bricks per day.

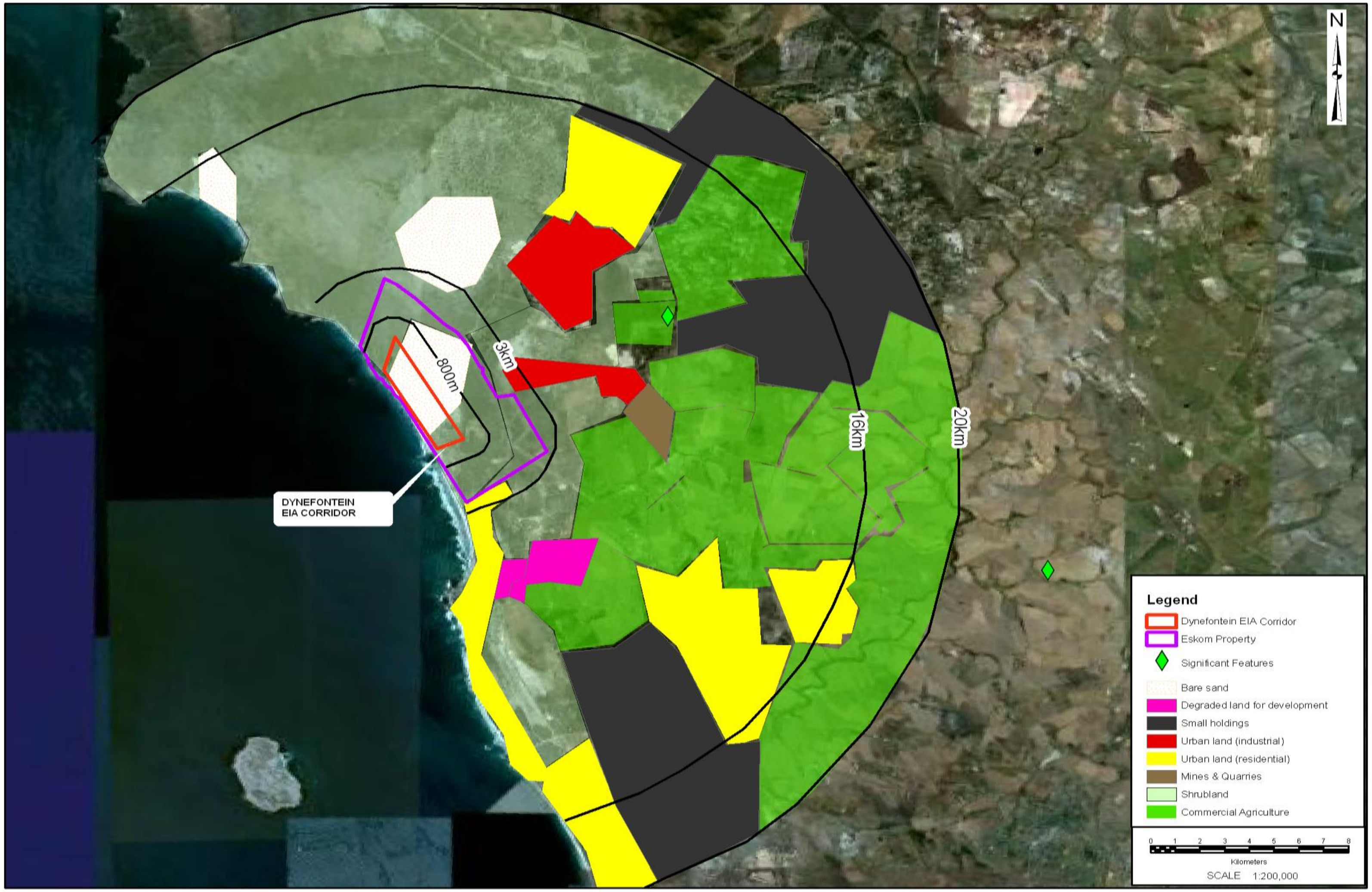

Figure 2-7: Land Use Map - Duynefontein

2.2 Agricultural Survey

2.2.1 Soils

In evaluating the potential agricultural production of an area, one of the first elements that is considered is the type of soils that can be found in the region. The type of soil can give a good indication of the agricultural potential of an area.

Figures 2.8, 2.9 and 2.10 show broad soil patterns for the proposed sites, obtained from the National Department of Agriculture and the Agricultural Research Council's Agricultural Geo-Referenced Information System (AGIS). Figures 2.11, 2.12 and 2.13 show the land type for the proposed sites.

All three proposed sites for Nuclear-1 lie within a coastal plain landform flanked inland by mountains. The soils at the three sites have relatively low agricultural potential. Further inland the soils have medium to low agricultural potential. High-potential soils with high clay contents and good depth lie away from the proposed sites, occurring within the flood-plains of the rivers rising in the mountains and flowing towards the Indian and Atlantic Oceans.

For example, map unit Ca (an important soil inland of all three sites), indicates land that qualifies as a plinthic catena (sequence of soils) which has, in upland positions, margalitic (dark coloured topsoils with a high-base status dominated by Ca and Mg cations) and/or duplex soils (with a relatively permeable topsoil abruptly overlying a very slowly permeable horizon which is not a hardpan) and covering more than 10% of the area. Plinthite, whether as a soft or hard layer, forms from the localisation and accumulation of iron and manganese oxides under conditions of fluctuating water table, and may have reddish brown, yellowish brown and/or black mottles. Soils with key codes Ea and Eb are generally shallow and are suitable for grazing only: All three sites under consideration for the proposed new Nuclear-1 have soil code Ed, which indicates generally greyish, sandy, excessively drained soils. These soils have low potential for crop production due to poor ability to retain moisture and nutrients required for crop growth and development.

It should be noted that all these proposed sites are in areas that have been developed over a long period of time, and therefore the current agricultural development in the region reflects the areas of relatively high agricultural potential.

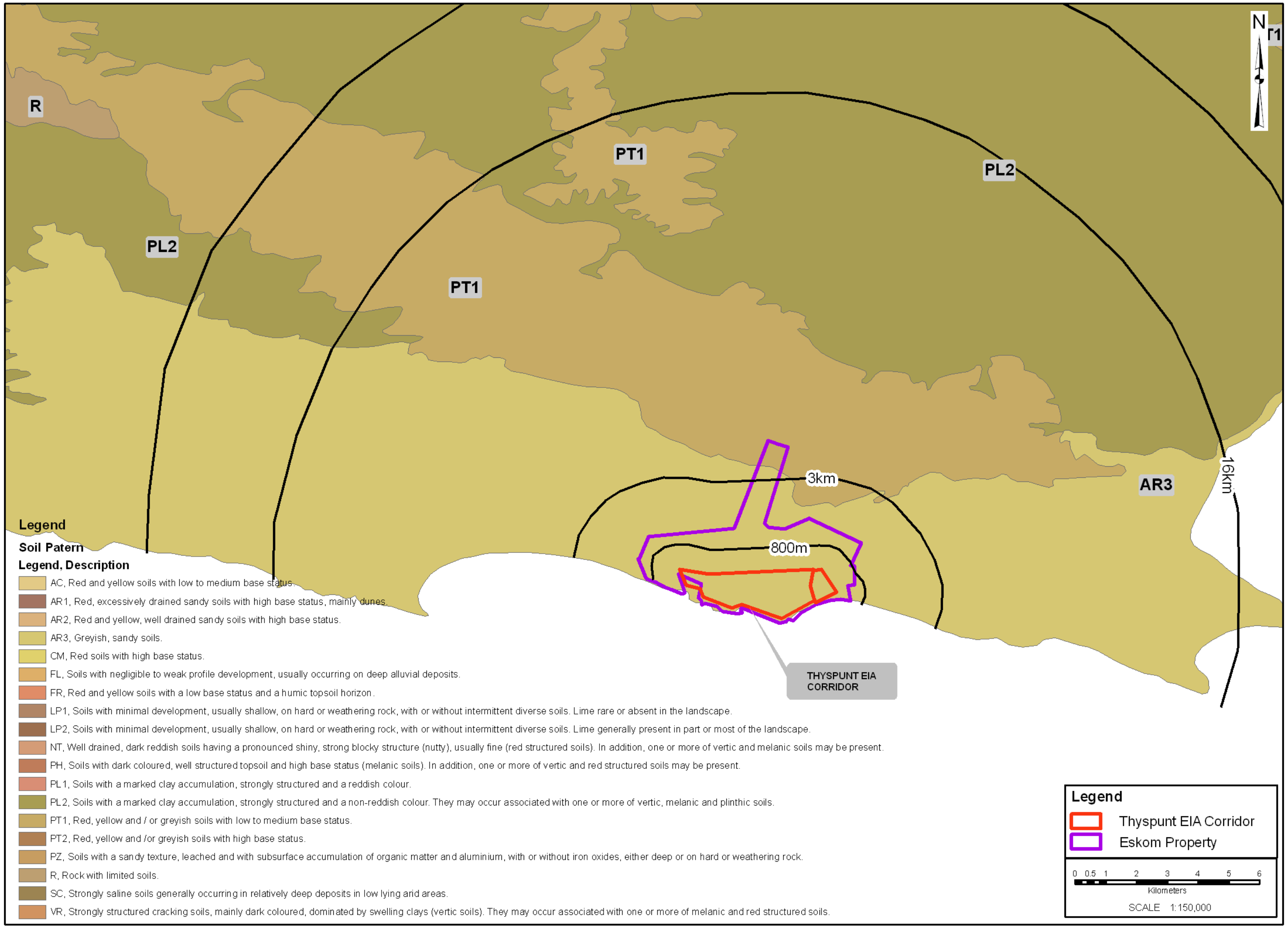

Figure 2-8: Broad Soil Pattern: Thyspunt

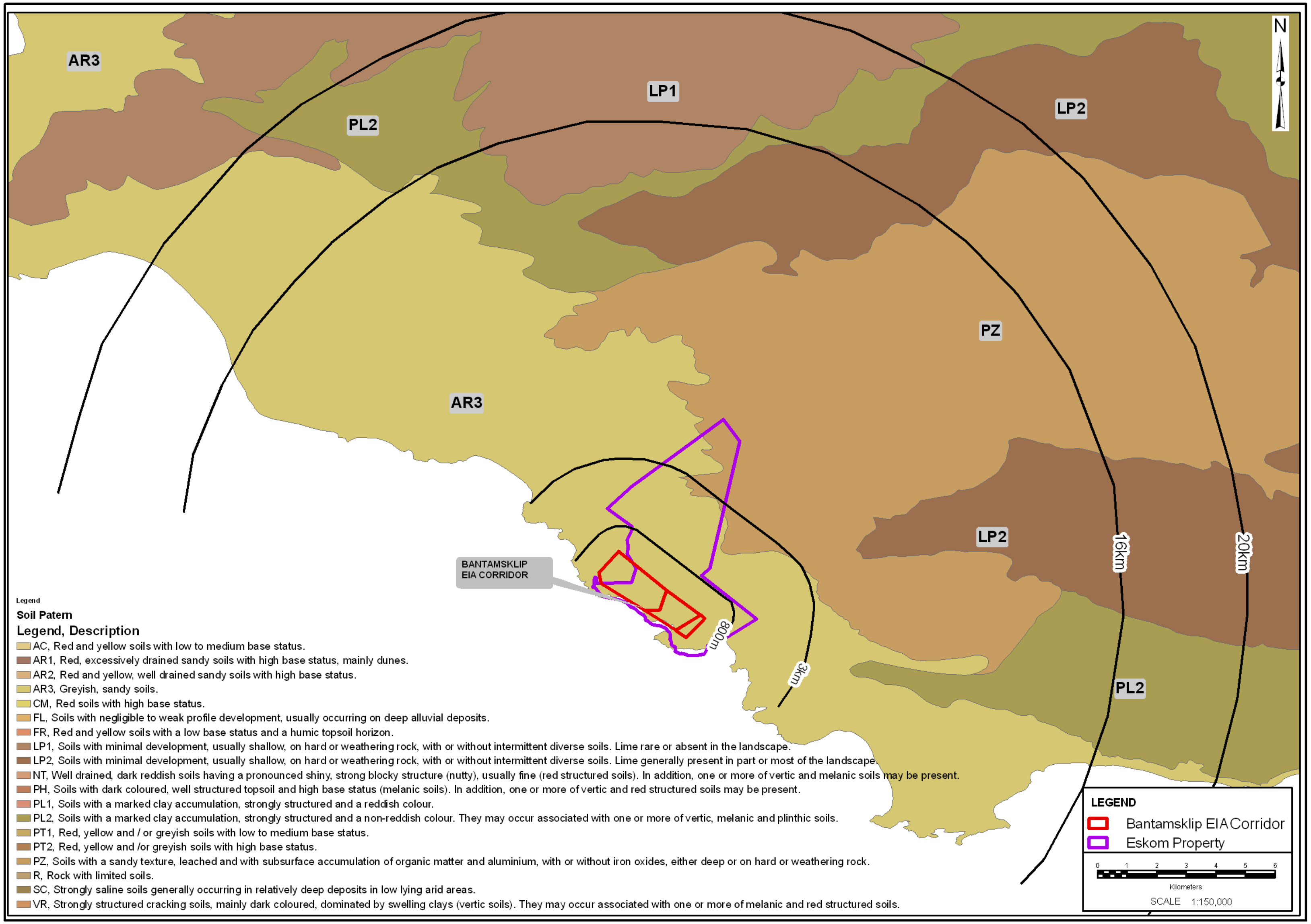

Figure 2-9: Broad Soil Pattern: Bantamsklip

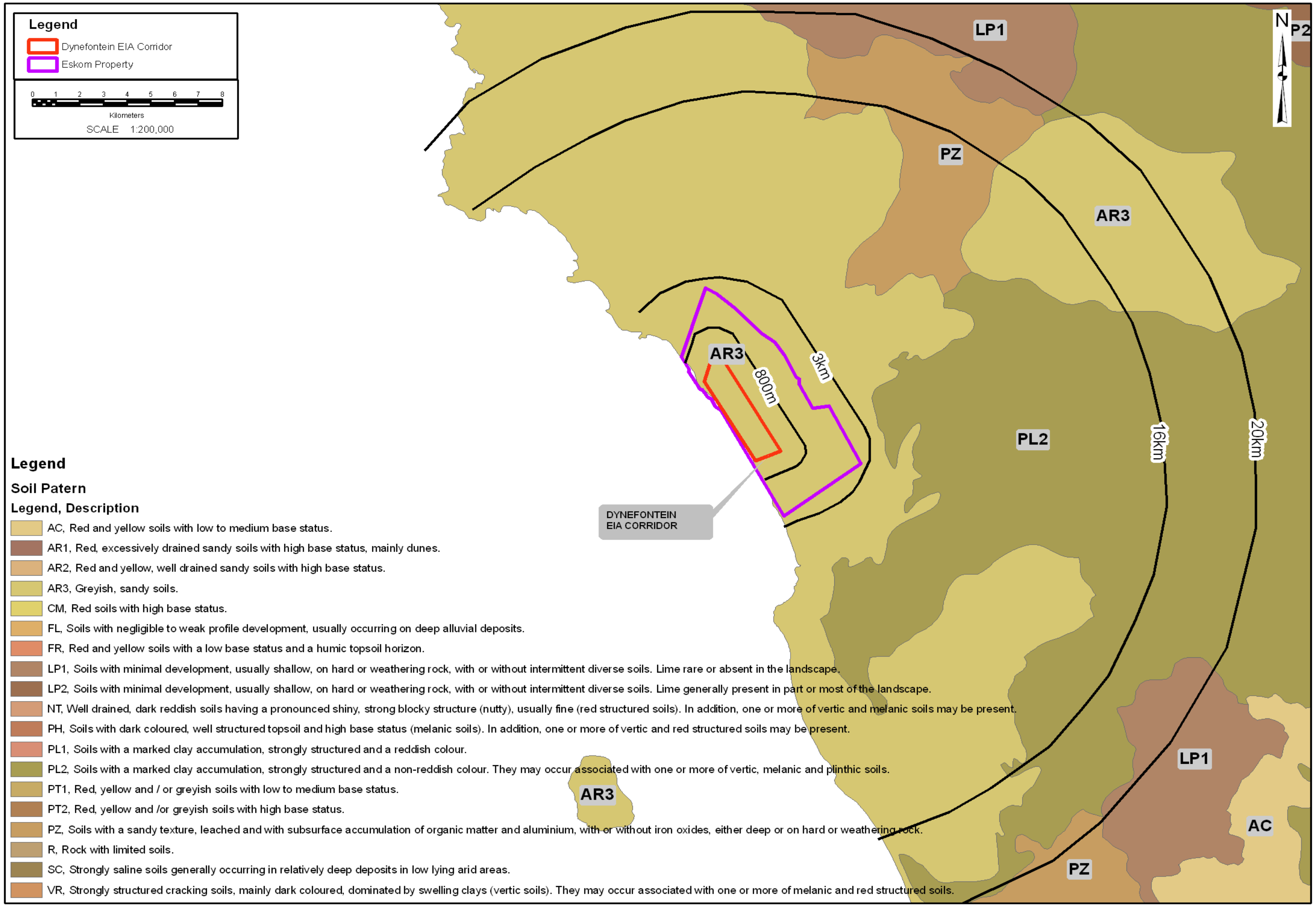

Figure 2-10: Broad Soil Pattern: Duynefontein

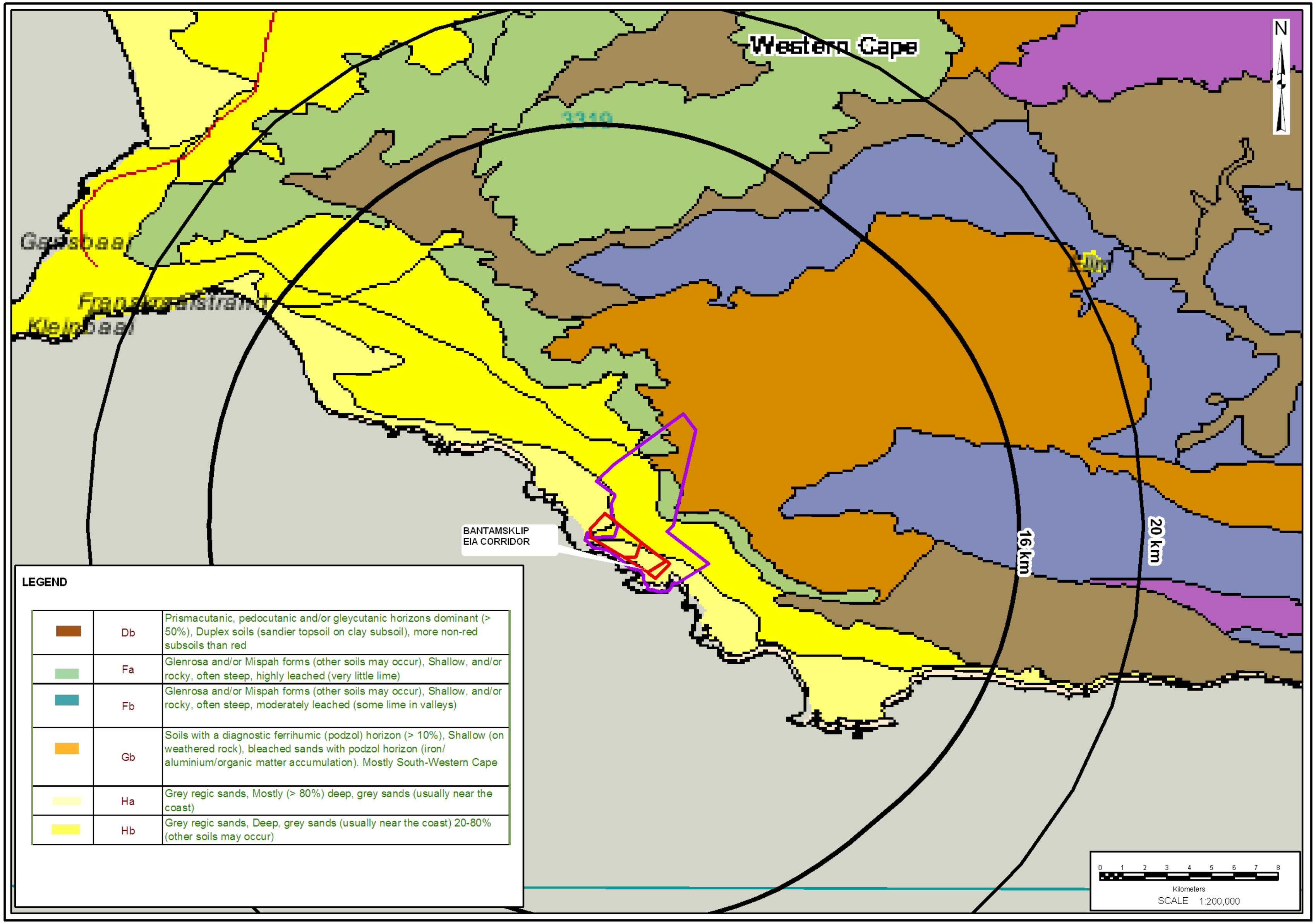

Figure 2-11: Land Types: Bantamsklip

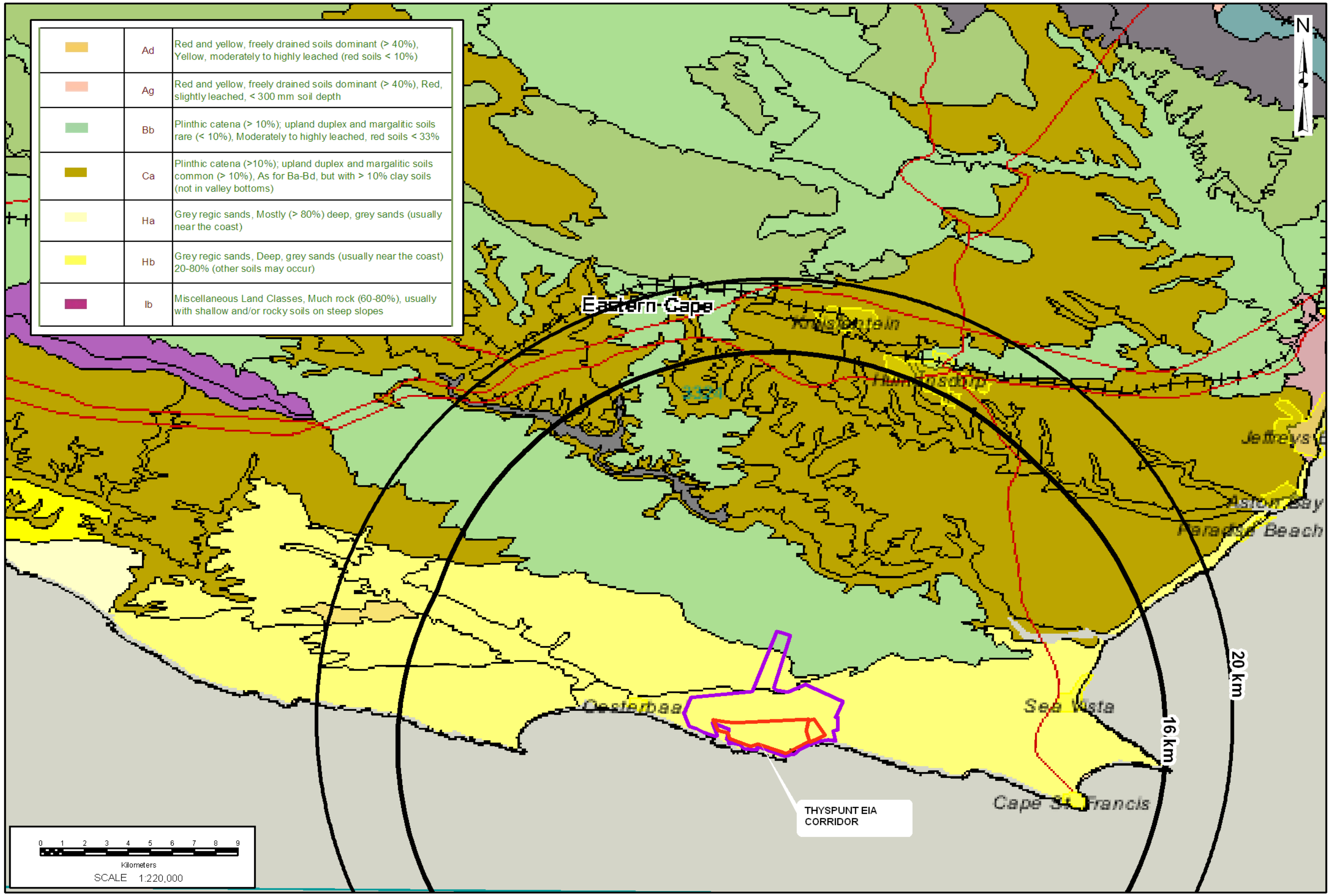

Figure 2-12: Land Types: Thyspunt

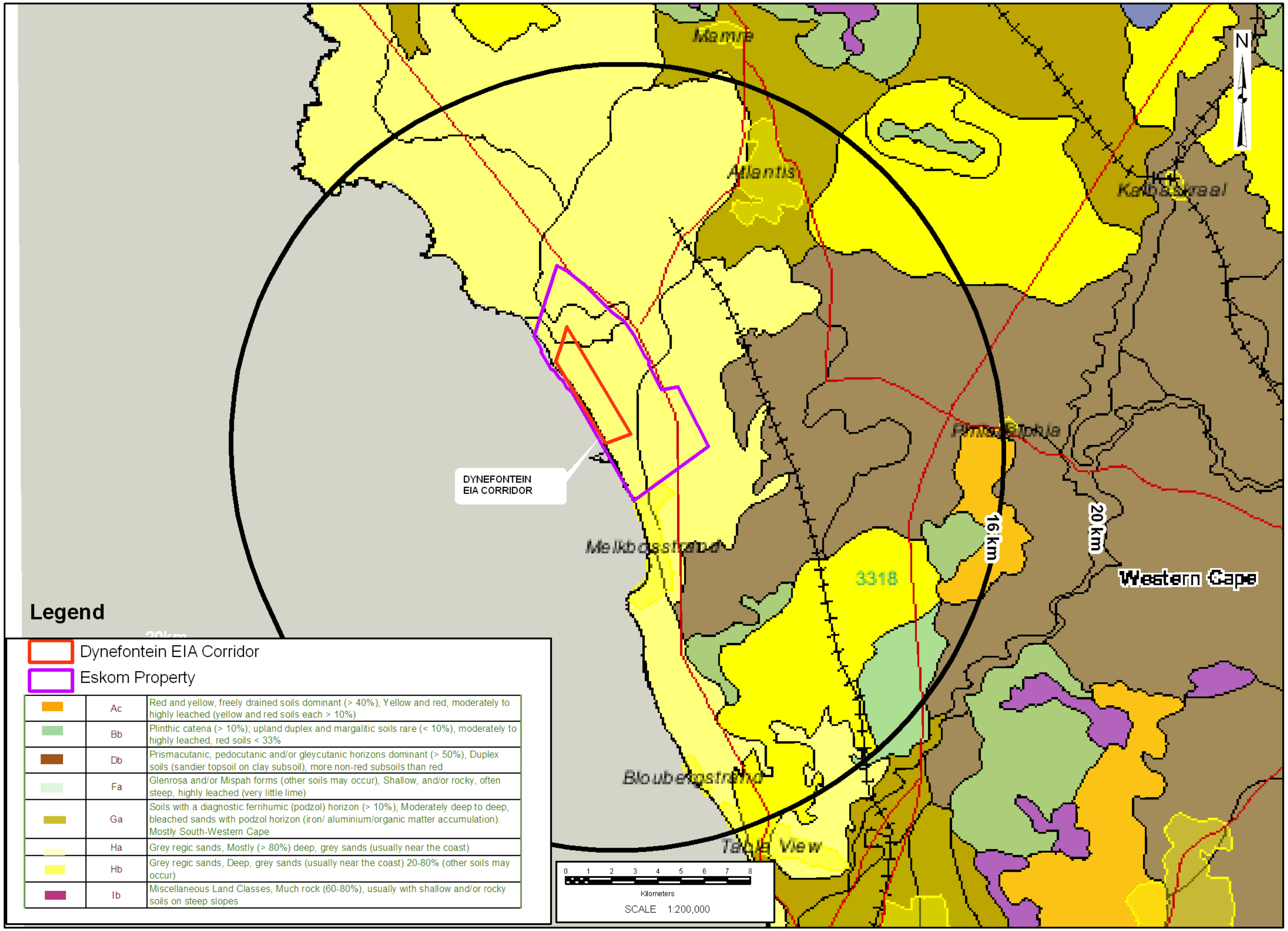

Figure 2-13: Land Types: Duynefontein

2.2.2 Agricultural Survey of Farm Units within a 16km radius

An agricultural survey was undertaken at each of the proposed sites. During the months of June and July 2008 two consultants visited each proposed site and firstly identified all farm units within the 16 km radius. Appointments were set up with the farm owners and each farm was visited and information collected on each farm. The information collected included:

- Name of farmer;
- Extent of farm;
- Main business of farm and current enterprises;
- Area of cultivated land;
- Amount produced of each enterprise;
- Types of livestock;
- Number of livestock;
- Main purchaser of enterprises; and
- Other significant features of farm.

A breakdown of this information for each farm can be found in Appendix 1. This information was used in order to calculate the current agricultural production around each of the proposed sites. The following section gives a summary of the available climate information for each area along with the main current features of agricultural production.

2.2.3 Thyspunt

Climate Data

Data were obtained from Cape St. Francis, which has the closest weather station operated by the South African Weather Services.

The most dominant wind directions in this region are generally westerly. The western sites of Brakkeduine and Klippepunt are characterised by winds of a greater northerly direction than are Thyspunt and De Hoek. Off-shore wind flows occur about 30% of the time.

The air temperature data for Cape St. Francis are summarised in **Table 2-1**. The tables contain the average daily maximums, minimums and extreme maximums and minimums. The average daily maximum and minimum temperatures recorded at Cape St. Francis are 22.8°C (January and February) and 11.2°C (July), respectively. The extreme maximum and minimum were 36.5°C (May) and 5.0°C (August), respectively.

Table 2-1: Means and Extremes of Temperature for Cape St. Francis − 2004 (June) to 2007.

Month	Average Daily Maximum (°C)	Extreme Maximum (°C)	Average Daily Minimum (°C)	Extreme minimum (°C)
January	22.8	27.4	18.5	12.9
February	22.8	28.3	18.4	14.1
March	21.8	25.5	16.7	12.9
April	19.6	25.3	14.7	9.1

Month	Average Daily Maximum (°C)	Extreme Maximum (°C)	Average Daily Minimum (°C)	Extreme minimum (°C)
May	19.4	36.5	13.3	7.1
June	18.8	29.0	11.7	6.8
July	18.1	28.0	11.2	6.6
August	17.9	30.5	11.6	5.0
September	18.1	24.4	12.9	7.0
October	19.2	25.5	14.2	8.5
November	20.9	31.1	15.9	11.2
December	22.0	25.0	17.4	12.6
Annual	20.1	36.5	14.7	5.0

The rainfall observations made at the SAWS station in Cape St. Francis recorded an annual average of 610.9 mm for the period 2004 (June) to 2007 (**Table 2-2**).

Table 2-2: Average, Maximum and Minimum Monthly Rainfall (mm) for Cape St. Francis − 2004 (June) to 2007

Month	Average Monthly	Maximum Monthly	Minimum Monthly
January	32.2	46.4	18.6
February	18.4	33.8	8.6
March	80.6	173.4	12
April	61.2	71.8	41.6
May	61.6	106.8	18.4
June	33.9	51	19.2
July	40.4	80.4	6.6
August	101.1	211.4	26.8
September	32.8	69	17
October	43.0	64	17.4
November	44.6	94.2	12.4
December	61.3	138	15.4
Annual *average*	**610.9**		

Current Agricultural Production

The Thyspunt area is dominated by dairy farming. Within the 16km radius there is only one other farm type, ***on a relatively*** large property (over 2,000 ha in extent) carrying a flock of 6 500 sheep. The dairy farms supply milk to dairies such as Woodlands, Parmalat, Nestle and Clover Dairies. Woodlands Dairy and Clover Dairies together produce an average of 700 000 litres (2008/09) of milk per day, and make dairy products such as cheese, butter and yoghurt. In an updated survey, it has been found that Woodlands Dairy on its own now processes over one million litres per day in summer and 600,000 litres per day in winter (2013). The estimated production (2013) from the farms within a 16 km radius is 108,000,000 litres per year (on average this amounts to 295,000 litres per day). This is a considerable increase over the production figures estimated in 2008/09)

The dairy farms consist mainly of cultivated pastures and crops for silage production for dairy cows. There is a considerable range in the sizes of dairy farms in the area, with some farms producing over 40,000 litres per day and other farms producing 6,000 litres per day. In discussion with farmers, their biggest constraint is infrastructure (roads and bridges) to get their produce to market and irrigation water to expand their irrigated pastures. There are a number of dam applications to the Department of Water Affairs for the construction of dams in the area, but these are still pending and have been for quite some time. The farmers have also stated that the current production method of grazing on pastures is the most profitable and that a zero grazing system to increase production of milk would not be profitable in this area. This is mainly due to the cost of feed in the region. The farmers also stated that their main concern regarding the proposed nuclear power station is around the negative social impacts, such as the influx of people looking for work and the increase in crime.

Much of the natural vegetation in the area is shrub land with the occasional outcrop of bushveld. Many of the farms produce their own silage for their own use or to sell to other local farmers. Some land is used for wheat production.

A summary of the information collected from each farm (2008/09) is given in Appendix 1.

Figure 2-14: Dairy cows on a farm

Figure 2-15: Extensive silage production on most farms

Figure 2-16: Silage bales

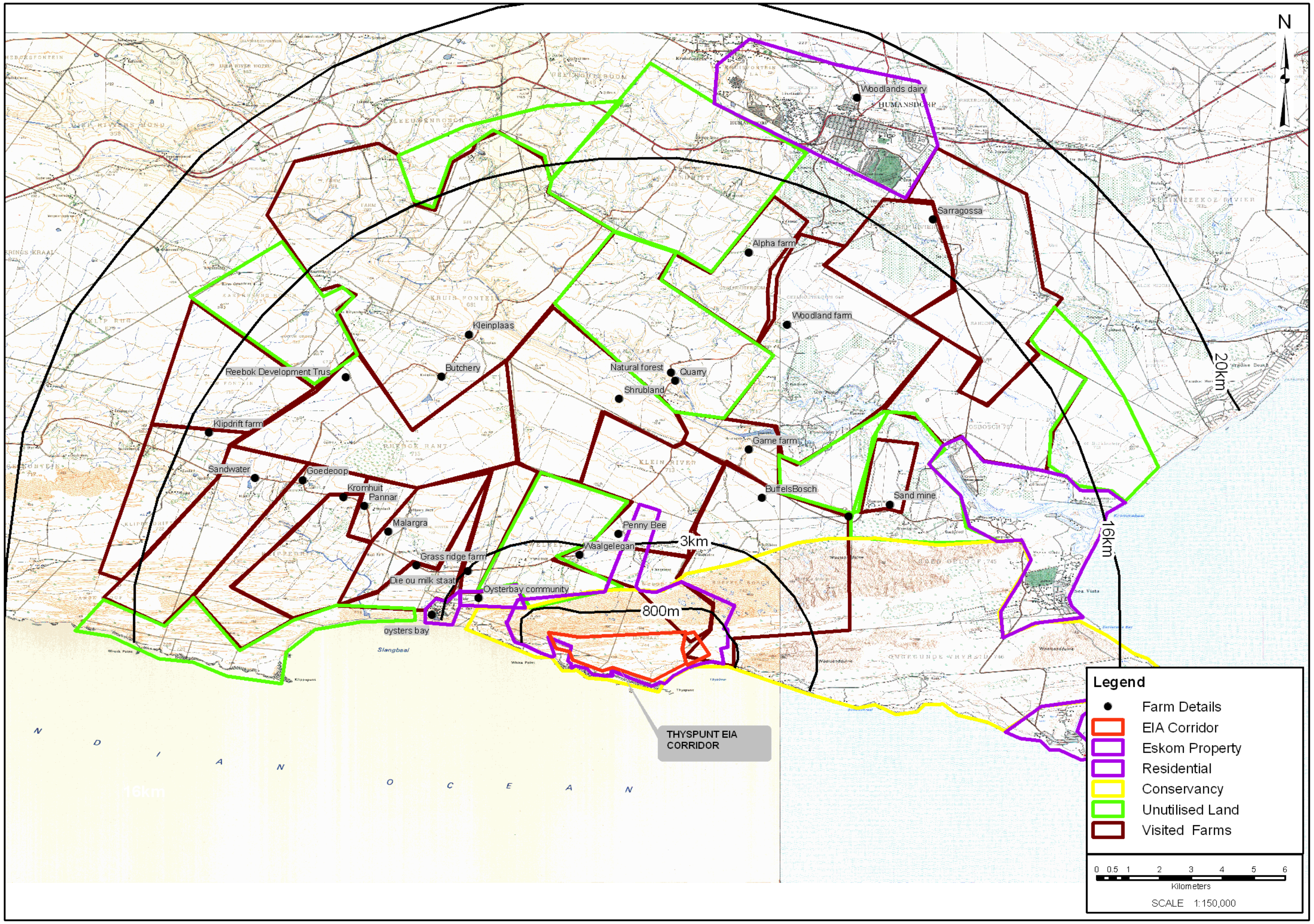

Figure 2-17: Agricultural survey: Thyspunt

Figure 2-18: Types of farming: Thyspunt

2.2.4 Bantamsklip

Climate Data

The closest SAWS weather stations are Hermanus and Struisbaai. The main wind direction in this region is west-northwest to northwest, a secondary direction being east to east-southeast.

The average daily maximum and minimum temperatures recorded at Hermanus were 23.4°C (January) and 10.5°C (August). In comparison, the average daily maximum and minimum temperatures recorded at Struisbaai were 24.1°C (January) and 8.7°C (July). The extreme maximums at Hermanus and Struisbaai were 33.2°C (October) and 32.6°C (October) respectively, and the extreme minimums 4.8°C (July) and 1.7°C (July) respectively.

Table 2-3: Means and extremes of dry-bulb temperatures for Hermanus − 2001 - 2007.

Month	Average Daily Maximum (°C)	Extreme Maximum (°C)	Average Daily Minimum (°C)	Extreme Minimum (°C)
January	23.4	32.8	17.2	12.1
February	23.2	30.8	17.2	11.3
March	22.4	30.8	15.8	9.8
April	20.9	30.3	14.3	9.5
May	19.6	32.0	13.1	7.5
June	18.2	31.1	11.2	5.0
July	17.4	29.6	10.6	4.8
August	17.0	30.9	10.5	5.2
September	18.6	31.5	12.5	7.7
October	20.4	33.2	13.9	8.1
November	21.5	29.9	15.3	10.5
December	22.9	30.5	16.7	11.2
Annual	20.5	33.2	14.0	4.8

Table 2-4: Means and extremes of temperature for Struisbaai − 2001 to 2007

Month	Average Daily Maximum (°C)	Extreme Maximum (°C)	Average Daily Minimum (°C)	Extreme Minimum (°C)
January	23.8	29.9	18.5	10.2
February	24.1	28.4	19.2	11.4
March	22.8	31.7	17.1	7.7
April	20.3	25.9	14.7	5.6
May	18.7	31.0	11.7	3.2
June	17.1	24.9	8.8	2.0
July	16.5	27.5	8.7	1.7
August	16.4	30.1	8.9	2.1
September	17.7	25.7	11.4	4.0
October	19.1	32.6	13.6	5.9
November	21.0	29.2	15.3	6.6
December	22.8	31.2	17.2	9.5
Annual	20.0	32.6	13.8	11.4

As shown in **Table 2-3**, the rainfall regime for the Bantamsklip area is typical of a winter rainfall season area. Rainfall observations are made at the SAWS stations in Hermanus and Struisbaai. These are summarised in **Table 2-5**. The annual average recording for this period is 533.2 mm at Hermanus and 385.9 mm at Struisbaai.

Table 2-5: Average, maximum and minimum monthly precipitation (mm) for Hermanus and Struisbaai − 2001 to 2007 (South African Weather Service)

Month	Hermanus			Struisbaai		
	Average Monthly	Maximum Monthly	Minimum Monthly	Average Monthly	Maximum Monthly	Minimum Monthly
Jan	33.2	121.0	7.2	30.5	78.4	5.6
Feb	23.4	37.4	11.2	13.2	33.6	4.8
Mar	20.5	60.6	5.8	20.8	85.4	0.2
Apr	68.7	232.6	21.2	53.4	175.8	19.6
May	50.9	87.4	9.0	36.1	47.2	8.0
Jun	59.1	132.8	11.6	39.7	75.2	15.4
Jul	68.0	111.0	10.4	49.3	94.6	13.4
Aug	73.3	130.6	33.6	47.2	84.4	25.8
Sep	27.9	52.0	0.0	25.3	45.0	9.8
Oct	52.1	131.4	16.4	34.8	98.6	12.8
Nov	33.9	120.2	9.8	20.8	60.6	3.8
Dec	22.2	51.0	6.6	14.8	33.2	3.0
Annual *average*	**533.2**			**385.9**		

Current Agricultural Production

The majority of the land within the 16km radius is natural fynbos vegetation. The farms further inland are mainly devoted to cattle or sheep. Recently ***wine farms within*** the broader region have been developed into the Agulhas wine region. It is envisaged that this trend toward wine estates and eco-tourism will continue in the medium term.

The coastal belt, which stretches approximately 6km inland, is predominantly natural vegetation, with some uncultivated and cultivated fynbos. This land is used for flower harvesting, with the occasional small-scale subsistence ***fishing*** activity or holiday property within it. The areas further inland produce dairy, cattle and sheep. Here there is a small village called Baardskeerdersbos with some small scale-farmers and a residential area.

The farms that produce dairy, cattle and sheep are ***spread*** over 10km from the proposed site. The dairy farms sell predominantly to the Parmalat Dairy. The bigger farms, other than those that do game farming, are all in dairying or fynbos harvesting. There are a few farms that produce sweet potatoes, cucumber and oats, and there is a small amount of trout farming. A butchery on one of the farms (Kleinplaas Farm) buys and sells much of the local produce. There are a number of small-scale farms in the area, most of them being operated at a subsistence level.

With regard to fynbos, the flowers are boxed and sold to local distributors for export. The primary buyers are from the UK. The fynbos production is a major source of income in the area, as many of the local people rely on such farms for seasonal employment.

A summary of the information collected from each farm is given in Appendix 1.

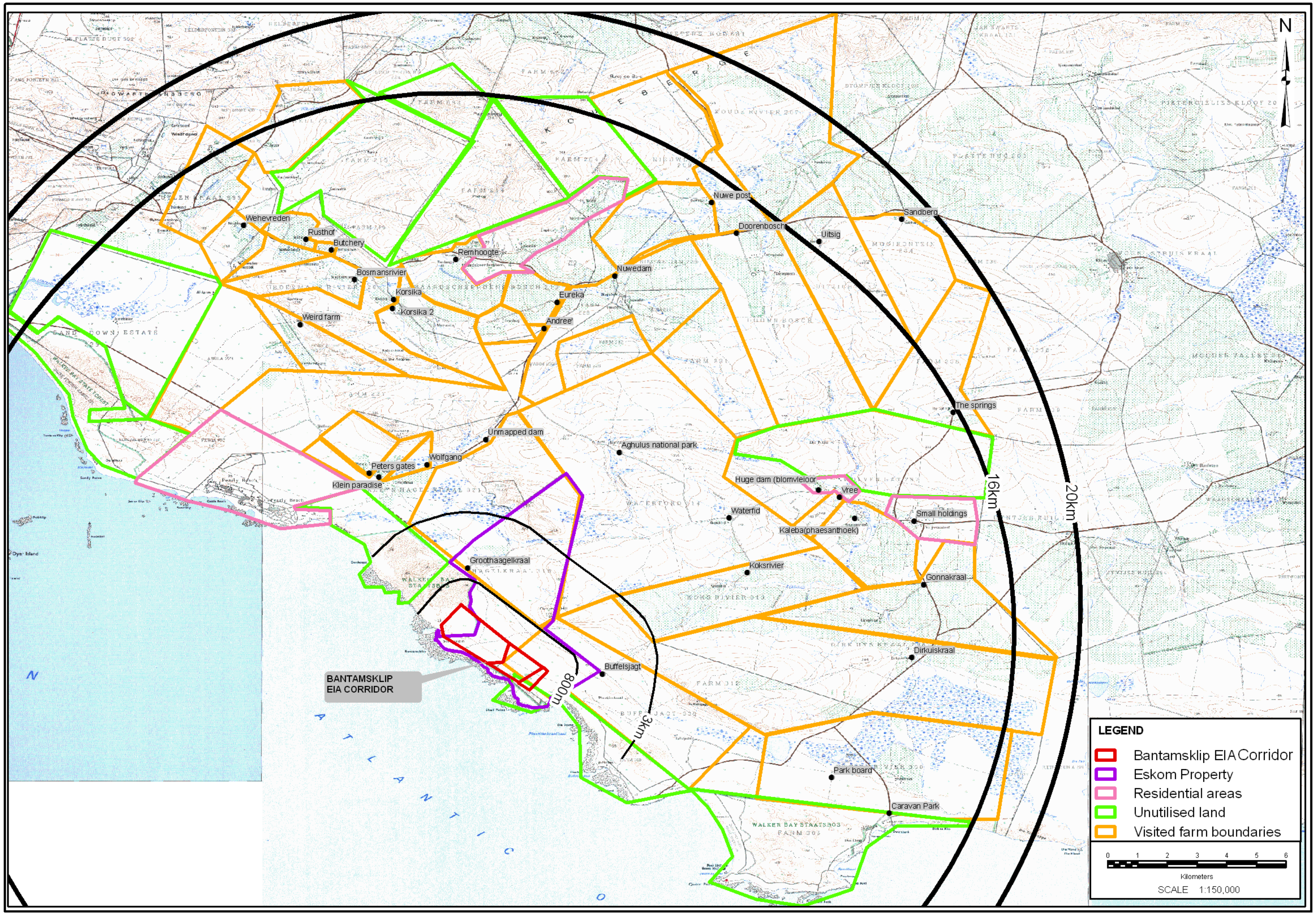

Figure 2-19: Agricultural Survey: Bantamsklip

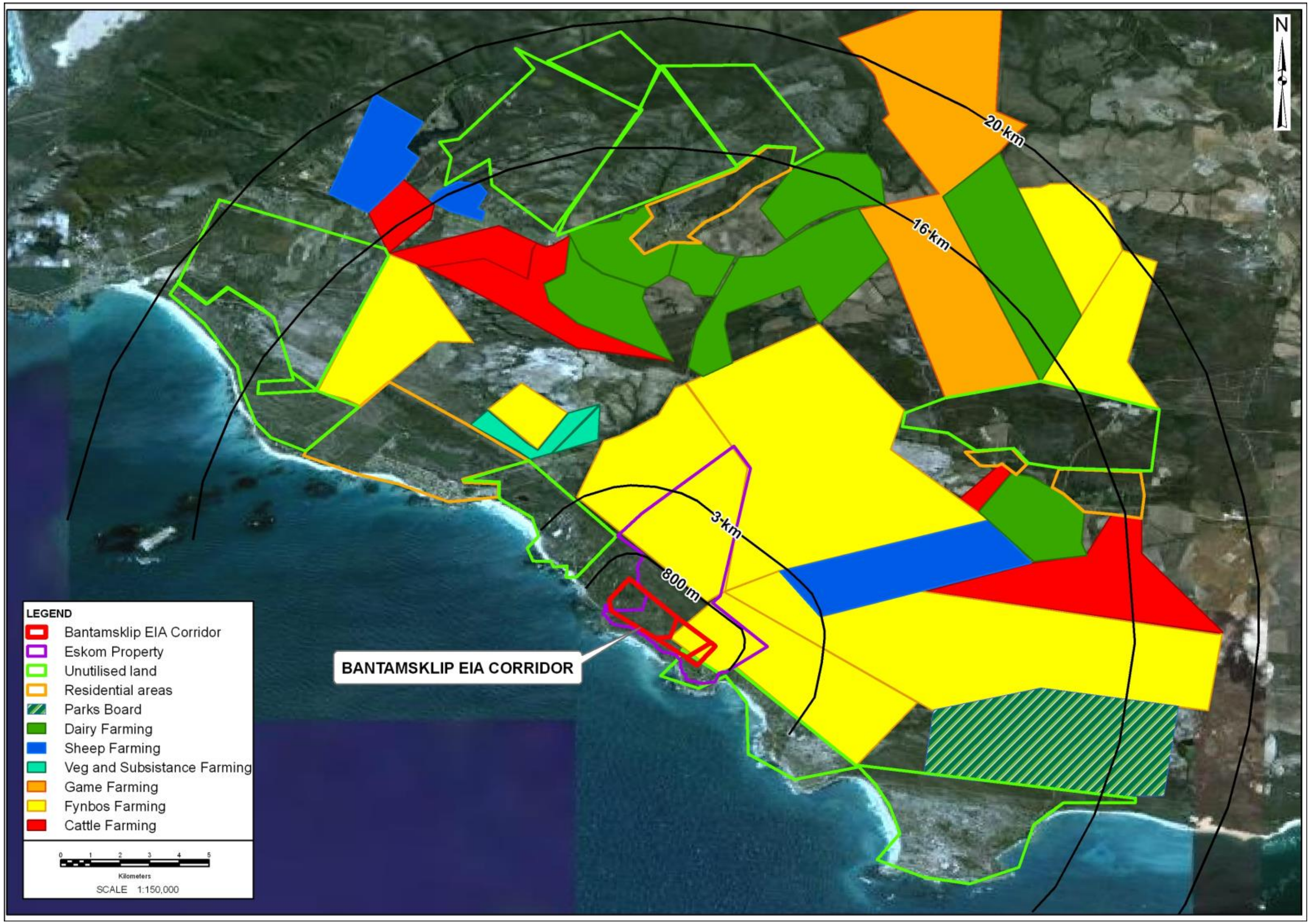

Figure 2-20: Types of Farming: Bantamsklip

2.2.5 Duynefontein

Climate Data

In terms of wind south-south-easterly winds dominate, with approximately 13% occurrences during a year. During winter months (July to August), an increase in frequency of east-north-easterly winds occurs, and in the summer months there is an increase in the frequency of southerly winds

As indicated in **Table 2-6**, temperatures measured at Duynefontein site are largely influenced by the close proximity of the cold ***Benguela*** current which has a moderating effect on the temperatures. The lowest temperature recorded at the Duynefontein site was above freezing (2.2°C on 2 August 1981) and the maximum was 38.2°C (13 September 2005).

Table 2-6: Means and extremes of dry-bulb temperature at the Duynefontein site (measured 10 m above ground level) − (1980 to 2007)

Month	Average Daily Maximum (°C)	Extreme Maximum (°C)	Average Daily Minimum (°C)	Extreme Minimum (°C)
January	25.4	38.1	15.9	10.5
February	25.5	38	16.1	9
March	24.3	36.6	15.3	9
April	21	35.5	13.3	5.5
May	19.1	33.6	11	5.7
June	19.4	31.4	9.6	4.1
July	19.5	29	9.2	2.8
August	17.2	32	8.2	2.2
September	19.7	38.2	10.4	2.3
October	20.4	37.2	11.6	5.4
November	22.6	36.3	13.6	6.3
December	22.9	37.4	14.5	9.3
Annual *average*	21.4	38.2	12.4	2.2

Air temperatures at Cape Town International Airport (1956-1973) show an extreme maximum of 40.7°C and an extreme minimum of -1.3°C.

The rainfall season for the Duynefontein site is classified as a winter area (Figure 2 20).

Table 2-7: Monthly measurements of precipitation at the Duynefontein site – 1980 to 2007

Month	Average Monthly (mm)	Maximum Monthly (mm)	Minimum Monthly (mm)
January	10.3	67.6	0.0
February	8.1	42.0	0.0
March	13.0	48.4	0.0
April	34.6	107.8	2.8
May	46.9	98.2	1.3
June	65.0	157.4	12.0
July	65.3	162.4	22.8
August	54.0	134.4	12.8
September	32.7	75.0	2.5
October	19.0	114.8	0.6
November	12.3	52.4	0.4
December	13.5	32.8	0.3
Annual *average*	**374.8**	**162.4**	**0.0**

Current Agricultural Production

Agricultural production around Koeberg consists of commercial farms (large to medium scale) producing mainly grapes, dairy and wheat. The two most popular farming activities in the surrounding area are wheat and grape farming. However, many small-scale subsistence or semi-commercial farms are found just out of the Atlantis industrial and residential areas.

An important point that should be noted is that a very large portion of the 16k m radius of the Koeberg site is taken up by the presence of an extensive sand dune that is located across the R307 road from the Atlantis industrial park. This has very limited agricultural potential.

Many of the wine farms also grow an alternate crop like wheat or run cattle. The dairy farms mainly sell to Clover Dairies, and the sheep farms ***sell*** mainly to local butcheries in the Cape. There is an egg hatchery which produces 1 700 000 eggs a month, selling to Pioneer Food/Bokomo. Most of the farms have small irrigation dams, frequently emptied throughout the year.

The small-scale farms in and around Atlantis do not contribute on a commercial basis. Such farms grow a small amount of vegetables, and run some chickens ***or small livestock*** for home consumption.

A summary of the information collected from each farm is given in the Appendix 1.

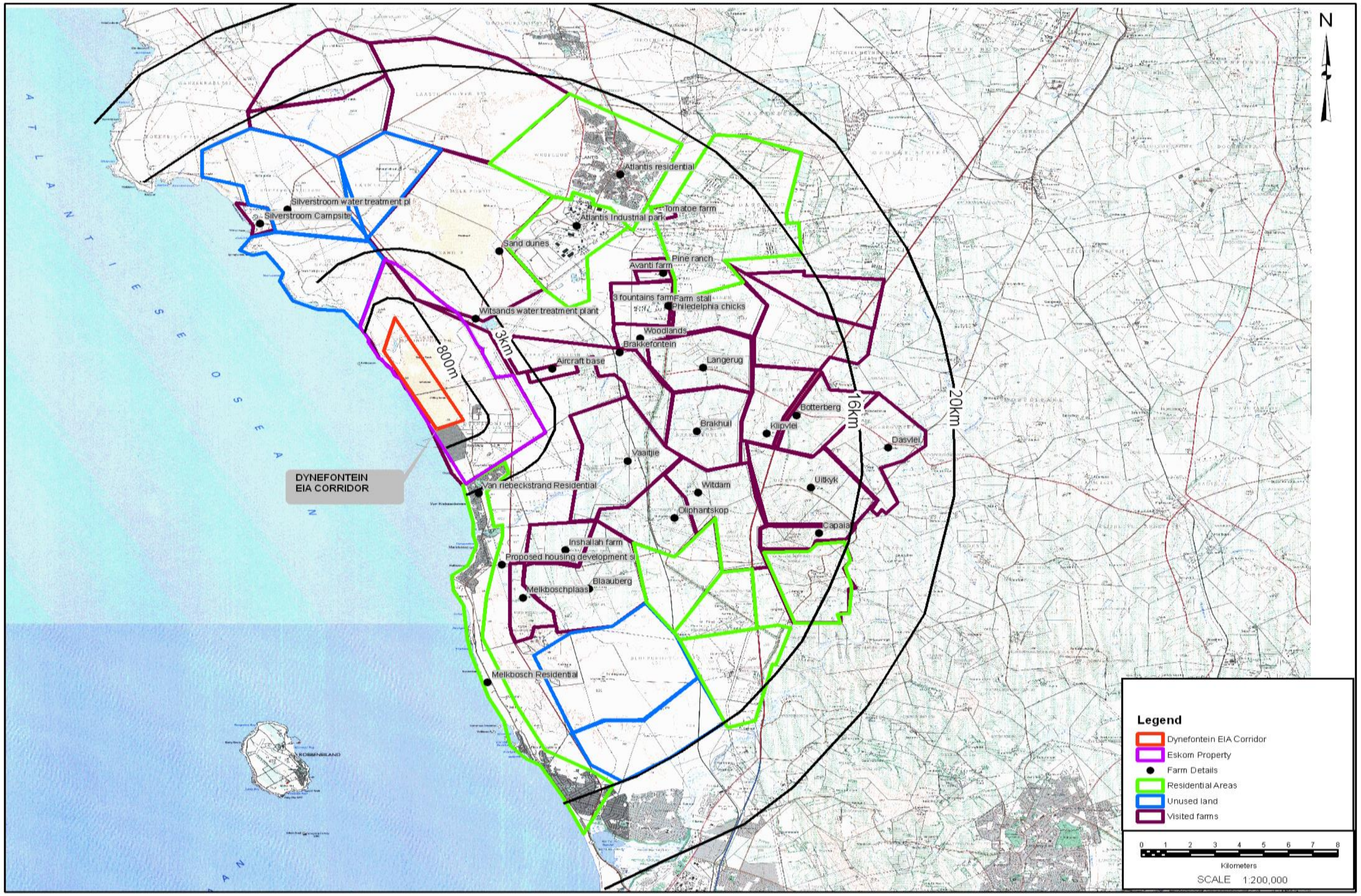

Figure 2-21: Agricultural Survey : Duynefontein

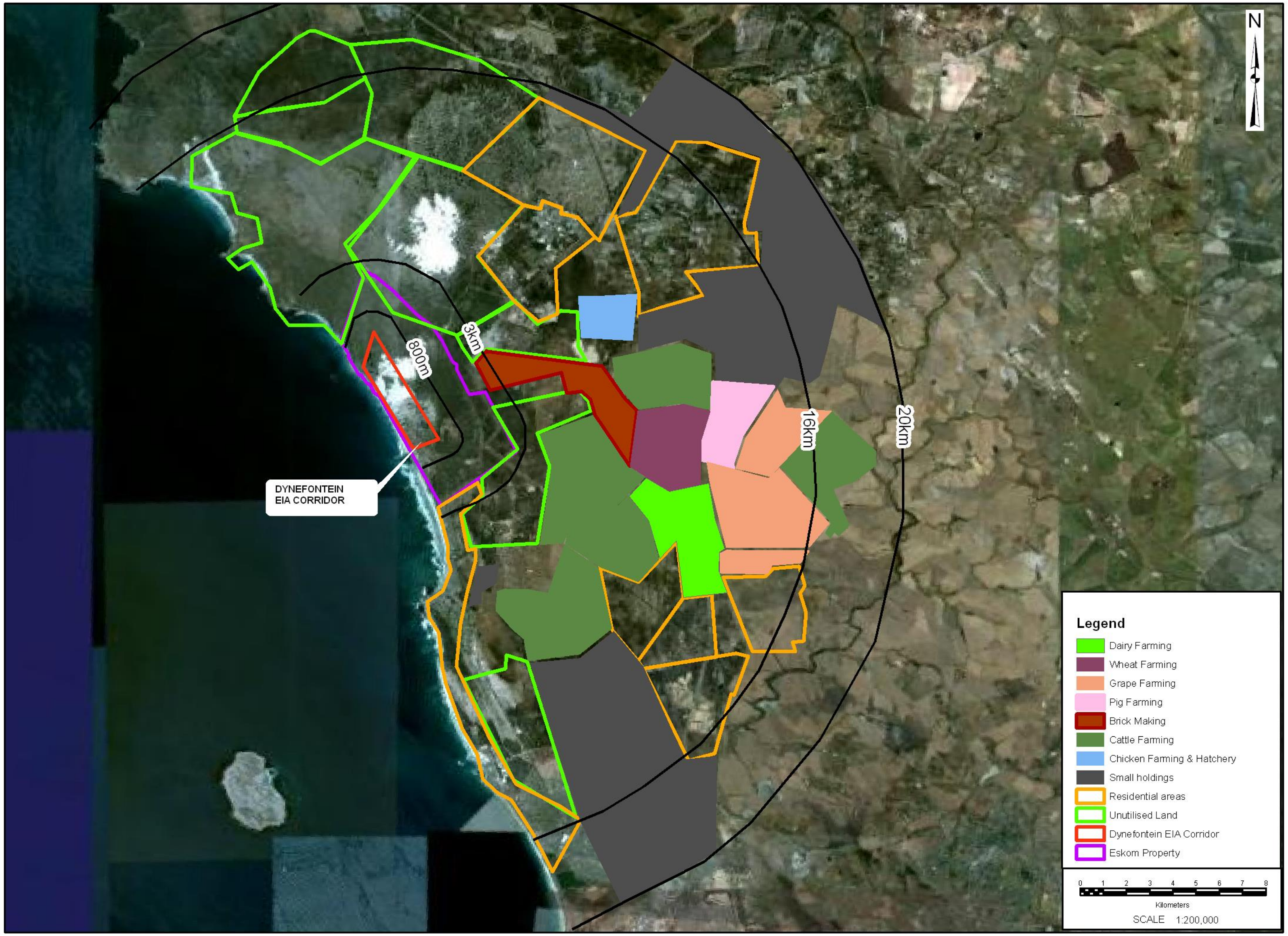

Figure 2-22: Types of Farming: Duynefontein

2.2.6 Summary of Farming Practices

The farming practices for each of the proposed sites are summarised in **Table 2-8** below.

Table 2-8: Farming Practices (number of farms)

	Duynefontein	Bantamsklip	Thyspunt
Farming practice			
LIVESTOCK			
Dairy	2	7	16
Beef	6	7	0
Sheep	2	5	1
Pigs	1	0	0
Poultry	1	0	0
Game	0	1	1
CROPS			
Vines	4	0	0
Wheat	7	0	0
Fynbos	0	13	0
Vegetables	3	3	0
Other agric	3	3	3
Total properties	31	33	26

From the data in this table it is clear that:

- The ***region around the*** Thyspunt site is predominately a milk-producing area, with dairy production on 16 of the 26 properties;
- The ***region around the*** Bantamsklip site is ***predominantly*** a fynbos ***harvesting*** area, with fynbos being utilised on 13 of the 33 properties. However, livestock are carried on 20 of the properties, and this includes dairy, beef, sheep and game; and
- Mixed farming ***is practiced*** in the ***region around the*** Duynefontein ***site*** , with 12 of the properties carrying livestock of which ten are dairy, beef or sheep.

The extent of the area of each farm and farm type can be seen on the types of farms maps given in the previous section.

2.3 Economic Analysis of Agriculture

Using the information gathered in the agricultural survey, an estimate of the value of the agricultural production from each site within the 16km radius was undertaken. The quantity produced by each enterprise was calculated and the financial value estimated. ***Where exact production figures were not available from the individual farms, an estimate was made using the average production from the area.*** For example, from the information collected on dairy production an estimate has been made, based on the amount of milk produced per annum in the 16km radius. This is then multiplied by the current producer price of milk to obtain the value of dairy production. An estimate is also added for the value of cull cows and bull calves sold per annum. ***This estimate was done for all the other enterprises produced in the area.***

The breakdown of the estimated gross value at 2008 prices of agricultural production for the three sites is shown in Table 2-9.

Agricultural Enterprise	Gross Value (R million) (2008/9)
Thyspunt	
Sheep	6.5
Beef	0.5
Dairy	143.0
Sub-total	**150**
Bantamsklip	
Fynbos	***Between*** 8 – 14
Dairy	9
Crops	2
Beef/sheep	6.4
Sub-total	***Between 25-31***
Duynefontein	
Grape	16.0
Wheat	13.0
Milk	14.0
Egg/chicks	20.0
Vegetables	5.0
Beef/sheep/pigs	7
Sub-total	**75**

From the above it can be seen that Thyspunt has the highest value of commercial agricultural production, followed by Duynefontein and then Bantamsklip. It should be noted that an accurate estimate of the value of fynbos harvesting is difficult to obtain, and a more detailed survey would need to be undertaken for a more accurate estimate.

3 POTENTIAL IMPACTS ON AGRICULTURAL PRODUCTION

3.1 Introduction

Using data from the Air Quality Impact and Climatology Assessment Study for Environmental Impact Assessment for ***Nuclear-1*** (Nov 2009), the maximum predicted doses of **µSv/annum** under normal operating conditions for the three sites and two different engineering designs for a nuclear power station are given in Table 3-1.

Table 3-1: Maximum Inhalation and External Effective Dose Predicted In the 40 *km* by 40 *k*m Study Area for 4 000 MWe *nuclear power station*

Site	**Effective Dose (µSv/annum)**	
	EPR	**AP1000**
Duynefontein	4.07	2.56
Bantamsklip	4.60	2.19
Thyspunt	11.31	4.56

The report further goes on to state that the NNR Regulation R388 specifies that the annual effective dose limit for members of the public from all authorised actions is 1 000 µSv with an additional provision of an annual dose constraint of 250 µSv. The highest predicted inhalation and external effective dose of 11.3 µSv is therefore about 4.5% of the dose constraint and about 1% of the annual effective dose limit. With the ***possible*** addition of more units to eventually generate 10 000 MWe[1], the maximum external effective dose would be less than 30 µSv.

Therefore, it can be taken that, under normal operating conditions, the µSv/annum are well below the recommended limits ***and that no impacts would occur during normal operation of Nuclear-1***. As a result, any discussion on the impact of radionuclides on agriculture relates to the unintentional or accidental release of radionuclides.

3.2 Literature review and related case studies

In terms of agriculture the best researched nuclear power plant disaster is Chernobyl in 1986. Much of the information that we have on the effect of radiation on agriculture comes from research carried out after the incident. It should be stressed that any reference to Chernobyl refers to the agricultural research that took place, and in no way should any comparison be made concerning this disaster and what could happen at one of the proposed sites.

The Soviet authorities declared an emergency exclusion zone within 19 miles (30.5 km) of the Chernobyl No. 4 reactor after the accident. The contamination - particularly from Cesium-137 (137Cs) as well as Strontium-90 and Plutonium - was not confined to the 19-mile exclusion zone. Around these areas were areas with lower levels, creating a patchwork of go and no-go zones. In these areas farming never

[1] ***The current EIA process is only applying for 4 000 MW. Possible later capacity expansions would be subject to separate EIA applications.***

stopped entirely, though the economy collapsed. Instead, the state farms adopted measures to minimise contamination of crops, including the use of certain fertilisers. Some crops absorb less radiation; those that absorb more are grown only for fodder. In October 2006 of the 1 000 square miles of contaminated land, only 54 square miles had been returned to active agricultural use. The survey completed in 2004 found that still more land could be reclaimed.

The main effect on plants of unintentional radiation fallout from accidents at nuclear power stations accelerated mutation rates. For example, wheat plants exposed to radiation in the Ukraine show unusually high mutation rates. The plants' mutation rates were six times higher than normal, the result of some unknown effects of low-level chronic exposure to radiation. One possible explanation - and it is speculative - is that over a ten-month period (one season) the damage to the plant might be so small that the DNA repair system simply failed to recognise it.

The genetic consequences of radioactive contamination by the fallout to agricultural crops have been studied by Geraskin *et al* (2002). In the first acute period of this accident, when the absorbed dose was primarily due to external Beta-and Gamma-irradiation, the radiation injury of agricultural crops, according to the basic cytogenetic tests, resembled the effect produced by acute Gamma-irradiation at comparable doses. The yield of cytogenetic damage in leaf meristem of plants grown in the 10-km zone during 1987–1989 (the period of chronic, lower-level radiation exposure) was shown to be enhanced and dependent on the level of radioactive contamination. The rate of decline with time in cytogenetic damage induced by chronic exposure lagged considerably behind that of the radiation exposure. Analysis of genetic variability in three sequential generations of rye and wheat revealed increased cytogenetic damage in plants exposed to chronic irradiation during the second and third years.

In many of the reports great concern is shown about the impact of radionuclides affecting humans through entering the human food chain. Initially the unintentional radiation fallout comes into contact with crops or animal feeds. In the case of animal feeds the radionuclides pass into the livestock and are then passed onto humans through the animal products consumed by humans.

It is worth noting that in a report by the FAO (1994) it is stated that “the amount of radioactive contamination required to destroy or injure the productivity of plants and animals is much greater than that which would render the resultant foodstuffs unsafe for human consumption”. Against this background, and because of public sensitivity to possible or imaginary radiation harm to man, a consensus has emerged that “it is the impact on humans” that would be important “rather than the effects on other components of the biosphere”. Nevertheless, there is an impact on animals and their products.

3.3 Livestock

This section evaluates the impact of the development of a nuclear power station on livestock and their products in the Duynefontein, Thyspunt and Bantamsklip sites. ***The section describes the effect of radionuclides if there is an accidental or an emergency condition where abnormal radiation is released. Under normal operating conditions there is no effect on livestock or other agricultural produce.***

3.3.1 Effect of radionuclides on livestock

Radionuclides enter an animal mainly through feed and in smaller quantities through inhalation or through the skin. The level of contamination of the feed is the main determinant of the overall volume of radionuclides in the animal's body. After entry to the animal's stomach the radionuclides are included in the process of metabolism, and all the animal's systems respond to the impact of radiation. The radionuclides participate in processes of digestion, being transferable by blood to different organs and tissues, and then being either deposited there or removed from the body. The balance between all these processes is given by the radionuclide content of the different organs and tissues of animals.

Intake and digestion of radionuclides

The process of radionuclide intake and subsequent transfer through the cell membrane may be based either on passive diffusion or on mechanisms of active transport. The speed of radionuclide digestion and transport depends upon the physical and chemical characteristics of the compounds in which these nuclides are included. The first step in radionuclide metabolism is their transformation by digestion with the help of physical fragmentation, enzyme treatment and the acid reaction with the gastric juices. The digestion of radionuclides transformed into ionising forms depends upon the chemical nature of the elements and upon the animal species. For example, for iodine-131, 100 % is digested by dairy, beef cattle and sheep, 75 % - 80 % by poultry and 33 %- 76% by pigs, while 100 % of caesium-137 is digested by pigs, 67 % by poultry and only 50 - 75 % by cattle and sheep. The digestion of strontium-90 is usually much lower than other radionuclides and is 6 %-16 % for cattle and sheep and 13 % for pigs, although it is 50 % - 80 % for poultry.

The coefficient of digestion depends upon the animal's age. In newborn calves the digestion of strontium-90 increases to 93 %, in lambs to 100 % and in piglets to 97 %, but for poultry chicks it remains at 50 %. The digestion of caesium-137 by young animals varies from 93 % to 100 %.

Metabolism of radionuclides

After digestion, the radionuclides enter the blood and become attached to elements of the blood to form components of the serum. The iodine-131 forms compounds with blood proteins, and about 65 % of this radionuclide in blood is linked with erythrocytes. By contrast, caesium-137 does not form any links with proteins in sheep blood, and about 93 % to 99 % of their ions are excreted from the kidneys. For strontium-90, from 30 % to 40 % of its ions concentrate on the serum proteins.

The radionuclides delivered by blood to the organs and tissues may be selectively deposited inside them. The selectivity in the dispersion of radionuclides inside the animal body is better expressed in young individuals. For example, the concentration of strontium-90 in the skeleton of calves comprises 1.9 % of the total amount taken in orally. For lambs this proportion is 69 % and for piglets it is 14 %. The adult animals have proportions of 0.1 %, 5 % and 1 % respectively. The deposition of strontium-90 in the muscle, heart, liver, kidneys and lungs of calves was 0.01 % to 0.04 %, and in the organs of adult animals 0.002 % to 0.005 %. In the organs of calves caesium-137 is deposited in the following proportions: in the skeleton 0.2 %, in muscle 0.35 %, in the heart 3.6 %, in lungs 1.7 %, in the liver 1.65 %, and in kidneys 4.8 %. After long-term feeding on contaminated feedstuffs, the strontium-90 concentrates in the skeleton of animals and the caesium-137 in the soft organs and tissues. During long-term intake of radionuclides, at first their content in organs and tissues increases but after a while a balance is established between radionuclide intake and removal, and their content in the animal tissue remains at the same level. The equilibrium state for strontium-90 is achieved after 5-7 days for soft tissues of cattle and sheep and after 30-90 days for pigs and poultry. The caesium-137 content achieves a state of equilibrium later than strontium-90. In sheep this is after 105 days and in cattle after 150 days. After long-term intake of radionuclides, strontium-90 concentrates in the skeleton while caesium-137 is from 20 % to 55 % in soft tissue of calves and from 4 % to 9 % in the tissues of adult animals.

Excretion of radionuclides

The radionuclides are excreted from the animal organs and tissues via the gastrointestinal system, lungs, kidneys, skin and milk producing glands. The radionuclides deposited in soft tissues are removed more easily than those in the skeleton. For example, for caesium-137 after ***three*** days 45 % of deposited radionuclides are removed and after 46 days 55 % have gone, but more than 3,000 days are required for the removal of half the strontium-90 from the skeleton of cows. The radionuclides caesium-137 and iodine-131 are excreted mainly by the kidneys and in smaller quantities (about 3 %) through the milk-producing glands of cows.

The radionuclides deposited in meat, eggs and milk may be transferred to humans by ingestion. The transfer of radionuclides in meat products from animal feed rations depends on the physical and chemical characteristics of the radionuclides, and on the age and the species of animal. After long-term intake of strontium-90, the skeletons of cattle contained 7.4 % of the daily ration and the muscles only 8 %. For pigs these figures were 1.3 % and 1.15 % respectively. At equilibrium, the caesium-137 content in the skeleton of cows was 22 % and in muscle 8.1 % of the daily ration. The skeletons of pigs contained 3.5 % of the daily content in the ration of strontium-90 and the muscles 22 %. The young animals accumulate more radionuclides in their organs and tissues than older animals.

After intake of radionuclides by cows, their intensive excretion in the milk is observed for two days. Initially, one litre of milk contained 0.09 % of strontium-90 and 0.42 % of caesium-137 ingested. During the following eight days 2.8 % of strontium-90 and 18 % of caesium-137 were removed from the animal's body in the milk. The intensity of radionuclide extraction in milk varies and depends upon species, stock and individual characteristics. The average coefficient of transfer into milk is 1.0 for caesium-137 and 0.15 for strontium-90.

In poultry the transfer of strontium-90 from feed to eggs comprises between 40 % and 60 % of daily intake. About 96 % of this radionuclide concentrates in eggshell, 3.5 % in the yolk and 0.2 % in the white. The maximum amount of radionuclides is observed on the first day after intake. The maximum concentration for strontium-90 was observed in the eggshell, for caesium-137 in egg-white and for iodine-131 in the yolk.

Potential agricultural countermeasures

From the above-mentioned information, it is clear that in the event of a nuclear accident there is likely to be a release of various radionuclides, which can be ingested by livestock primarily through eating contaminated food. This includes dairy and beef cattle, sheep, pigs and poultry. These radionuclides will be stored in the skeleton and/or soft tissues of these species and subsequently released from their bodies at various rates, depending on many factors.

Of greatest concern to humans is that the radionuclides stored in the soft tissues (meat) and more importantly those transferred into the milk, will lead to radioactive exposure of humans utilising these products.

In the event of a nuclear accident the consequences of nuclear fallout affecting livestock can be alleviated by agricultural countermeasures. In this regard there are three periods of post-accident radiological danger (Savchenko 1995).

The first is called the period of iodine danger and has a duration of several months. The mixture of short-lived radionuclides, including iodine-131, is deposited on the vegetation and enters the food chain through livestock consuming the fodder crops and storing amounts of radiation in the meat and more importantly in milk. The best counter measure in this case is to ensure that livestock only consume uncontaminated feedstuffs. In the case of poultry and pigs this is quite easy because most of their feed is “out of the bag” and therefore protected in storage sheds. In the case of dairy cows a lot of their feed is “out of the bag” or from silage which is protected underground. They also consume hay which often is stored in covered sheds. Unfortunately dairy cows also traditionally consume fairly large quantities of pasture which would have been exposed to contamination. In this case the cows would have to be kept off the pastures and only fed uncontaminated feed. Beef cattle and sheep depend almost entirely on natural or artificial pastures which would have been contaminated and as it is uneconomical to feed this stock “out of the bag” and they would have to be removed from the area. In addition, confining animals to sheds, especially in the early stages of contamination, will protect the animal from personal exposure to radiation. This is particularly important in lactating animals where it has been shown that milk secretion of radioiodine increases in cattle after whole body irradiation (rather than feed intake). These cows showed clinical signs of acute radiation sickness.

The second period relates to the utilisation of the present crops which have been contaminated mainly from rain-carrying radionuclides or from radionuclides that have settled on the crops. Unless these crops are washed they cannot be utilised by stock. Rainfall does contaminate the crops but on the other hand can wash off a lot of the early contamination.

The third phase is long term and is related to contamination of future crops through the uptake of radionuclides through the roots. However, the contamination through roots is considered much lower than through the aerial parts of plants and the counteractive measures during this third phase are long term in character and are directed at preventing the onward transfer of contaminated food and protecting agricultural workers from irradiation.

Management methods of reducing contamination of animal food products relating to specific radionuclides.

Jones (1993) reviewed the research on those factors of importance in managing the effect of the three most important radionuclides contaminating foodstuffs. These radionuclides are Caesium 137, Strontium 90 and Iodine 131.

Caesium 137

In feeding experiments increased levels of fibre in the diet have been shown to decrease the gastro-intestinal uptake of radio caesium both in rats and in dairy cows where a decrease in milk transfer was measured. A high fibre diet decreased the transfer factor to milk by about 50% in cows. These results show that it would be beneficial to increase the fibre content by feeding more roughage like hay and silage, especially in cows receiving a high concentrate ration. After consuming contaminated feed caesium binders like bentonite can be used to decrease contamination of the cows.

The biological half-time determines the rate of decrease in different products when clean feeds are introduced after a period of contamination. In cattle the half-time for radio caesium in milk is 7 to 10 days and in meat of adult animals it is 30 to 40 days. The half-time in meat is shorter in growing animals partly due to the dilution effect that occurs when the body mass increases during growth. Physical exercise has been reported to decrease the biological half-time.

Strontium 90

Radio strontium is a chemical analog of calcium (Ca) and there will be competition between these two elements for uptake from soil to plants and plants to animals. Radio strontium as a food contaminant is of major importance in milk as the contamination level of meat is only about one tenth of that in milk. Due to the competition between Ca and strontium, increased Ca intake with normal Ca/Phosphate ratios will decrease gastro-intestinal uptake of radiostrontium but excessive amounts of Ca will disturb Ca homeostasis. No differences have been found in radiostrontium transfer to milk in dairy cows fed a grass diet or a concentrate rich diet. The same authors reported a biological half-life for strontium in milk of about 40 hours. Due to its relative mobility in the soil, strontium will be available for many years after it has been deposited in the environment. Countermeasures to reduce soil to plant transfer will therefore be important in producing uncontaminated forage for animals.

Iodine 131

A constant adequate supply of stable iodine is essential for normal thyroid function and this will minimize thyroid accumulation of radioiodine. This is especially important in inland areas with endemic iodine deficiency and in feeding systems using large amounts of cruciferous plants. That is kale, rape or other plants containing goitrogenic substances which suppress normal thyroid function. If the demand for stable iodine is satisfied the gastrointestinal uptake of radioiodine will be minimal and subsequently also the uptake into the thyroid gland and transfer to milk. A high stable iodine intake in the dairy cow will also give a high iodine concentration in the milk which will decrease uptake of radioiodine in people who drink such milk thus protecting them from thyroid irradiation. It must be noted that excessive intake of iodine can be toxic to humans. Apart from the intake of radioiodine through contaminated food there can also be a high respiratory intake of radioiodine. The biological half-time of radioiodine in milk is only about 20 hours.

In a more recent case study concerning the Fukushima Daiichi Nuclear Power Station the radiation levels of agricultural products has been monitored since 11 March 2011 (Nihei 2013). Radioactive materials released during the accident reached farmlands in Fukushima and neighbouring prefectures and contaminated the soil and agricultural products. To ensure the safety of agricultural, forestry and marine products, emergency monitoring of radiation levels was implemented. The livestock that were monitored were beef, chicken, pork and raw milk. This was in addition to the monitoring of a number of crops.

The samples were measured from March 2011 to March 2013, using the Germanium semiconductor detector (CANBERRA). The detection limit for radiocaesium was 10Bq/kg. The provisional guideline levels for raw milk were 200Bq/kg of milk and 500Bq/kg for cereals, vegetables, and marine products. The concentration of radioiodine was 300Bq/kg in raw milk and 2,000 Bq/kg in vegetables and marine products. There are no provisional regulation levels for radioiodine in cereals and meat.

Raw Milk

Raw milk was investigated at each of the numerous collection stations. In March 2011, 78% of the raw milk collected contained radioactive material less than the detection limit, 21% contained radioactive material ranging from the detection limit to 500Bq/kg, and 1% contained more than 500Bq/kg. In May 2011, 83% contained less than the detection limit, and 17% contained radioactive material ranging from the radioactive detection limit to 500Bq/kg. In June 2011, 97% contained less than the detection limit and 3% contained radioactive material ranging from the detection limit to 500Bq/kg.

Radiocaesium was not detected in raw milk in June or subsequent months. In March 2011, 10% of the raw milk contained radioiodine less than the detection limit, 76% contained radioiodine ranging from the detection limit to 300Bq/kg, and 14% contained more than 300Bq/kg.

Meat

The meat samples inspected included beef, chicken and pork. 84% of the beef samples contained less than the detection limit and 15% contained radiocaesium ranging from the detection limit to 100Bq/kg. However, 98% of Pork samples contained less than the detection limit, whereas 100% of chicken samples contained less than the detection limit. It is considered that the radioactive contamination of beef was due to the feed being contaminated. It is therefore important that the cereal straw and grass should be left outside during the contamination period.

Vegetables and Cereals

The vegetables and cereals did have measurable radioactive contamination at a low level. However, the leafy vegetables (Eg. Spinach and Broccoli) did have higher levels of contamination than the non-leafy vegetables (e.g. cucumber). The grass pastures were not evaluated for contamination but it is assumed that, being leafy, they would have a similar contamination to spinach and broccoli. As the cattle graze these pastures it could be assumed that the low, but higher contamination in the beef was also due to grazing contaminated pastures.

Soils

The crops growing on contaminated soils could have additional contamination due to their relationship with the soil and this could be passed onto the grazing livestock. The long-term problem of radiocaesium contamination of the soil has to be solved in the future, particularly Caesium 137 with a half-life of 30 years. In future, the farming of highly contaminated areas will require active decontamination processes, such as topsoil removal, deep ploughing, and soil turning tillage. Depending on the soil conditions, the application of potassium fertilizers and the addition of absorbents may be effective methods of inhibiting any further uptake of radiocaesium by plants.

From the above it can be seen that small levels of radioactive contamination could be measured in milk and meat during the first few months after the nuclear accident and within a year these levels had dropped significantly to below the detection limits.

3.3.2 Potential impacts on livestock

In terms of agriculture there are three phases/scenarios where the potential impacts can be evaluated:

1. The construction of the power station;
2. The operation of the power station;
3. Decommissioning of the power station; and
4. The possibility of a nuclear incident/disaster at the power station.

(1) Construction phase

There is considerable agricultural activity within the 16km radius surrounding the three sites. Construction of a nuclear power station could ***potentially*** have an impact on farming in these areas.

Road congestion:

Construction of the power station may result is some congestion on local roads due to the large volumes of building materials that will be brought into the site. This increased traffic is likely to have some impact on the local farmers because they transport produce to market on a daily basis.

The impact is likely to be greater where the produce is milk, vegetables and flowers, in which case the farmers around the Thyspunt and Bantamsklip sites are more likely to be affected than the more extensive farming operations around the Duynefontein site.

A specific concern in this regard would be dairy cattle crossing the roads to get to other pastures or for milking. This will need to be well-controlled, with traffic flags stopping the traffic.

Dust impacts:

It is expected that, as a result of the large amount of transport involved in construction, there will also be a certain amount of dust generated over an extended period. The amount of dust will depend on the surface of the roads. If they are mainly dirt roads a considerable amount of dust will be generated which is not desirable in any farming operation. This is especially so where fresh produce like milk and vegetables are produced around the Thyspunt and Bantamsklip sites, but also around the Duynefontein site where grapes are an important fresh product.

Increase in livestock diseases

As the region is an intensive livestock area, an increased number of people (plus domestic animals) entering the area as a result of the proposed project, there is a possibility of an increase in diseases that can be transmitted to livestock. This could include contagious abortion and similar diseases. This can be mitigated against through restrictions on the movement of people (construction workers) on farms.

Impact on the job market:

Industrial intrusion into any agricultural area has an impact on farms. First, industrial jobs traditionally pay more than agricultural jobs. This creates unhappiness amongst some agricultural workers, which results in demands for higher wages. Secondly, there is a move away from farming to industry, resulting in a shortage of agricultural labour. Thus, one would expect there to be some competition for labour, particularly casual, between the Nuclear-1 project and the agricultural sector. However, according to the Social Impact Specialist (personal communication), the personalities and lifestyle of farm workers are so different to those of construction workers that such competition is unlikely to occur on any significant scale.

Stock theft and general crime

As a result of the increased influx of people during the construction period there may be an increase in stock theft and related crime. This issue is dealt with in the Social Impact Assessment.

(2) Operational phase

The operation of the power station should not affect livestock producers or their livestock or livestock produce in any substantial way.

(3) Decommissioning phase

Eskom provided the decommissioning plan developed for the Koeberg Nuclear Power Station as the basis for the decommissioning phase of the proposed ***Nuclear-1***. Eskom developed a strategy for decommissioning based on the United States Nuclear Regulatory Commission (US NRC) “Decon” alternative.

Given the above, the exposure to radiation would therefore be kept to a minimum and below the required dose stipulated by the National Nuclear Regulator (NNR) through continued radiation measurement. Since these dose limits are based on safe exposure levels, it is expected that the radiation exposure during decommissioning would be negligible. Therefore, decommissioning of the power station should not affect livestock producers or their livestock or livestock produce in any substantial way.

(4) Impact in the event of a nuclear incident

The actual risk of an accidental release of radionuclides over and above normal operations will need to be verified in the licensing process of the National Nuclear Regulator. Given that the probability that an incident happening is very low, the discussion below must be seen in this context.

The accidental release of radionuclides from a nuclear reactor and their effect on crop and livestock has been researched and summarised in the preceding sections of the study. It should be noted that caution should be exercised in regard to the accuracy of these measurements due to the complex nature of the biological systems involved in the uptake, storage and release of the radionuclides in animals. Nevertheless, there is naturally great concern that radionuclides will enter the food chain through domestic farm animals, and there is sufficient evidence to show the nature of the potential transfer of radionuclides from the air to the soil and plants and thereafter into animals and the human food chain.

With livestock, the major concern regards the contamination of meat and milk. As milk is more likely to contain higher levels of radionuclides than meat and is immediately moved into the human food chain, the main concern with livestock products is directed at milk. The meat from longer-living animals, e.g. beef cattle, which live up to 2-10 years (as opposed to shorter-living animals such as pigs and poultry), is less likely to be contaminated because of the reduction in beef of those radionuclides with a short half-life. However, pigs and poultry are usually kept inside sheds where they are fed with feed from outside the area and are therefore less likely to be contaminated in the first place.

Therefore, in the event of a nuclear incident involving nuclear fallout, the main concern is that milk will immediately be contaminated and enter the human food chain within 24 hours. Beef cattle, sheep and game that feed on contaminated grazing will also be immediately contaminated, but the meat will enter the human food chain only after a period of time when radionuclides have diminished to an extent in the meat. Poultry and pigs are unlikely to suffer contamination except through the ingestion of radioactive material.

A number of proposals for reducing the effect of radionuclides in livestock have been made and also implemented, but few have any great significance.

(i) Dairy producers

In the event of a nuclear incident all dairy cattle will have to be removed from the area immediately. If they are to continue to be milked they will then need to be fed with uncontaminated fodder for the length of their lives. Their original farms will need to be evacuated for a period exceeding their own productive lives.

(ii) Beef farmers:

The majority of feed for beef cattle will come from grazing natural or artificial pastures, and these feed sources will be contaminated immediately, in which case the cattle will need to be removed immediately from the farms and put on ‘clean’ grazing.

(iii) Poultry and pig producers:

Poultry and pigs in enclosed housing and fed “out of the bag” are the least likely of the farm animal species to be affected by radionuclides. It would appear that, in the case of a nuclear incident, they could continue to be produced in this manner, but the farm workers would not be allowed to continue working in the area because of the likelihood of them being exposed to radiation. In this case the stock would need to be slaughtered or moved outside the danger area.

3.4 Crop production

The survey of agricultural activities at the three sites indicates that Thyspunt is predominantly a dairy farming area, Bantamsklip has fynbos and dairy farms, and Koeberg has irrigated grapes and wheat under dryland production.

The information gathered in the agricultural survey has been used in identifying potential impacts on agricultural production of the proposed nuclear power station. These were analysed and mitigation options prepared. The impacts on crop production and mitigation measures have been separated into three phases, - construction, normal operation and nuclear accident.

The impacts on agriculture have been confined to the 16km radius around the proposed sites, although experience such as at Chernobyl shows that farming is vulnerable to the effects of a nuclear accident hundreds, even thousands, of kilometres away from the site.

3.4.1 Potential impacts of radionuclides on crop production

Radionuclides that mainly enter the food chain by direct contamination (e.g. radiocaesium, 137Cs) are especially important in the context of the study, in particular in the contamination of cereals such as wheat and pasture grasses.

The radionuclide contaminants of most significance in agriculture are those that are relatively highly taken up by crops, have high rates of transfer to animal products such as milk and meat, and have relatively long radiological half-lives. However, the ecological pathways leading to crop contamination and the radio-ecological behaviour of the radionuclides are complex and are affected not only by the physical and chemical properties of the radionuclides but also by factors which include soil type, cropping system (including tillage), climate, season and, where relevant, biological half-life within animals. The major radionuclides of concern in agriculture following a large accident are 131I, 137Cs, 134Cs and 90Sr.

While the caesium isotopes and 90Sr are relatively immobile in soil, uptake of roots is of less importance compared with plant deposition. Plant deposition takes place when radionuclides are brought to earth in the rain or through dry deposition. Soil type (particularly with regard to clay mineral composition and organic matter content), tillage practice and climate all affect the propensity for radionuclides to move to groundwater. The same factors affect availability to plants insofar as they control concentrations in soil solution. In addition, because caesium and strontium are taken up by plants by the same mechanism as potassium and calcium respectively, the extent of their uptake depends on the availability of these elements. Thus, high levels of potassium fertilisation can reduce caesium uptake and liming can reduce strontium uptake.

The dynamics of radioactive contamination of aquatic ecosystems (1986–1990) is considered on the basis of observational data in the near and distant zones of the Chernobyl fallout (the Chernobyl Nuclear Power Plant (CNPP) cooling pond, the Pripyat River, the Dnieper reservoirs, and the Kopor inlet of the Gulf of Finland). Radionuclide accumulation in aquatic biota was analysed. The results obtained by Kryshev (1995) indicate that the radio-ecological conditions in the water bodies under investigation were in a state of non-equilibrium over a long period of time. Reduction in the 137Cs concentration proceeded slowly in most of the aquatic ecosystems. The effect of trophic levels, which consisted of increased accumulation of radiocaesium by predatory fish, was observed in various parts of the contaminated area.

From the above discussion, and in particular the non-equilibrium state over time (radiation clearing slowly), the restrictions in place on food grown around a disaster might have to remain in force for half a century.

Radioactive materials, especially cesium-137, with a half-life of 30 years, will decay over time, but life in the contaminated parts will take time to return to normal.

3.4.2 Potential impacts on crop production

As in livestock there are four phases/scenarios where the potential impacts can be evaluated:

1. The construction of the power station;
2. The operation of the power station;
3 Decommissioning of the power station; and
4. The possibility of a nuclear accident/disaster.

(1) Construction

During the construction phase of the proposed new ***nuclear power station***, the main risk to crop production will be dust and increased cost of unskilled labour.

(a) Dust:

Dust in the air or deposited on plant foliage will reduce photosynthesis in the plants. Reduced photosynthesis will mean less energy for growth and lower crop yields. The impact of dust on the plants will reduce when rain or irrigation washes the dust off the foliage.

Prevailing wind direction over the study areas varies during the year. The risk of dust during construction will be highest at Bantamsklip, where farming mainly involves harvesting of flowers from fynbos grown under dryland conditions. Dust on leaves of perennial fynbos plants will result in some loss of photosynthetic activity and reduced flower yields.

At Thyspunt the pastures of most farms used for dairy production are too far downwind of the proposed nuclear power station, and are therefore not likely to be impacted by dust. The farms Waalgelegan, Penny Bee and BuffelsBosh may encounter some loss of fodder production due to dust. In summer the prevailing wind at Thyspunt (Cape St. Francis) is mainly off-shore.

The coastline at Koeberg lies north-west to south-east, and therefore dust from construction during summer will mainly affect beaches. The south-westerly winds are associated with rain, which will settle the dust and therefore reduce dust depositions on farms inland of the coast.

(b) Impact on the labour market:

Labour-intensive farming activities such as grape harvesting and flower harvesting from fynbos may be negatively impacted during the construction phase when local labour costs, mainly for unskilled persons, will increase because of demand for labour. The situation could normalise after construction, when semi-skilled and skilled staff is recruited to operate the power station. However, as mentioned in Section 3.3.2 above, it appears from the Social Impact Specialist study (personal communication) that competition between these sectors will not be of any significance.

(2) Operational Phase

The normal operation of the power station should not affect crop production in any substantial way.

(3) The Decommissioning Phase

Decommissioning of the power station should not affect crop production in any substantial way.

(4) Impacts in the event of a nuclear incident

Countermeasures applied during the first few weeks after deposition are concerned particularly with reducing exposure from short-lived radionuclides such as iodine-131. Thus, crops may be harvested and stored, or harvesting may be delayed, to allow for radioactive decay before consumption.

Once radioactive contamination is distributed through the biosphere, a wider range of countermeasures needs to come into play to take into consideration the transfer of the relevant radionuclides from soils into the food chain. For example, since mineral uptake by plants is related to the total available and relative abundance of their different ions, the application of high levels of potassium fertilizer can reduce radiocaesium uptake, while liming, by increasing calcium levels, can reduce radiostrontium uptake.

It may be possible to use alternative crops or varieties that accumulate lower levels of radionuclides than those normally grown in a region - for example, cereals in place of leafy vegetables and pasture. Another possibility is to grow crops such as sugar-beet or canola where the edible product is processed and contamination reduced. In order to maintain some form of agriculture wherever possible, the production of non-food crops such as flax for fibre, oilseed for lubricants or biofuel, and ornamental plants would need to be considered.

Finally, burying the contaminated surface of the land by deep ploughing can be an effective procedure for large farms, provided that proper ploughs and powerful tractors are available.

3.5 Potential for Water Contamination

All the sites are located on the coast in close proximity to the sea. Therefore, in the event that there is a contaminated spillage and a subsequent seepage into the ground water, this will not affect the ground water used by farmers as they are inland of the sites. In terms of surface water, this will only be contaminated by general fallout, which has been described in the previous section.

3.6 Potential Economic and Marketing Impacts

As a result of the development of a nuclear power station, there is potential to increase the market demand of local agricultural production in the area of the proposed sites. This potential impact could be negated to some extent by the perceived consumer concern of produce grown in the proximity of a nuclear plant. ***This perception has no scientific basis*** during normal operation of the nuclear plant (given the dosage emission in Section 3.1), but could be a short-term impact until the consumer becomes more knowledgeable about the environmental impacts of a nuclear plant on agricultural production. ***The normalisation of the market for agricultural produce grown in close proximity to a nuclear plant can to some extent be shown by the agricultural production around the Koeberg nuclear power station. As can be seen from the farm survey around Duynefontein, there is extensive agricultural production around Koeberg, none of which is***

significantly different to the regional production in the area further away from the nuclear plant. This can also be seen on some nuclear plants in other countries (e.g. France) where there is agricultural production in close proximity to the nuclear plant. Related to this market concern is the fact that there is currently an increase in the move towards organic farming in South Africa. A number of organic certification organisations were contacted and they confirmed that production in close proximity to a nuclear plant would not preclude a farm from obtaining certification and that normal criteria would apply for certification.

Notwithstanding the above, an estimate is made on the potential market increase for each site given the potential to increase agricultural production in each area. ***This potential increase in demand for agricultural produce is a result of the influx of people during the construction phase and to a lesser extent during the operational phase.***

This potential economic benefit is based on the potential of a region to increase its agricultural production as a result of the potential increased demand within the region.

In regard to Duynefontein it is estimated that there will not be a significant increase in demand in the region, as the region is a peri urban region in close proximity to a large expanding city (i.e. a large market for agricultural produce). Therefore, the influx of people for the proposed Nuclear-1 development will not have a significant effect on the local demand for agricultural produce.

In regard to Bantamsklip the majority of the current and potential production is from fynbos harvesting, which will not be significantly impacted by the influx of people. There are some dairy and mixed farming activities, which potentially can take advantage of the increase in demand for agricultural production. A major constraint in this area is the availability of water for irrigation purposes. Therefore, any potential increase in current production is very limited. If the region is not able to increase production then the increased production to meet the demand will come from another region. For these reasons it is estimated that the potential market increase will be less than 5%.

The region around Thyspunt has relatively high agricultural production, which is illustrated by the estimate of total agricultural revenue from the region. The dominant farming activity is currently dairy farming, with farmers supplying large dairy factories, which then distribute the milk nationally and internationally (Zimbabwe).

As Thyspunt is a region with high agricultural production it does warrant more detailed analysis than the other two sites. As stated earlier, it is estimated that the average production of milk is approximately 295 000 litres/day (2013) within a 16 km radius of the site. Therefore, even if the local consumption had to increase by 5000l/day as a result of the proposed development, this would have very little impact on the supply of milk in the region (less than two percent). However, when looking at the region (Eastern Cape) as a whole there would be a significant impact on agriculture as highlighted in the Economic Impact Assessment. The results are given in the regional macro-economic model (Economic Impact Assessment) where the total impact on agricultural production for the region (Eastern Cape) is estimated. The results are summarised in the following table below.

Table 3-6: Regional Macro Economic Impact of the Proposed Development

Type of Farming	Total - Impact on Production per Annum			
	Direct impact	Indirect impact	Induced impact	Total impact
		(R millions)		
Citrus farming	R 0.0	R 0.7	R 8.6	R 9.3
Sub-tropical fruit farming	R 0.0	R 0.0	R 1.3	R 1.4
Livestock farming	R 0.0	R 0.8	R 29.5	R 30.3
Dairy farming	R 0.0	R 1.7	R 22.1	R 23.8
Game farming	R 0.0	R 0.0	R 1.4	R 1.4
Forestry (Plantations)	R 0.0	R 5.3	R 1.7	R 7.0
Other agriculture	R 0.0	R 3.9	R 36.7	R 40.6
Agriculture - Subsistence	R 0.0	R 0.2	R 4.5	R 4.8
TOTAL AGRICULTURE	**R 0.0**	**R 12.7**	**R 105.8**	**R 118.5**

From the above table it can be seen that as a result of the proposed development of establishing the nuclear station it is estimated that agricultural production in the region (Eastern Cape) may increase by a potential R118.5 million in total. It should be noted that that this estimate is derived from indirect and induced impacts and not direct impacts. The breakdown of the increase in demand (R118.5 million in 2008/9 values) and hence the potential increase in agricultural production of the different types of farming have been given in the table. It should be noted that there has been a significant increase in milk production from 2008 (when the initial survey was undertaken) to 2013 (estimate given by Woodlands Dairy). This indicates that there is potential to increase production in the region.

In a 2013 survey of some of farmers in the region it was found that the large farmers in the area are currently generally producing at capacity and do not have much flexibility to change their production system on their current farms. Some farmers have purchased land in different regions in order to expand their production. However, some of the smaller farmers (those that produce less than 12,000 litres of milk per day) do have potential to expand their production and to diversify production (i.e. increase meat production). In this regard the switch to alternative crops (e.g. vegetables) would be difficult as most farmers want to remain as livestock farmers and agricultural production around Hankey (north of Humansdorp) would have a comparative advantage (better soil and climate) to take advantage of an increase in demand for vegetables around the Thyspunt site.

Like all other businesses, farmers are continually looking at improving their efficiency and profitability in production. There are many references that show that improved pasture nutrition could increase production. However, a balance needs to be found between increasing production and maximizing profitability.

Given the above it is estimated that the potential increase in the market for agricultural produce around the Thyspunt site could be 10-15%. It needs to be stressed that this is an estimated potential increase in production based on technical factors and it would be up to the farmers in the region to decide whether they are willing and able to take advantage of this potential opportunity.

Table 3-2 summarises the estimated potential increase in agricultural production as a result of the possible increase in demand for agricultural production in the regions ***of the three alternative sites.***

Table 3-2 : Estimated Economic Impact on the Markets of Agricultural Produce

Site	Gross Value R (million)	Estimated impact
Bantamsklip	29	Increase by 0-5%
Duynefontein	75	No change
Thyspunt	150	Increase by 10-15%

One of the most significant economic impacts on agricultural production would be the potential shortage of unskilled labour and the resultant increase in cost of labour. This has been discussed in the technical considerations above. As indicated, a number of the enterprises are labour intensive and therefore would experience increased production costs. It is envisaged that this would be a short-to medium-term impact as it would mainly be during the construction phase of the development, and labour from other areas will move into the proposed sites.

3.7 Potential impact of climate change

Using the research undertaken by Prof Roland Schulze and the School of Bioresources Engineering and Environmental Hydrology, University of KwaZulu-Natal (Knoesen et al 2009), the average change in temperature and rainfall as a result of climate change for the three sites can be estimated. The results from three global climate models plus the average from the three models are given in Tables 3-3 to 3-8.

Table 3-3 : Indicative Summary of Projected Changes in Mean Annual Rainfall at Table View (Duynefontein)

GCM Model	Current Volume	2045-2065 increase
GISS	337 mm per annum	0%
ISP		8%
ECH		14%
Average		**7% to 362 mm**

Table 3-4 : Indicative Summary of Projected Changes in Mean Annual Rainfall for Pearly Beach (Bantamsklip)

GCM Model	Current Volume	2045-2065 increase
GISS	523 mm per annum	10%
ISP		22%
ECH		12%
Average		**15% to 600 mm**

Table 3-5 : Indicative Summary of Projected Changes in Mean Annual Rainfall for Oyster Bay (Thyspunt)

GCM Model	Current Volume	2045-2065 increase
GISS	691 mm per annum	14%
ISP		26%
ECH		7%
Average		**16% to 799 mm**

Table 3-6 : Indicative Summary of Projected Changes in Temperature for Table View (Duynefontein)

GCM Model	Current	2045-2065 increase
Mean Annual Temperature		
GISS	16°C	+1.7°C
ISP		+2.9°C
ECH		+1.5°C
Average		**+2.0°C to 18°C**
July Minimum Temperature		
GISS	8°C	+1.5°C
ISP		+3.0°C
ECH		+1.7°C
Average		**+2.1°C to 9.1°C**
January Maximum Temperature		
GISS	26°C	+1.6°C
ISP		+2.6°C
ECH		+1.3°C
Average		**+1.8°C to 27.8°C**

Table 3-7 : Summary of Projected Changes in Temperature for Pearly Beach (Bantamsklip)

GCM Model	Current	2045-2065 increase
Mean Annual Temperature		
GISS	17°C	+1.6°C
ISP		+2.7°C
ECH		+1.6°C
Average		**+2.0°C to 19°C**
July Minimum Temperature		
GISS	7°C	+1.4°C
ISP		+2.8°C
ECH		+1.7°C
Average		**+2.0°C to 9°C**
January Maximum Temperature		
GISS	25°C	+1.7°C
ISP		+2.2°C
ECH		+1.4°C
Average		**+1.8°C to 26.8°C**

Table 3-8 : A Summary of Projected Changes in Temperature for Oyster Bay (Thyspunt)

GCM Model	Current	2045-2065 increase
Mean Annual Temperature		
GISS	17°C	+1.5°C
ISP		+2.2°C
ECH		+1.4°C
Average		**+1.7°C to 18.7°C**
July Minimum Temperature		
GISS	8°C	+1.3°C
ISP		+2.2°C
ECH		+2.0°C
Average		**+1.8°C to 9.8°C**
January Maximum Temperature		
GISS	24°C	+1.7°C
ISP		+1.5°C
ECH		+1.3°C
Average		**+1.5°C to 15.5°C**

Source: Knoesen et al 2009

From the above tables it can be seen that it is expected that there will be an increase both in temperature (1-2^{o}C) and rainfall at all three sites. It is expected that the increase in rainfall will mainly be from extreme events at specific times in the season as opposed to a general increase over the year.

From this it is expected that there will be a positive impact on agricultural production with an increase in heat units. However, this impact is not expected to be significant.

With regard to the impact with or without a nuclear power station, the only impact would be wind and the effect of dust. Unfortunately there is no information on wind in relation to climate change. However, wind is expected to increase as a result of an increase in extreme climatic events.

3.8 Impact of the desalination plant

For all three sites it is assumed that the waste from the desalinisation plant (brine) will be pumped back into the ocean in a controlled way. If this is the case there will be no impact on agricultural production as a result of the desalinisation plant.

4 MITIGATION MEASURES

4.1 Construction phase

In order to minimise dust from construction the following measures should be implemented:

- Build the roads serving the nuclear power station as a first priority, and have these tarred or lined with concrete;
- Regular spraying of water on bare soil at site to reduce generation of dust.

In terms of negative market perspective of agricultural produce grown near a nuclear power station, an awareness programme showing the impacts of a nuclear plant on agricultural production needs to be implemented.

With regard to labour, although it appears that competition will not be a significant factor, an awareness campaign needs to be undertaken among existing farm labourers to highlight the benefits of permanent work on farms as against the essentially short-term nature of construction work on a nuclear power station.

4.2 Operational phase

In the planning and preparation of responses to a nuclear accident, possible protective actions should be assessed in a general way in relation to a range of credible accident scenarios. From this, the criteria for action to be used immediately and for a short time after an accident can be developed. The response plan could follow two phases.

4.2.1 Phase 1 − Data gathering and laboratories

Response plans require a database which includes information about the transfer of the radioisotopes caesium and strontium between local soil, water, plants, animals and fish. These are the isotopes most likely to cause more than transient problems to agriculture. In addition, data on soils, weather patterns, local dietary preferences, and some feasible countermeasures with estimates of their costs should be included. A network of laboratories for radionuclide analysis must also be identified.

With regard to acceptable levels of radionuclides in food, radioactivity in foodstuffs and soil are expressed as activity per unit mass (g or kg). The FAO/WHO Codex Alimentarius Commission has developed international standards for radionuclide contamination to be applied to food moving in international trade. These are shown in **Table 4-1**.

Table 4-1: Guideline Levels for Radionuclides in Foods for Use in International Trade following Accidental Nuclear Contamination

Dose per unit intake factor	Representative radionuclides	Level (Bq/kg)

Foods destined for general consumption		
10^{-6}	Americium-241, Plutonium-239	10
10^{-7}	Strontium-90	100
10^{-8}	Iodine-131, Caesium-134, Caesium-137	1000
Milk and infant foods		
10^{-5}	Americium-241, Plutonium-239	1
10^{-7}	Iodine-131, Strontium-90	100
10^{-8}	Caesium-134, Caesium-137	1000

Source: http://www.iaea.org/Publications/Magazines/Bulletin/Bull383/38305493843.pdf

Note 1: The standard SI unit for radioactivity is the Becquerel (Bq). A becquerel is equal to one unit of disintegration per second.
Note 2: These levels are designed to be applied only to radionuclides contaminating food moving in international trade following an accident and not to naturally occurring radionuclides which have always been present in the diet. The Codex Alimentarius Guideline Levels remain applicable for one year following a nuclear accident. By an accident is meant a situation where the uncontrolled release of radionuclides to the environment results in the contamination of food offered in international trade.

The levels are based on a number of conservative assumptions in order to be confident that there will be essentially no effect over a lifetime of exposure. Hence, if alternative food is not available, higher values would be acceptable in the short term. On the other hand, lower levels may be appropriate, for example, if external radiation makes a high contribution to the total dose. However, in many cases the choice of countermeasures will be constrained by social factors and infrastructure of the region, so it is important that the database for decision-making includes this information too.

4.2.2 Phase 2 – Protective measures

The second phase begins some time after an accident has happened when specific information on its nature and likely consequences is available. Specific protective measures can then be considered.

Agricultural countermeasures address long-term health effects in the human population; the more immediate impact of radiation exposure on plant and animal life is not directly considered.

Test plantings of crops which were grown in the past, such as wheat, grapes and pastures, should be done over time until acceptably low radiation levels are measured in the harvested products. Thereafter, the area can be used for large-scale crop production. An alternative strategy would be to use the contaminated lands for industrial biofuel crops such as sugar-beet for ethanol and canola for biodiesel.

4.3 Decommissioning Phase

There have been no significant impacts identified for agricultural production during the decommissioning phase.

5 IMPACT ASSESSMENT

5.1 Impact Criteria

The following criteria impacts are analysed for the construction phase:

- Dust;
- Availability/cost of labour; and
- Market effects.

The potential impacts are summarised in Table 5-1 (a) to (c) ***for*** the three Nuclear-1 sites.

5.2 Assessment

From the above it can be clearly seen that the potential negative impacts during the construction phase are least significant at the Duynefontein site. The main reason for this is that the area already has the infrastructure for a nuclear station and the surrounding ***areas of agricultural production*** have adapted to the existing plant.

In the operational phase, the biggest impact in ***unlikely event of*** a nuclear incident would be at the Thyspunt site, as the area is the most intensively used for agriculture.

The largest potential increase in agricultural production due to the construction and operation of the power station would be at Thyspunt, due to the favourable agricultural conditions, which would allow farmers to capitalise on the inflow of employees into the area. There would be a smaller potential increase at Bantamsklip, and no positive impact at Duynefontein.

Table 5-1: Agricultural Impacts at alternative sites

(a) Thyspunt

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Dust pollution	***Medium***	***Low***	***Low***	***Low***	***Medium***	***High***	***Medium***
Dust pollution (mitigated)	***Low***	***Low***	***Low***	***Low***	***Low***	***Low***	***Low***
Availability/Cost of labour	***Medium***	***Low***	***Medium***	***Low***	***Medium***	***Medium***	***Medium***
Availability/Cost of labour (Mitigated)	***Medium***	***Low***	***Medium***	***Low***	***Medium***	***Medium***	***Medium***
Change in market condition (Positive)	***Medium***	***Low***	***Medium***	***Low***	***Medium***	***Medium***	***Medium***
Change in market condition (Optimised)	***Medium***	***Low***	***Medium***	***Low***	***Medium***	***Medium***	***Medium***

(b) Bantamsklip

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Dust pollution	***Medium***	***Low***	***Low***	***Low***	***Medium***	***High***	***Medium***
Dust pollution (mitigated)	***Low***	***Low***	***Low***	***Low***	***Low***	***Low***	***Low***
Availability/Cost of labour	***Medium***	***Low***	***Medium***	***Low***	***Medium***	***Medium***	***Medium***
Availability/Cost of labour (Mitigated)	***Medium***	***Low***	***Medium***	***Low***	***Medium***	***Medium***	***Medium***
Change in market condition (Positive)	***Low***	***Low***	***Medium***	***Low***	***Low***	***Medium***	***Low***
Change in market condition (Optimised)	***Low***	***Low***	***Medium***	***Low***	***Low***	***Medium***	***Low***

(c) Duynefontein

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Dust pollution	***Low***	***Low***	***Low***	***Low***	***Low***	***High***	***Low - medium***
Dust pollution (mitigated)	***Low***	***Low***	***Low***	***Low***	***Low***	***Low***	***Low***
Availability/Cost of labour	***Low***	***Low***	***Medium***	***Low***	***Low***	***Medium***	***Low***
Availability/Cost of labour Mitigated)	***Low***	***Low***	***Medium***	***Low***	***Low***	***Medium***	***Low***
Change in market condition (Positive)	***Low***	***Low***	***Medium***	***Low***	***Low***	***Medium***	***Low***
Change in market condition (Optimised)	***Low***	***Low***	***Medium***	***Low***	***Low***	***Medium***	***Low***

6 CONCLUSIONS AND RECOMMENDATIONS

This report has examined the impact of ***the*** proposed ***Nuclear-1 power station*** on agriculture at the three ***alternative*** proposed sites. The report has focused on the regional impact as opposed to the specific site, as the ***power station*** itself will have ***no impact*** on agricultural production.

In order to obtain a regional perspective a land use survey and an agricultural survey was undertaken on a 20km and 16km radius respectively. Each farm unit was identified and information was collected on each farm. In this way the amount of agricultural production taking place within the 16km radius was estimated for each ***alternative*** site. From this information it was found that the Thyspunt site had the highest agricultural production and also the biggest potential to increase production compared to the other two sites.

With regard to potential impacts, it was found that the Duynefontein site would have the least ***negative*** impact on agriculture as agricultural ***production*** has already taken place in the surrounding region alongside the construction and operation of the Koeberg ***Nuclear Power Station***.

From an agricultural production perspective, Thyspunt would experience the largest potential benefit because its agricultural production could potentially expand the most of the three alternative sites.

For all three sites there are no “no-go” areas and no preferred siting of the facility from an agricultural point of view.

In summary, the impacts on agriculture at the three sites are as follows:

Duynefontein – no significant impact on agriculture during construction and normal operations. No increase in agricultural production during the operational phase.

Thyspunt – ***short term*** negative impact on agriculture in terms of dust during the construction phase. However, there is potential for a positive impact on production by taking advantage of the increase in demand for agricultural produce on a regional basis (Eastern Cape) as a result of the proposed construction and operation of the power station and for some of the smaller scale dairy producers, who could diversify their production..

Bantamsklip – negative impact on agricultural production with regard to dust during the construction phase. There is an estimated potential of less than 5% to increase the market for local agricultural produce because of water limitations that restrict expansion.

In terms of the impact on agriculture, there are no fatal flaws in respect of any of the three sites, and all of them would be suitable to accommodate Nuclear-1.

7 ADDITIONAL NOTE

The recently completed report on the 'Radiological Impact Assessment Report (August 2015)' is considerably more complete than the screening-level assessment undertaken by the Airshed report. However, the routine emissions in this recent report are generally only slightly higher than previously reported in the "Airshed study". At Thyspunt the effective dose in the Radiological Impact assessment (4.5 to 5.9 mSv) is even lower than in the Airshed study' (11.31 mSv).

In this report we outline the effect of radionuclides on livestock production and it is stated "Radionuclides enter an animal mainly through feed intake and only in smaller quantities through inhalation". The first dairy herds appear at a distance of 2.5km from the plant site and only appear in larger numbers after 3km. Therefore the new information from the report "Radiological Impact Assessment" will have no additional impact on the milk quality from the dairy cows.

The consultants have also been through the recently completed Town Planning and Development Perspective Report (September 2014). An integrated meeting was held on the 27 July 2015 with a number of specialists and the key aspects of the report were discussed. The conclusion from the agricultural side in that the Town Planning Report does not have any material impact on the findings of this report.

8 REFERENCES

Alexakhin, R. (2008). Database on Sr-90 and Cs-137 transfer factors in the soil-fodder-animal products chain. Russian Institute of Agricultural Radiology and Agroecology. [online]. Available: http://www.fgi.icc.gov.ua/eng/1Publications/radioecology/SP-23b-Alexakhin.doc [15 August 2008].

ANON (1959). Radioactive Materials in Food and Agriculture. Rome: FAO.

ANON (2000). Radionuclides (including Radon, Radium and Uranium. Technology Transfer Network. [online]. Available: http://www.epa.gov/ttnatw01/hlthef/radionuc.html (13 August 2008).

ANON (2006). French dairy cattle given water contaminated by leaking nuclear dumpsite. Greenpeace Report. [online]. Available: www.greenpeace.org [12 August 2008].

Anon (2007). Eskom Fact Sheet - Nuclear Waste. Generation Communication. [online]. Available: http://www.eskom.co.za/content/NU%200002NucWastRev2.doc [August 2008].

ANON (Unknown-a). Facts on nuclear waste from Koeberg. [online]. Available: http://www.eepublishers.co.za/view.php?sid=1204 [15 August 2008].

ANON (unknown-b). What you should know about nuclear incidents. [Online]. Available: www.agriculture.state.pa.us [13 August 2008]

Beresford, N.A., Gashchak, S., Lasarev, N., Arkhipov, A., Baglay, Y.G., Loginova, L. and Burov, N. (2000). Transfer of Cs137 and Sr90 to dairy cattle fed fresh herbage 3.5 kilometres from the Chernobyl Power Plant. *Journal of Environmental Radioactivity,* 47(2):157-170.

Beresford, N.A., Mayes, R.W., Colgrove, P.M., Barnett, C.L., Bryce, L., Dodd, B.A. and Lamb, C.S. (2000). A comparative assessment of the potential use of alginates and dietary calcium manipulation as countermeasures to reduce the transfer of radiostrontium to them milk of dairy animals. Abs. *Journal of Environmental Radioactivity,* 51(3): 321-334.

Cook, J. (1986). Red Alert. Kent: New English Library.

Fig D. (1994). Nuclear Issues in Contemporary South Africa. Johannesburg: GEM monitor.

Geraskin, S. A., Dikarev, V.G., Zyablitskaya, Y.Y., Oudalova, A.A., Spirin, Y.V. and Alexakhin, R.M. (2002). Genetic consequences of radioactive contamination by the Chernobyl fallout to agricultural crops. *Journal of Environmental Radioactivity*. 66:(1-2)155-169.

Green, N, Wilkins, B.T, Davidson, M.F, and Hammond, D.J. (1995). The transfer of plutonium, americium and technetium along the soil-pasture -cow pathway in an area of land reclaimed from the sea, Abs. *Journal of Environmental Radioactivity*, 27: 35-47 [online]. Available:

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VB2-3YF4P15-J&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=10&md5=c870aa02a551d6ac8a1da7f52ece2196 (17 August 2008).

Harrison, J, and Phipps, A. (2002). Comparing man-made and natural sources of radionuclide exposure. Consultative Exercise on Radiation Risks of Internal Emitters. [online]. Available: http://www.cerrie.org/committee_papers/INFO_6-E.doc (11 August 2008).

IAEA Bulletin (1996). Guideline levels for Radionuclides in Foods following accidental nuclear contamination for Use in International Trade. [online]. Available: http://www.iaea.org/Publications/Magazines/Bulletin/Bull383/38305493843.pdf. [16 August 2008]

Jones, B.E. (1993). Management methods of reducing radionuclide contamination of animal food products. *Science of the Total Environment,* 137:227-233.

Knoeson D, R Schulze, C Pringle, M Summerton, C Dickens and R Kunz (2009). Water for the Future: Impacts of Climate Change on Water Services in the Orange-Senqu River Basin. Report to NeWater, a project funded under the Sixth Research Framework of the European Union. Institute for Natural Resources, Pietermaritzburg, South Africa,

Kryshev, I. I. (1995). Radioactive contamination of aquatic ecosystems following the Chernobyl accident. *Journal of Environmental Radioactivity,* 27(3): 207-219.

Mayes, R.W. (1989). The quantification of dietary intake, digestion and metabolism in farm livestock and its relevance to the study of radionuclide uptake. *Science of the Total Environment*, 85: 29-51. [online]. Available: http://www.sciencedirect.com/science?_ob=ArticleListURL&_method=list&_ArticleListID=779844250&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=27d287ae385795d1adfb6bda14d284c6 (Accessed August 2008).

Medvedev, Z. (1990). The Legacy of Chernobyl. New York: WW Norton.

Mitchell, P. I., Vintro, L.L., Dahlgaard, H., Gasco, C. and Sanchezcabeza, J.A. (1997). Perturbation in the Plutonium 240/239 global fallout ratio in local sediments following the nuclear accidents at Thule in Greenland and Palomares in Spain. Abs. [online]. Available: http://www.ncbi.nlm.nih.gov/pubmed/9241884 (13 August 2008).

Pasqualetti, M. (1990). Nuclear Decomissioning and Society. New York: Rutledge, Chapman & Hall.

Richards, J. and Hance, R (Unknown). Agricultural countermeasures. . International Atomic Energy Agency, Austria. Savchenko VK (1995). The Ecology of the Chernobyl Catastrophe. Paris: ONFSCO.

Smith, F, and Clark, M (1989). The Transport and Deposition of the Airborne Debris from the Chernobyl Power Plant with Special Emphasis on the Consequences to the United Kingdom. London: HMSO Publication Centre.

Ward, G. (1989). Recent research involving the transfer of radionuclides to milk. *Journal of Dairy Science* 72:284-287.

Wikipedia (unknown). The Three Mile Island nuclear accident [online]. Available: http://en.wikipedia.org/wiki/Three_Mile_Island_accident (14 August 2008).

Winteringham, F.P.W. (1989). Radioactive fallout in soils, crops and food. FAO Soils Bulletin, 61. [online]. Available: http://www.fao.org/docrep/T0228E/T0228E00.htm (15 August 2008).

Woodman, R.F.M, and Nisbet A.F. (1999). Derivation of working levels for radionuclides in animal feedstuffs for use following a nuclear accident. *Abs. Health Physics*, 77: 383-391. [online]. Available: http://www.health-physics.com/pt/re/healthphys/abstract.00004032-199910000-00005.htm;jsessionid=LsDNcqhgH9Ncy83lNrGHG2Qv2Zpw5KmhTJ0CRvtnpY71Cvznww2v!2087890851!181195629!8091!-1 (10 August 2008).

World Nuclear Organisation (2008). Chernobyl accident. [online]. Available: http://www.world-nuclear.org/info/chernobyl (13 August 2008).

APPENDIX 1

DETAILED INFORMATION ON EACH FARM UNIT

Detailed Information: Thyspunt

X	Y	_FARM_NAME	Farm_activ	Farmer	Size_ha	Main_bus	Tonnage	Livestock	Type_lives	Production	Area_cuti	Buyers	Pastures	Bare_sand	Dams_river	Cultivated	Naturl_veg	Degraded_A	Degraded_D	Sandmines
24.74430	-34.13702	BuffelsBosch	Dairy farming	R Gerber	1400 ha	Dairy farming	-	Dairy cows & cattle	400 beef cattle & 200 Dairy cows	1000 lt milk / day	-	Clover	200 ha	100 ha	1 dam	200 ha	1200 ha	-	-	-
24.74062	-34.12272	Game farm	Game farming	Y Jeewa	(198 ha)	Game farm	-	Buck, zebras, etc.	Various	-	-	Game hunters	-	-	-	-	Whole farm	-	-	-
24.69213	-34.15383	Waalgelegan	Dairy & sileage farming	J D W Strydom	271 ha	Dairy farming	1000 tons sileage/ yr	Dairy cattle	400 Dairy cattle	2500 lt milk / day	-	Woodlands dairy	220 ha	-	9 small dams	220 ha	30 ha	-	-	-
24.64535	-34.15683	Grass ridge farm	Dairy farming	R Dreyer	337 ha	Dairy farming	250 tons maize / yr	Dairy cattle	850 dairy cows	13 500 lt milk / day	30 ha	Clover	300 ha	-	3 rivers & 1 dam	330 ha	5 ha	-	-	1 small quarry
24.66013	-34.15850	Die ou milk staat	Dairy farming	O Sillies	250 ha	Dairy farming	300 tons sileage/ yr	Dairy cows	280 milking stock & 280 growing stock	3800 lt milk / day	50 ha	Parmalat	100 ha	20 ha	1 stream	150 ha	60 ha	-	-	-
24.62442	-34.13672	Kromhuit	Dairy & sileage farming	W Du Plessis	500 ha	Dairy farming	800 tons maize & grass / yr	Dairy cows	800 milking cows & 400 young stock	14 000 lt milk / day	150 ha	Clover	300 ha	-	1 dam, 1 river	450 ha	50 ha	-	-	-
24.59912	-34.13113	Sandwater	Dairy & sileage farming	S Van de Merwe	800 ha	Dairy farming	800 tons sileage / yr	Dairy cows	1200 milking cows & 380 young cows	16 000 lt milk / day	220 ha	Clover	300 ha	5 ha	2 dams	520 ha	260 ha	-	-	-
24.58598	-34.11772	Klipdrift farm	Dairy & sileage farming	Engberte	522 ha	Dairy farming	400 tons maize & 100 tons Grass sileage / yr	Dairy cows	500 Milking cows & 500 young stock	10 000 lt milk / day	45 ha	Clover	450 ha	-	4 dams	495 ha	20 ha	-	-	-
24.62512	-34.10145	Reebok Development Trus	Dairy & sileage farming	J Duistruing	1000 ha	Dairy farming	-	Dairy cows	200 milking cows& 400 beef cows	2000 lt milk / day	150 ha	Woodlands Dairy	600 ha	-	2 dams	750 ha	250 ha	-	-	-
24.66043	-34.08900	Kleinplaas	Sheep farming & abbatoir	K Du Plessis	2012 ha	Sheep farming	-	Sheep	6500 sheep	103 / day	-	Public & Butchery	1500 ha	-	7 dams		500 ha	10 ha	-	-
24.65250	-34.10138	Butchery	Butchery business	K du Plessis	(431 ha)	Butchery	-	-	-	-	-	Public	-	-	-		-	-	-	-
24.70333	-34.14763	Penny Bee	Dairy & sileage farming	R Ceney	(279 ha)	Dairy farming	800 tons sileage / yr	Dairy cows	500 milking cows	10 000 lt milk / day	400 ha	Woodland dairy	200 ha	-	1 dam		30 ha	20 ha	-	-
24.61287	-34.13177	Goedeoop	Dairy & sileage farming	B C Strydom	500 ha	Dairy farming	-	Dairy cows & sheep	1100 Cattle & 50 sheep	6500 lt milk / day	60 ha	Nestle	400 ha	-	3 dams & 1 river	460 ha	30 ha	-	-	1 small quarry
24.58557	-34.11597	Powfontein	Dairy & sileage farming	Stefan	330 ha	Dairy farming	600 tons sileage / yr	Dairy cows	560 milking cows & 500 young stock	8000 lt milk / day	30 ha	Parmalat	300 ha	-	1 dam	330 ha	5 ha			
24.75163	-34.08607	Woodland farm	Dairy & sileage farming	Lex Gucci	(330 ha)	Dairy farming	66 tons dry sileage / yr	Dairy cows	1600 milking stock	12000 lt milk / day	20 ha	Woodlands dairy	1050 ha	-	2 rivers & 4 dams	1070 ha	400 ha	-	-	-
24.77163	-34.01935	Woodlands dairy	Dairy Production	Lex Gucci	(1550 ha)	Milk processing	-	-	-	-	-	Chain stores & public	-	-	-		-	-	-	-
24.74062	-34.06477	Alpha farm	Dairy farming	H Pretorius	(607 ha)	Dairy farming	-	Dairy cows	460 Milking cows	6000 lt milk / day	-	Woodland dairy	-	-	2 dams		-	-	-	-
24.79332	-34.05515	Sarragossa	Dairy farming	D Masterson	(110 ha)	Dairy farming	-	Dairy cows	Milking cows	-	-	Parmalat	-	-	1 dam		-	-	-	-
24.64982	-34.17135	oysters bay	Residential	-	-	Residential	-	-	-	-	-	Residential	-	-	-		-	-	-	-
24.63043	-34.13943	Pannar	Seedling Farming	Pannar	(62 ha)	Seedling Farming	-	-	-	-	-	Crop farmers	-	-	-		-	-	-	-
24.63738	-34.14688	Malargra	Dairy farming	A Masterson	(68 ha)	Dairy farming	-	Dairy cows	Milking cows	-	-	Clover	-	-	-		-	-	-	-
24.70348	-34.10793	Shrubland	Shrubland	-	(515 ha)	Shrubland	-	-	-	-	-	-	-	-	-		-	-	-	-
24.71958	-34.10260	Quarry	-	-	(515 ha)	-	-	-	-	-	-	-	-	-	-		-	-	-	-
24.71835	-34.10017	Natural forest	-	-	(255 ha)	-	-	-	-	-	-	-	-	-	-		-	-	-	-
24.78108	-34.13895	Sand mine	-	-	(26 ha)	-	-	-	-	-	-	-	-	-	-		-	-	-	-
24.66322	-34.16648	Oysterbay community	Residential	-	-	Residential	-	-	-	-	-	Residential	-	-	-		-	-	-	-

(amounts in brackets are estimates)

Detailed Information: Bantamsklip

X	Y	FARM_NAME	Farmer	Farm_activ	Size_ha_	Mainstream	Crop_tons	Livestock	Type_lives	Production	Buyers	Bare_sand	Dams_river	Quarries_m	Naturl_veg	Degraded_A	Degraded_D	Run_costs	Cultivated
19.534667	-34.656750	Klein paradise	Susan Fuchs	Holiday Guest houses	140 ha	Accomodation	-	Few horses	-	-	Holiday makers	5 ha	1 dam	-	50 ha	30 ha	15 ha	-	-
19.642889	-34.581944	Doorenbosch	Mr O Nickelson	Cattle & sheep and game farming	3500 ha	Game Farming	-	190 cattle, 800 sheep, 300 buck, 14 zebras, 4 ostriches, 10 horses	beef cattle, mutton sheep, game animals	-	Huntera + holiday makers	40 ha	2 dams & 2 rivers	1 small quarry	3000 ha	-	-	R 30 000/ month	-
19.692944	-34.577639	Sandberg	-	Fynbos farming and tourism	670 ha	Fynbos farming	-	25 ostriches	-	-	UK Fynsel Ltd.	-	4 dams	possibility for roads	600 ha	30 ha	40 ha	-	30 ha
19.667917	-34.584500	Uitsig	Mr Uitsig	Dairy & fynbos farming	1250 ha	Dairy farming	-	200 cows, 24 buck, 80 ostriches, 120 sheep	100 milking cows. others for sale.	1289lt milk/ day	Parmalat	-	1 river, 2 dams	-	1000 ha	-	-	-	250 ha
19.512694	-34.583806	Rusthof	Mr Langehoven	Sweet potatoes & sheep	55 ha	Sheep	2.6 tons / an	450 sheep	450 sheep	100 sheep / annum	Various locals & Abbatoirs	-	2 dams	-	5 ha	-	-	-	33 ha
19.527333	-34.596139	Bosmansrivier	Unknown	Cattle farming	200 ha	Ox farming	-	400 cattle, 50 sheep	380 oxen. 20 milking cows, 50 sheep	-	Free state farmers	-	1 dam, 2 rivers	1 small quarry	1 ha	-	-	-	170 ha
19.538889	-34.605056	Korsika 2	Mr Korsie	cattle farming & fynbos farming	990 ha	Cattle farming	=	Cows & sheep	250 beef cows, 80 sheep	-	Auction house	-	1 dam & 1 river	-	350 ha	-	-	-	690 ha
19.539167	-34.602222	Korsika	Mr J.P De Wet	Dairy and fynbos farming	1500 ha	Dairy farming	-	Dairy cows	250 milking cows	2000 lt milk / day	Parmalat	-	2 dams & 1 river	-	1000 ha	-	-	-	500 ha
19.561611	-34.684583	Groothaagelkraal	Eskom Farm	Fynbos farming	1500 ha	Fynbos Farming	-	Horses	15 horses	Daily	Export market	-	1 river	-	1400 ha	-	For eskom	-	-
19.606111	-34.595000	Nuwedam	Mr J Van Dyk	Dairy, sheep & Fynbos farming	2000 ha	Dairy	-	cows & sheep	250 milking cows & 900 sheep	1500 lt / day	Parmalat & export market for fynbos	10 ha	4 dams, 3 streams	-	500 ha	-	Potentially	-	1100 ha
19.588639	-34.603056	Eureka	Hendrika	Dairy farming	75 ha	Dairy farming	-	cows	85 milking cows	750 lt milk / day	Parmalat	-	1 river & 2 dams	-	-	-	-	-	62 ha
19.584806	-34.611139	Andree'	Andree'	Fynbos	2 ha	Fynbos	-	-	-	-	Local market	-	-	-	2 ha	-	-	-	-
19.549194	-34.652889	Wolfgang	Mr Wolfgang	small subsistance farming	(37 ha)	subsistance farming	-	few horses	-	-	-	-	-	-	-	-	-	-	-
19.531861	-34.655583	Peters gates	Mr Roelofse	Vegetable farming	100 ha	Veg farming	minimal	ostriches	7 ostriches	seasonal	Local market	3 ha	3 dams	-	60 ha	-	-	-	15 ha
19.558056	-34.590000	Remhoogte	Mr J Uis	Dairy farming & wheat	180 ha	Dairy farming	-	cows & sheep	100 milking cows & 40 sheep	1500 lt milk / day	Parmalat	-	2 dams & 2 rivers	-	10 ha	-	-	R 40 000/ month	170 ha
19.696083	-34.712111	Dirkuiskraal	Mr A Pennels	Fynbos and Cattle farming	4400 ha	Fynbos farming	-	cows & sheep	100 cows & 40 sheep	Daily	Exported to UK	30 ha	1 river & 2 dams	-	3800 ha	-	-	-	-
19.699639	-34.689750	Gonnakraal	Unknown	cattle farming	1500 ha	Cattle farming	-	cows & sheep	1000 beef cattle & 500 sheep	-	Auction house	-	14 dams & 5 rivers	-	500 ha	-	-	R 1 000 000/ year	1400 ha
19.708556	-34.636861	The springs	Unknown	Fynbos arming	800 ha	Fynbos farming	-	-	-	15 000 stems/ day	Exported to UK	-	1 dam & 1 river	-	700 ha	70 ha	-	R 50 000/ month	30 ha
19.678722	-34.669333	Kaleba(phaesanthoek)	Mr Julien	Dairy & fynbos farming	421 ha	Dairy farming		cows & sheep	200 milking cows & 110 sheep	800 lt milk/ day	Parmalat	-	6 dams & 1 river	-	200 ha	-	-	R 100 000/ month	220 ha
19.640722	-34.669306	Waterfid	Unknown	Fynbos farming	4000 ha	Fynbos farming	-	horses & buck	6 horses & 20 Buck	daily	Exported to Holland	-	2 dams & 3 rivers	-	4000 ha	-	-	-	-
19.646139	-34.686083	Koksrivier	Mr Joubert	Sheep, fynbos, bee farming	1250 ha	Sheep farming	-	sheep	1500 sheep	-	Exported fynbos and locally sold sheep	-	3 dams & 1 river	1 sand mine	1600 ha	20 ha	-	-	500 ha
19.674056	-34.662944	Vree	Unknown	Cattle farming	50 ha	Cattle farming		cows	16 cows	-	Auction house	-	2 dams & 1 river	-	20 ha	-	-	R 25 000/ annum	220 ha
19.520389	-34.587028	Butchery	Mr Erwin	Butchery & abbatoir	(261 ha)	Butchery	-	cows & sheep	-	Daily	Local community	-	1 dam	-	-	-	-	-	-
19.510833	-34.609944	Weird farm	-	Tunnel farming	(196 ha)	Tunnel farming	-	-	-	Seasonal	Local market	-	1 dam	-	Majority	-	-	-	-
19.493833	-34.579556	Wehevreden	-	Cattle farming & sheep farming	(256 ha)	Cattle farming	-	-	-	-	-	-	2 dams	-	-	-	-	-	-
19.567167	-34.645222	Unmapped dam	-	-	(1798 ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.635389	-34.572528	Nuwe post	Mr Mike Gafney	Dairy farming	(1169 ha)	Dairy farming	-	Cows	Milking cows	-	Parmalat	-	3 dams & 1 river	-	-	-	-	-	-
19.607472	-34.649111	Aghulus national park	EC national Parks	-	(2436 ha)	-	-												-
19.667722	-34.660694	Huge dam (blomvleioor	Blomvlei Oord	-	(248 ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.696694	-34.670222	Small holdings	-	-	(1.8 ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.689167	-34.759917	Caravan Park	-	Caravan Park	(649 ha)	Caravan park	-	-	-	-	Holiday makers	-	1 river	-	-	-	-	-	-
19.671667	-34.748917	Park board	EC national parks	-	(2016 ha)	Game Park	-	various wild animals	-	-	Holiday makers	-	-	-	-	-	-	-	-
19.602444	-34.717139	Buffelsjagt	Mr A Pennels	Fynbos farming	(1239 ha)	Fynbos Farming	-	-	-	Daily	Exported to UK	-	-	-	-	-	-	-	-

(amounts in brackets are estimates)

Detailed Information: Duynefontein

X	Y	FARM_NAME	Farm_activ	Size_ha	Main_busin	Tonnage	Livestock	Type_Lives	Production	Area_cult	Buyers	Pastures	Bare_sand	Dams_river	Sandmines	Cultivated	Naturl_veg	Degraded_A	Degraded_D	Run_costs	Farmers
18.513750	-33.620972	Philedelphia chicks	Chicken Hatchery	65 ha	Chicken Hatching	-	cows and chickens	60 cows & 1 500 000 Chicken	1 700 000 eggs / month	-	Pioneer foods	40 ha	-	1 river	-	40 ha	25 ha	-	-	R 3 000 000/ month	-
18.560861	-33.665528	Botterberg	Grape Farming	660 ha	Grape farming	1000 tons / annum	-	-	Seasonal	150 ha vineyards	Nederburg Winery	-	10 ha	-	-	150 ha	100 ha	-	260 ha for housing	-	Mr Hannekom Egbert
18.594444	-33.678722	Dasvlei	Dairy, cows, sheep, & grape farming	800 ha	Cows & sheep farming	1000 tons/ annum	Cows & sheep	40 beef cattle, 1000 sheep, 180 milking cows	5500 lt milk/ day	60 ha vineyards	Nederburg & clover	400 ha	-	2 rivers	-	460 ha	340 ha	-	-	R 600 000/ month	Mr Tooby
18.569139	-33.713361	Capaia	Wine farming	140 ha	Grape Farming	200 tons / annum	-	-	200 tons / annum	60 ha vineyards	Own use	-	-	1 dam	-	60 ha	60 ha	-	-	-	Mrs Capaia
18.526528	-33.646194	Langerug	Cattle & wheat farming	800 ha	Beef Farming	500 tons wheat / annum	cattle	500 beef cattle	Seasonal	500 ha wheat	Agri western cape, Auction house	500 ha	100 ha	2 dams	1 sandmine	600 ha	100 ha	-	-	-	Mr B Van de Merwe
18.566028	-33.694861	Uitkyk	Wheat, grapes, cattle & sheep farming	570 ha	Wheat farming	800 tons / annum	cows & sheep	100 beef cattle and 800 sheep	Seasonal	200 ha wheat & 65 ha vineyards	Nederberg & local mill	100 ha	-	5 dams	-	365 ha	180 ha	-	-	R 72 000/ month	M A. J Herald
18.549806	-33.672944	Klipvlei	Pig & wheat farming	450 ha	Pig farming	-	pigs	1800 pigs	Daily sales and seasonal wheat	120 ha wheat	Abbatoirs & Agri western cape	130 ha	-	-	-	250 ha	200 ha	-	-	-	-
18.524611	-33.696944	Witdam	Dairy farming	700 ha	Dairy farming	-	cows	400 milking cows	9000 lt milk / day	250 ha grass	Bellville dairy	400 ha	15 ha	1 river	1 sandmine	650 ha	minimal	-	-	-	Mr darnie
18.524278	-33.672056	Brakhuil	Wheat & cattle farming	800 ha	Wheat farming	500 tons wheat / annum	cattle	110 beef cattle	seasonal	250 ha wheat	Local mill	400 ha	-	1 river	-	650 ha	120 ha	-	-	-	-
18.495889	-33.639944	Brakkefontein	Brickmaking & sand mining	457 ha	Brick making	-	-	-	300 000 bricks/ day	-	Construction companies	-	yes	-	1 large quarry & sand mine	-	257 ha	-	200 ha	R 6 000 000 / month	Apollo Bricks
18.498972	-33.684056	Vaaitjie	Sand mining, cattle, wheat	916 ha	Cattle & sand mining	100 tons wheat/ annum	cattle	400 beef cattle	Seasonal	350 ha wheat	Pioneer foods & auction house	366 ha	200 ha	1 river		716 ha	-	-	-	R 40 000 / month	Mr N Stofberg
18.516056	-33.707194	Oliphantskop	Beef & wheat farming	640 ha	Beef farming	500 tons wheat / annum	cattle	400 Beef cattle	Seasonal	-	Kliphuis auctioneers & Local mill	140 ha	400 ha	4 dams	-	140 ha	100 ha	-	For eskom	-	Mr Tinnie
18.484694	-33.735944	Blaauberg	Beef & wheat farming	1700 ha	Beef farming	650 tons wheat / annum	cattle	1200 beef cattle	Seasonal	200 ha wheat	Abbatoirs & cape wheat association	1400 ha	-	3 dams	-	1600 ha	-	100 ha	-	-	-
18.460444	-33.739583	Melkboschplaas	Entertainment farm	(253 ha)	Tourism	-	-	-	-	-	Holiday makers	-	-	-	-		-	-	-	-	-
18.447528	-33.773944	Melkbosch Residential	Residential	-	-	-	-	-	-	-	Locals	-	-	-	-		-	-	-	-	-
18.444250	-33.697139	Van riebeckstrand Residential	residential	-	-	-	-	-	-	-	Locals	-	-	-	-		-	-	-	-	-
18.364167	-33.587722	Silverstroom Campsite	Camp site	-	Camping Facility	-	-	-	-	-	Holiday makers	-	Beach	-	-		-	-	-	-	-
18.451750	-33.599000	Sand dunes	-	(1284 ha)	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
18.496250	-33.567861	Atlantis residential	Residential	-	-	-	-	-	-	-	Locals	-	-	-	-		-	-	-	-	-
18.513667	-33.605139	Pine ranch	Small subsistance farming	(27 ha)	Small subsistance farm	-	horse	few horses	-	1 ha	Own use	-	-	1 dam	-		-	-	-	-	-
18.516889	-33.620833	3 fountains farm	none	(23 ha)	small time entertainment farm	-	horses, sheep, goats, ostriches	-	-	-	Holiday makers	-	-	2 rivers	-		large	-	-	-	-
18.503361	-33.634389	Woodlands	semi commercial veg farm	<30 ha	Veg farming	Minimal	horse, sheep	-	minimal	10 ha	Local farm stall and market	-	-	1 dam	-		-	-	-	-	-
18.374194	-33.582111	Silverstroom water treatment pl	Water purification	-	Water purification	-	-	-	-	-	Local community	-	-	-	-		-	-	-	-	Municipality
18.443167	-33.626444	Witsands water treatment plant	Water purification	-	Water purification	-	-	-	-	-	Local community	-	-	-	-		-	-	-	-	Municipality
18.480222	-33.588556	Atlantis Industrial park	Industrial park	(450 ha)	Manufacturing/ processing	-	-	-	-	-	Various	-	-	-	-		-	-	-	-	Various
18.510778	-33.584750	Tomatoe farm	Tomatoe tunnel farming	(9 ha)	Tomatoe farming	-	-	-	-	20 ha tomatoes	Local market	-	-	1 river	-		-	-	-	-	Ms Fathima
18.511861	-33.607806	Avanti farm	Small time veg farming	(10 ha)	Veg farming	minimal	horses	-	minimal	-	Local farm stall	-	-	1 river	-		-	-	-	-	Mr T Williams
18.514278	-33.621333	Farm stall	Farm stall	-	Farm stall	-	-	-	-	-	Local communty	-	-	-	-		-	-	-	-	-
18.471333	-33.646611	Aircraft base	Mini airport	(959 ha)	Aircraft Assisstance	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
18.476111	-33.720222	Inshallah farm	School	-	School	-	-	-	-	-	School kids	-	-	1 river	-		-	-	preparing	-	-
18.452667	-33.726278	Proposed housing development si	Residential	-	Residential	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-

(amounts in brackets are estimates)

APPENDIX 2

SOIL SAMPLE RESULTS

KwaZulu-Natal Department of Agriculture and Environmental Affairs

Soil Salinity Laboratory, Soil Fertility and Analytical Services
Private Bag X9059, Pietermaritzburg,3200
Tel. 033 3559465

Print

Name: Jon Howcroft
Block C Bellevue Canpus
5 Bellevue Rd Kloof
Tel: 031 717 2790
Fax 031 717 2791

Advisor:
TEL:

Date 27/09/2010

PARTICLE SIZE ANALYSIS

According to:- Soil Classification, A Taxonomic System For South Africa 1991

Laboratory Number	Sample ID	Clay % (<0.002 mm)	Fine Silt % (0.02 - 0.002 mm)	Coarse Silt & Sand % (0.02 - 2 mm)	Texture Class
26507	Bamtamsklip 1A	17	9	75	Sandy Loam
26508	Bantamsklip 1B	18	10	72	Sandy Loam
26509	Bantamsklip 2A	9	2	88	Loamy Sand
26510	Bantamsklip 2B	10	2	89	Loamy Sand
26511	Thyspunt 3A	6	1	93	Sand
26512	Thyspunt 3B	5	1	94	Sand
26513	Thyspunt 4A	5	0	95	Sand
26514	Thyspunt 4B	4	1	95	Sand

Results are not to be used for litigation purposes.

Your's faithfully

KwaZulu-Natal Department of Agriculture and Environmental Affairs
Soil Salinity Laboratory, Soil Fertility and Analytical Services
Private Bag X9059, Pietermaritzburg,3200
Tel: 033
3559465

Report For: John Howcroft
Block C Bellevue Campus
5 Bellevue Rd Kloof

Fax:
Tel :

Adviser:

Fax:
Tel:

SOIL SALINITY ANALYSIS REPORT

Date: 01/10/ 2010

Results are not to be used for litigation purposes

Sample ID	Lab Number	Soil pH (H_2O)	% Sat.	EC (mS/m)	Na (me/L)	Ca (me/L)	Mg (me/L)	K (me/L)	SAR	Assessment Code*
Bantamsklip 1A	26507	7.92		99.80	3.36	5.57	1.49	0.62	1.79	1,4
Bantamsklip 1B	26508	7.98		88.80	2.85	5.55	1.13	0.41	1.56	1,4
Bantamsklip 2A	26509	8.08		68.10	0.83	5.05	0.62	0.32	0.49	1,4
Bantamsklip 2B	26510	8.08		80.60	1.59	5.37	0.62	0.38	0.92	1,4
Thyspunt 3A	26511	8.00							-	
Thyspunt 3B	26512	8.15		82.20	1.99	5.54	0.69	0.11	1.13	1,4
Thyspunt 4A	26513	8.20		187.50	6.66	7.67	2.56	0.68	2.94	2,4
Thyspunt 4B	26514	8.09		68.00	2.22	5.09	0.82	0.28	1.29	1,4
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	
									-	

Recommendations/Comments:

***Assessment Code:**
First number: 1-Non-Saline, 2-Potentially Saline, 3- Saline
Second number: 4- Non-Sodic, 5- Potentially Sodic, 6- Sodic

Code 1,4:- Soils suitable for irrigation
Code 2,5:- Poorly drained soils; not suitable for irrigation
Code 3,6:- Soils not suitable for irrigation

Your's
faithfully,