Proposal for rehabilitation of the Upper Peatland Basin

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July 25th 2014

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Co-funded and supported by

Natural Resource Management Programme of the **Department of Environmental Affairs– DEA**, South Africa

Gamtoos Irrigation Board – GIB, South Africa

Facilitated by

Living Lands

Special thanks to:

Japie Buckle

Fred Ellery

Pierre Oelofsen

PREFACE

We are pleased to present this proposal for the rehabilitation of the Upper Peatland Basin. This proposal is the final result established after a 3,5 month research for the organization Livinglands. Jelle van Veen and Frederik Jansen, both studying Land and Water Management at university of applied sciences Van Hall Larenstein, were attracted to the water scarcity problems in South Africa and really wanted to get acquainted with rehabilitation work. They got a chance to get involved when the opportunity emerged to write a proposal for rehabilitation of the Upper Peatland Basin. The final proposal could really be a helping hand to wetland rehabilitation work in the Upper Kromme Catchment. Marijn Zwinkels, co-director of Livinglands, has been our supervisor during this internship and we are really grateful for the information and recourses he made available for us. We would also like to thank Japie Buckle, wetland expert South-Africa, for all the efforts he made to help us in this project.

Jelle van Veen and Frederik Jansen

July 25th , 2014

Summary

In the Eastern Cape of South Africa, the Kromme river is not only very important for the agricultural community in the Langkloof, it also supplies about 55% percent of the water requirements for the growing Nelson Mandela Bay Municipality. Retention of water for the agricultural community and the Nelson Mandela Bay Municipality is realized by building the Churchill Dam and the Impofu Dam.

Upstream from the Churchill dam, the area is characterized as a high energy water system. This means that water out of the mountains flows rapidly into the Kromme river because of the steep slopes. In the recent past, large areas in the flood plain of this river were covered by Palmiet. Those Palmiet-dominated wetlands with thick peat layers have played an important role in this high energy water system for at least 5000 years already. Water purification, water storage, flood breaking and creation of unique rich ecosystems characterize how important these wetlands are in the upper Kromme catchment.

Unfortunately, many of those sensitive wetlands have deteriorated dramatically during the last couple of decades. Climate change in combination with human interferences like overgrazing, infrastructure, agricultural practices, sand mining, water abstraction, fires, and alien vegetation posed and still poses a serious threat. Therefore, the government decided to prohibit any farming activities in wetlands.

One of those protected wetlands is the Upper Peatland Basin, owned by Pierre Oelofsen and Dennis Ferreira. Despite this protection, the wetland is degrading at this moment. 19 % percent of this wetland has already disappeared between 1942 and 1999. In order to restore the Upper Peatland Basin, a proposal for rehabilitation and maintenance for this wetland is written down.

In the wetland, a few of the mentioned threats are detected. Two gullies and a few man-made drains with associated berms are threatening the wetland. Peat oxidation as a result of groundwater table lowering and erosion as result of an increasing water velocity both have a devastating effect to the wetland. In a few tributaries, which are the small streams flowing into the Kromme, heavy erosion is detected. Moreover, two roads are crossing the wetland and in turn river channelizing has occurred. The last detected threat is the presence of the Black Wattle. This alien species is not able to keep the soil together and causes heavy erosion during floods.

Research revealed that it is not feasible to tackle all the mentioned problems in the Upper Peatland Basin. However, it is feasible to counter the erosion in one gully. Stabilizing the slopes from this gully and planting new vegetation on the slopes could stop the area from further degradation. The man-made drains are probably one of the reasons for the gully erosion. It is necessary to block the drains and to fill them up by bulldozing the associating berms. Another problem is the Black Wattle spots scattered all around over the area. The Black Wattle trees should be regularly cut down and removed. The remaining stem should be sprayed by chemicals to prevent new sprouts growing. In addition to this, new wetland vegetation has to be planted on the bare area around the removed trees. Besides all the suggested measures, it is strictly recommended to protect the wetland against trampling as a result of livestock, especially the parts in which one or more suggested measures are executed. Fences all around the wetland should keep the livestock away.

Maintenance is needed to make sure this wetland will not disappear and lose its natural functions in the future. If the suggested measures will be executed, the structures and the stabilized gully slopes should be monitored to detect erosion in an early stage. The removal of the Black Wattle tree is more labor intensive, because this species always finds a way to get back into the area. At least, these trees should be removed once every 4 years. All the material dragged by the water and trapped in the fences has to be removed. The last maintenance measure is about fire regime. Fires are hard to control, although man-made fires for the aim of grazing should be reduced. Monitoring the whole project area after a big flood is certainly recommended, because of the major forces exerted on the wetland.

TABLE OF CONTENTS

TABLE OF FIGURES

GLOSSARY

Alluvial fan - Fan-shaped mass of sediment deposited as the flow of a river decreases in velocity.

Bedrock - Solid bottom of the sandstone valley.

Berm - Dyke next to a man-made drain, build to prevent the water from flowing freely.

Black Wattle - Evergreen alien invasive tree from Australia, very competitive and a big problem in wetlands in South Africa.

Concrete structure – Concrete wall built in the river in order to prevent headcuts.

Catchment - The area in which the caught water eventually flows into one particular river.

Drain - Channel or pipe carrying off water.

Ecolocks - Flexible tubes wrapped with geotextile and filled with sand. Six of those tubes piled like a pyramid form a flexible dam.

Fynbos - Special type of vegetation found only in southern Africa. Fynbos includes mainly shrubs and heath.

Gabion - Cages filled with rocks. The cages are build up like a dam wall with the purpose to stop erosion. Generally, there is concrete on the gabion to make it stronger. To stop the gabion from getting washed away, the gabion can have a lot of extensions of other materials attached to it.

Geotextile - Very strong plastic fabric used in association with soil.

Gully - Landform eroded by running water, looks like a large ditch or a small valley.

Gradient - Represents the steepness of the slope.

Headcut - Abrupt vertical drop of the channel, causing erosion.

Hydrostatic pressure - Pressure of non-flowing water caused by gravity.

High energy water system – Geomorphology of an area results in fast-flowing water and in turn erosion occurs.

Khoisan - Original southern African culture.

Kikuyu - rapid growing, aggressive grass. Alien Invasive with its origins in Central Africa.

Palmiet – Indigenous wetland plant with a dense network of roots, the most ideal plant to (re)create wetlands.

Peat - Brown, soil-like material consisting of partly decomposed vegetable matter.

Piping – Internal erosion of soil particles. Caused by a high hydrostatic pressure, which makes the water find a way downstream by flowing below a blockade, usually a dam. Piping can make a dam collapse.

Valley bottom fen - Marshy area of land on the bottom of a valley.

1. INTRODUCTION

South Africa is a water stressed country. Over the year, an average of approximately 500 mm precipitation supplies just enough clean water for the inhabitants of South Africa. An increasing demand of water as a result of a growing population and the growth of the agriculture sector will cause more pressure on the water resources. Furthermore, climate change causes a growing number of dry and wet years. This implies that water resource and supply management is becoming more difficult, and hence more important. To make matters worse, the availability of groundwater aquifers is limited because of the hard rock formation in most of the country. (JN Blignaut Et al. 2007) It can be concluded that surface water is a very important resource of drinking water to this country.

In the Eastern Cape, the Kromme river is not only the lifeblood of the agricultural community in the lower Langkloof, but also one of the main sources of clean drinking water for the growing urban areas of the Nelson Mandela Bay Metropolitan Municipality. (Japie Buckle et al. undated) The Kromme system supplies about 55 % of the water requirements for the Nelson Mandela Bay Metropolitan via the Churchill dam en the Impofu dam. (M. Mander, 2010)

Retention of water that can be used by the agricultural community and the urban area of the Nelson Mandela Bay Metropolitan Municipality is realised by building the Churchill dam and the Impofu dam. Wetlands in the Kromme river catchment are important for the retention of water as well as the special flora and fauna in this area. The wetlands have a few very important natural functions. The natural buffer against flood damage, purification mechanisms, the storage of water, and the rich, unique natural ecosystems characterise how important these wetlands are in the Kromme catchment.

During the last couple of decades, sensitive wetland systems in the Kromme River have deteriorated dramatically. At the moment, the levels of degradation are alarmingly high and the remaining wetlands can no longer perform the natural functions that contribute to the well-being of the Kromme River as a whole. It is estimated that more than 60 % of wetlands in the Kromme River have already been damaged beyond repair. (Japie Buckle, undated)

Degradation of the wetlands is caused by different activities. Burning or grazing in the catchment area of the Kromme River leads to insufficient ground cover. Furthermore, natural vegetation is being replaced by the alien invader Black Wattle. Moreover, draining, ploughing, building of roads and planting of riverbanks and flood plains through commercial agricultural practices irreparably destroy wetland systems. This automatically contributes to the uneven canalising of water, uneven draining of natural seepage areas, and narrowing and deepening of the river's natural course.(Mr. Japie Buckle et al. undated) Besides the human interference, climate change obviously contributes to the degradation of the wetlands.

There is a wetland located on Krugersland and Companjesdrift, in the upper part of the Kromme River. This wetland is defined as the Upper Peatland Basin and is one of the last well-functioning wetlands in the Kromme River catchment. However, this wetland is degrading as well because of a few threats. The biggest part of this wetland belongs to farmer Pierre Oelofsen, the owner of Krugersland. He is not allowed to execute any agricultural activities on his land due to the policy for wetlands. At the moment, he is not able to use this land for his own purposes, which is why he would like to sell it. However, there is nobody and no organisation who wants to buy it. A solution to help this farmer should be found.

1.1 PROBLEM STATEMENT

The main problem in this case is the degradation of the Upper Peatland Basin. A few threats have to be countered in order to prevent the wetland from disappearing. The statement of the problem is:

How does the Upper Peatland Basin currently function, and what measures could be taken to improve its functioning?

To gain information about the statement of problem, various objectives have to be investigated. More information is required about the 'original' and current state of this wetland and the view of different stakeholders regarding to this wetland. Based on these objectives, the following question are formulated:

- What is the current physical state of the project area?
- What is the utility of the Upper Peatland Basin in its environment?
- What are the threats for the Upper Peatland Basin?
- What is the view of the stakeholders regarding to this wetland?
- How could the Upper Peatland Basin be feasibly rehabilitated to a wetland in which the natural function operates in the best possible way?
- What feasible maintenance measures are required to prevent deterioration of the natural functions?

1.2 STATEMENT OF TARGET

A proposal should be established in order to clarify the utility of the Upper Peatland Basin at this moment and how to enhance the performing of its functions in the future. Statement of target is:

To establish a proposal for feasible rehabilitation and maintenance of the Upper Peatland Basin.

1.3 METHOD

To get a bright view of the project area and its problems, the authors of this report started their investigation with reading reports and visiting the project area. Landowners Pierre Oelofsen and Dennis Ferreira have been interviewed, and both of them gave permission to enter their wetland multiple times. During the fieldwork, many activities have been done; getting pictures from the project area, determining the coordinates of points of interest for instance drains or a cluster of Black Wattle trees, and measuring the sizes of the drains. Furthermore, wetland specialist Japie Buckle helped the authors a lot by sharing his knowledge with us and by letting them join some wetland-rehabilitation related meetings.

1.4 OUTLINES

This report contains first of all an introduction in chapter one. Chapter two encloses the topography, land use, geology, hydrology, flora and fauna, and the history of the Upper Peatland Basin. Chapter three contains a description about the utility of the wetland in its environment. The change in extent of wetland is discussed in chapter four. The view of the different kind of stakeholders is listed in chapter five. As to continue, chapter six shows the implementation and maintenance plan. A resume of the implementation- and maintenance plan concludes this report in chapter seven. The final chapter encloses a few recommendations to continue this project.

1.5 PROJECT LIMITATIONS

The assessment will focus on the Upper Peatland Basin, the rest of the Kromme River catchment is not included in this proposal. Furthermore, a solution for landowner Pierre Oelofsen is not included in this report. In this proposal, the focus is on rehabilitation and maintenance of the Upper Peatland Basin.

1.6 TARGET AUDIENCE

This proposal is written for the non-profit organization Living Lands. It can be used to make a final, concrete plan of action to calculate costs and to start realize the plans. This can be done by future students, full-timers of Living Lands or perhaps another organization. Furthermore, this report is used as a small thesis to present to University of Applies Sciences Van Hall Larenstein.

2. PROJECT AREA

In this chapter, the project area is introduced by discussing multiple aspects of the area. In the first paragraph, the location of the project area and the location of the Upper Peatland Basin are shown. The Upper Peatland Basin is the wetland itself. This wetland is located in a larger area of floodplain, defined as the project area. Other aspects in this chapter are different types of land use, geology, hydrology, water quality, flora and fauna, and the history of the project area. The two maps shown below are made to get a clear view of the project area. Pictures of the project area are presented around the map and the location of the pictures are indicated with the red dotted lines.

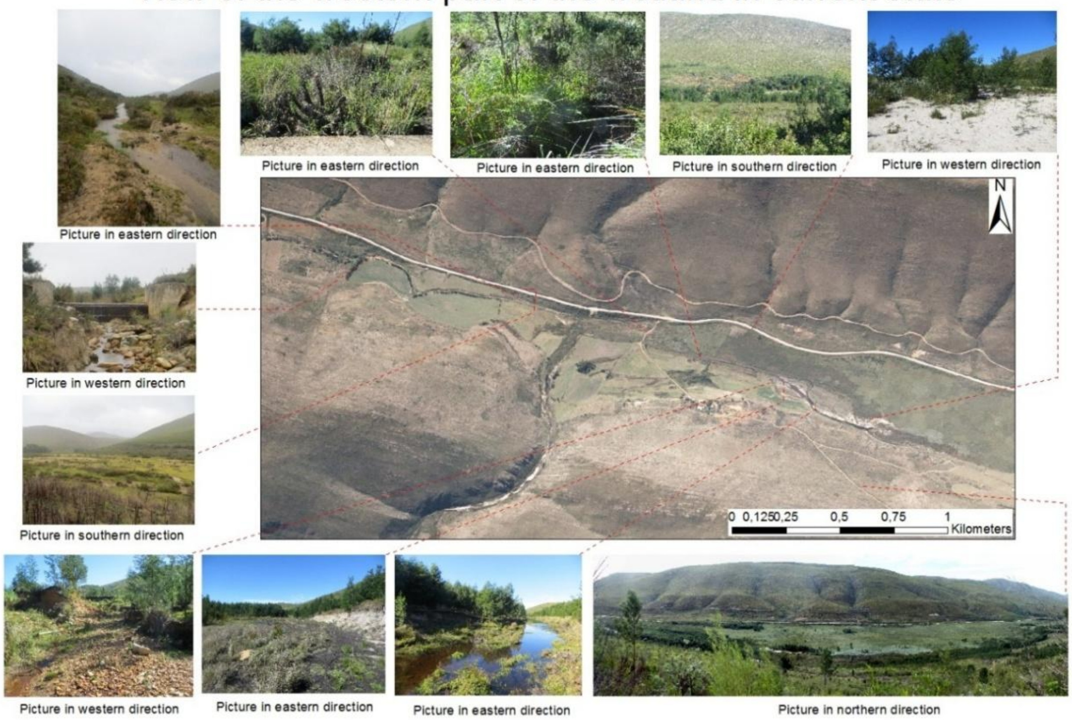

Figure 2: Western part of the wetland in current state
Source: Author's work

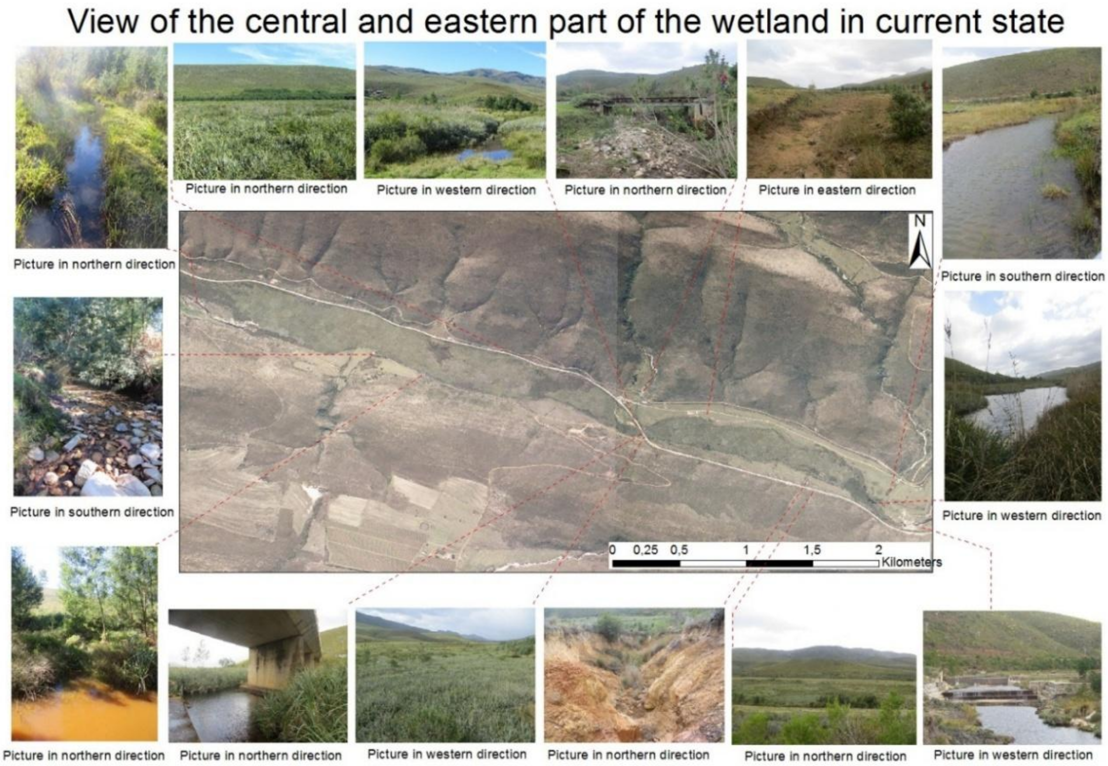

Figure 2: Central and Eastern of the wetland in current state

2.1 TOPOGRAPHY

The area of this project is located in the Eastern Cape Province in South Africa. The two largest cities of this area are Port Elizabeth and East London, but the capital is the city of Bhisho. The Kromme River Catchment is in the Cacadu District Municipality, which is in the south-western corner of the Eastern Cape Province, next to the Indian Ocean and the Western Cape. Port Elizabeth is the seat of Cacadu, and has a population over 310.000 inhabitants. The main river of the Kromme River Catchment is called the Kromme. This river flows from 'the Heights' eastwards, five kilometres south of Humansdorp, and will flow into the Indian Ocean at St. Francis bay. The location of the of the Kromme River Catchment is shown below.

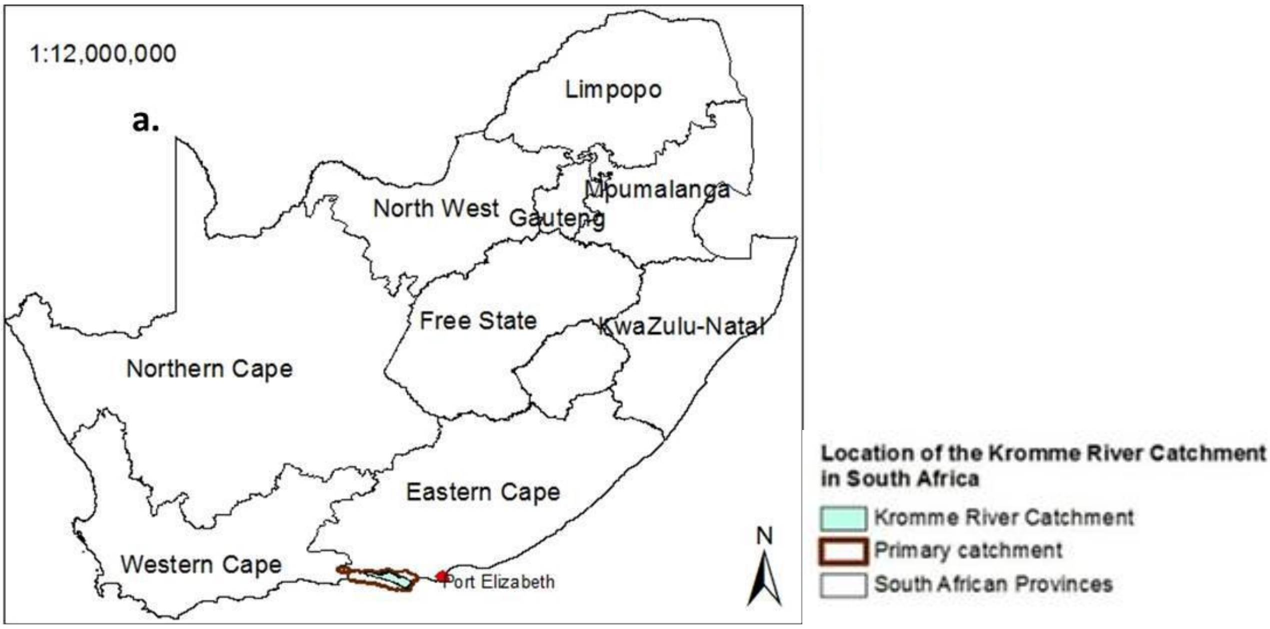

Figure 3: Location Kromme River Catchment.
Source (Czeglédi, 2013):

The two dams in the Kromme River are the Churchill Dam and the Impofu Dam. The Churchill Dam is established in 1943, and provides 40% of Port Elizabeth's water. The mentioned dam is the southern border of the Upper Kromme Catchment. (Department of Environmental affairs, 2013)As can be noticed in figure 4 the whole Kromme River Catchment is divided in five sub catchments. Together, he sub catchments K90A and K90B are called the Upper Kromme Catchment. The Impofu Dam is located downstream of the Churchill Dam, on the western border of sub catchment K90B.

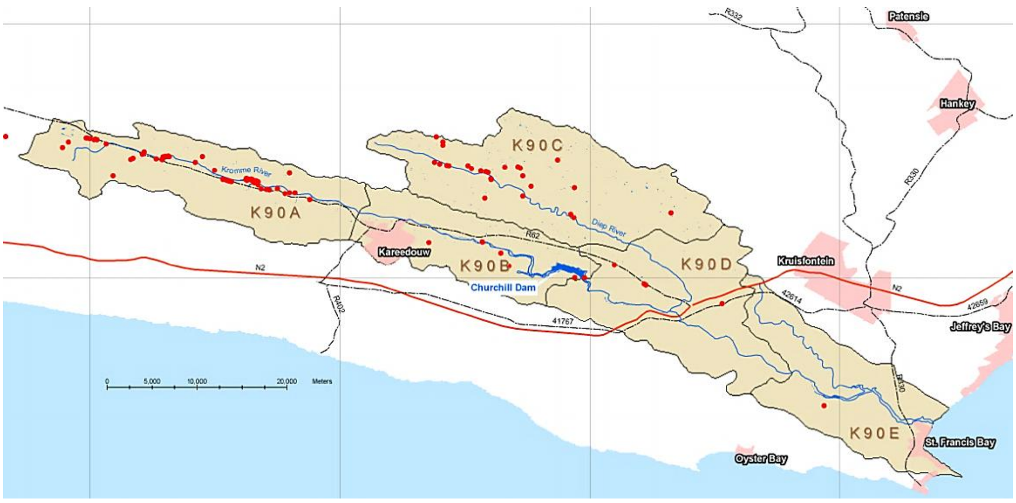

Figure 4: Kromme River Catchments
Source: (Explorer, 2004)

However, the issue of this report is about the Upper Peatland Basin. This wetland is mainly located on land owned by Pierre Oelofsen. Dennis Ferreira owns the part of the wetland on the eastern side of the R62 bridge. Pierre Oelofsen lives near the western border of the assessment area. The wetland on their farms is the largest area of intact wetland that is left in the whole river catchment. Figure 5 shows sub catchment area K90A, with a zoom on the area of the Upper Peatland Basin.

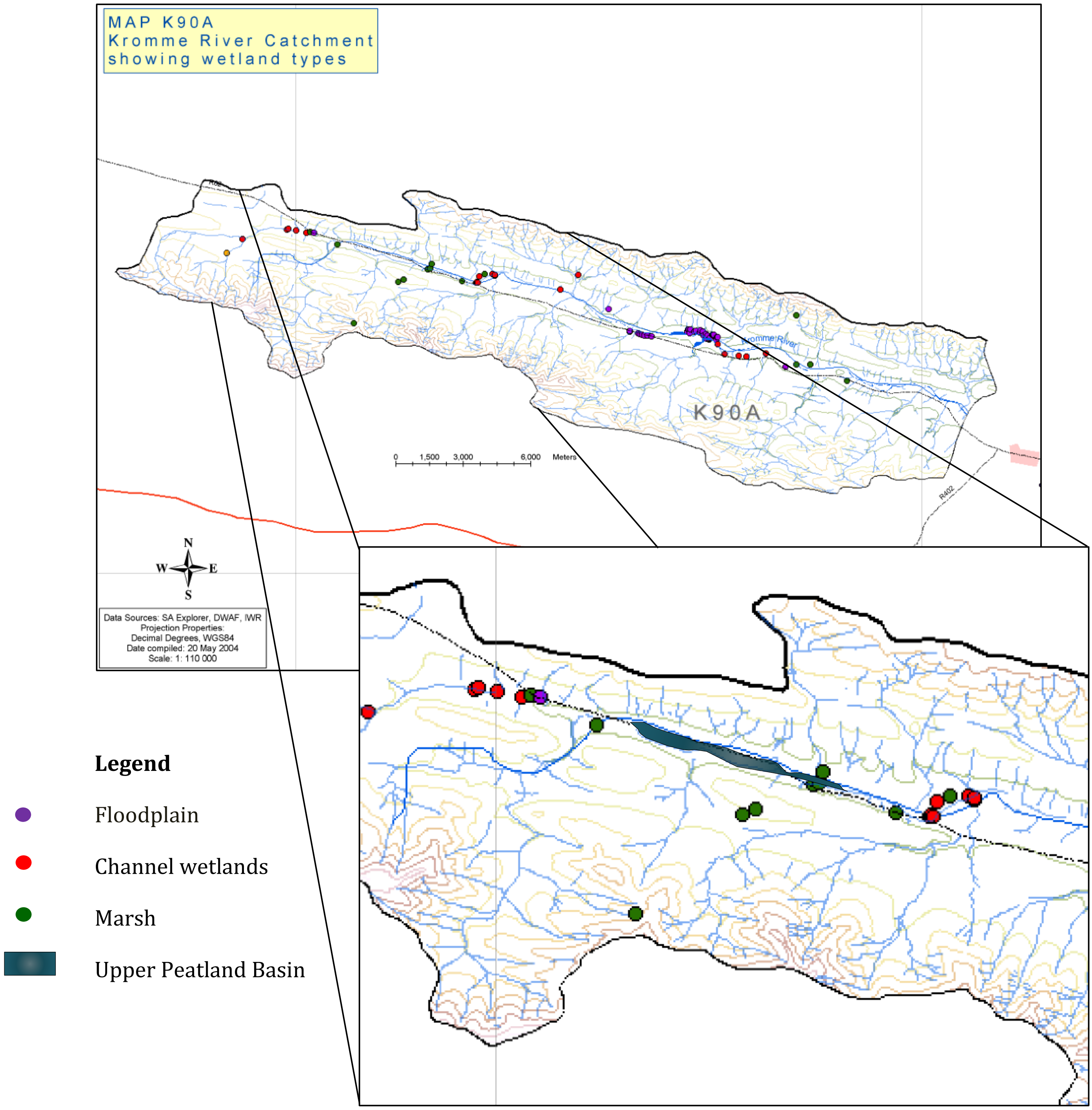

Figure 5: Kromme River Catchment K90A and the Upper Peatland Basin
Source: (A. Rebelo, 2012)

2.2 LAND USE

Figure 6 shows the current land use in the project area. The Upper Kromme River Catchment is mainly covered with fynbos. On the slopes a dry variant of fynbos is found, while the wetland is home to the fynbos species Palmiet. Besides palmiet, alien vegetation and other wetland vegetation like reeds and other bulrushes are found. The surroundings of the wetland are pastures used for big livestock. To make this wetland useful for agricultural practices as well as pastures, a few man-made drains are dug. Furthermore, places for water storage are dug to irrigate the area. The small streams coming out of the mountain, the so-called tributaries, and water flowing from the heights, defined as high energy water, are feeding the wetland with water. The sites with high water energy are characterized by erosion like gullies, due to the high water velocity. Other waters do not have that high energy and therefore erosion is not found at those places. The yellow areas are showing bare sediment areas deposited by the river. The only back road is the one going to the farm of Pierre Oelofsen and the main road is located along the wetland. On the eastern border two structures are built, and on the western border just one. These structures are built with the purpose to stop erosion.

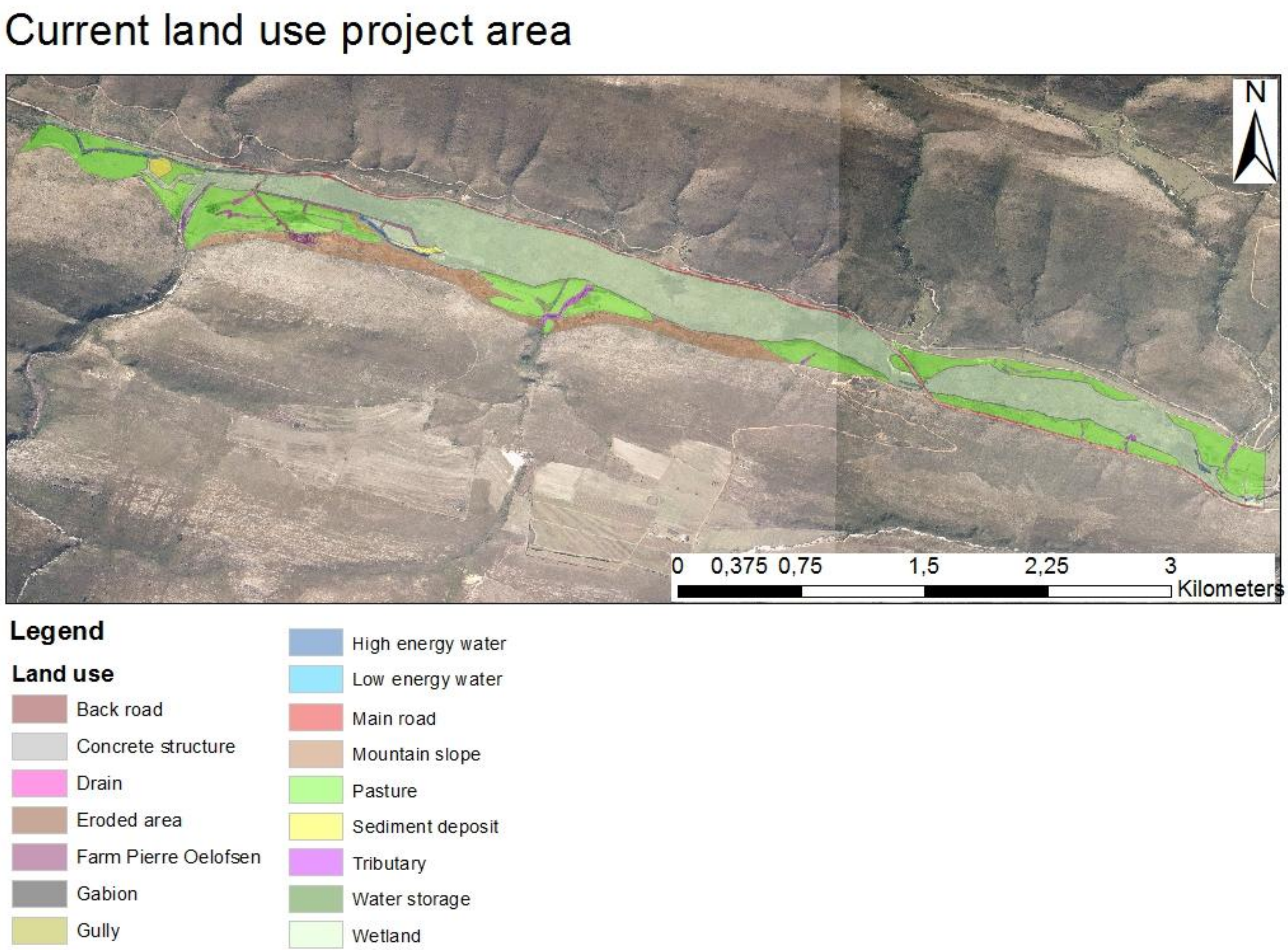

Figure 6: Current land use project area
Source: Author's work

2.3 GEOLOGY

The Kromme River Catchment is underlain by quartzite sandstones and shales of the Cape Supergroup (Lil Haigh P. I., 2008). The Cape Supergroup comprises three groups, and a total of 23 formations. All these groups combined, the maximum combined thickness of the Cape Supergroup is approximately 8 kilometers. The strata belonging to the Cape Supergroup have been largely deposited under marine conditions in environments ranging from outer shelf to beach (Johnson, 1976). 300 million years ago, the rocks of Cape Supergroup began to fold because of tectonic events. This folding process resulted in the formation of extensive ridges and valleys around the eastern and southern coasts of Southern Africa, known as the Cape Mountains. During this event, the Kromme River valley was formed. (Lil Haigh P. I., 2002) The age of the horizons increasing with distance away from the valley axis towards the flanking mountain ranges. (Mrs. E.H. Haigh et al, 2002)

The soil type of the lower slopes is heavy structured and dark, with sand and loam fractions. These soils form a very thin soil cover because of the shale horizons they developed. The higher slopes exist of extremely nutrient-poor, acidic lithosol soils. In the wetland, the soil exists mainly of peat. Peat is partially decayed vegetation or organic matter, and is unique to natural areas called peatlands or mires, like the Upper Peatland Basin. Peatlands are formed under waterlogged conditions from carbon rich, dead and decaying plant material. (IUCN, 2011) In natural peatlands, the annual rate of biomass production is greater than the rate of decomposition. (S. Hugron, 2013) Peat forms when plant material, usually in wet areas, is inhibited from decaying fully by acidic and anaerobic conditions. Peat can store a lot of water, thereby creating wetter conditions, which causes the area of wetland to expand. (Gorham, 1957)

The accumulation of peat in the upper Kromme catchment situated upstream from the Churchill dam is commenced at least 5620 – 5670 years before present. The majority of the peatlands are valley bottom fens with Palmiet constituting the dominant vegetation cover. Smaller areas are covered by grasses and sedges. The Palmiet peat tends to be a sandy, medium fine to fibrous peat. The grass and sedge peats are mostly medium- to fine- grained peat. Peat is sometimes a bit clayey, but contains often dispersed sand grains or less frequently charcoal or thin ash horizons. (Mrs. E.H. Haigh et al, 2002) The sandy sediment layers are result of ancient floods and alternate peat layers. (Personal comment Japie Buckle, May 22nd , 2014)

In the Upper Kromme Catchment, the peat lands extent is in total approximately 547 ha. Peat thickness varies from 0,5 meters to 2,8 meters with an average of 1,62 meters. The interfered peat volume ranges from 10000m^3 to 6,3 million m^3 with a total estimated resource of 12,9 million m^3. (E.H. Haigh et al, 2002) The Upper Peatland Basin extent is about 120 ha.

2.4 HYDROLOGY

The total length of the Kromme river is approximately 95 kilometers and drains a catchment of about 936 km². (MC Sale et al. 2009) The river flows between the steep Suuranys and Tsitsikamma mountain ranges. (Working for Wetlands, undated) Altitudes on the adjacent mountain ranges reach a maximum elevation of 1073 meters in the Suuranysberge to the north and a height of 1251 meters in the Tsitsikamma mountains to the south. The either sides of the valley are steep with slopes between 25 % and 60 % on the south facing mountain faces and slopes between 20 % and 30 % on the north facing mountains. The mean gradient of peatlands is 0,6% upstream from the Churchill dam. (Mrs. E.H. Haigh et al, 2002) The geomorphological characteristics of the catchment like high relief, rocky slopes, and sparsely vegetated areas are contributing to an high mean annual run off and therefore a high flood risk. (Dan Baird, 2006)

Figure 7 shows the entire Kromme catchment. The catchment is part of the eastern Langkloof. Rainfall in the mountain ranges of this area leads to groundwater flow or run off down to the Kromme river or their tributaries. The Kromme estuary opens into St. Francis Bay. (MC Sale et al. 2009)

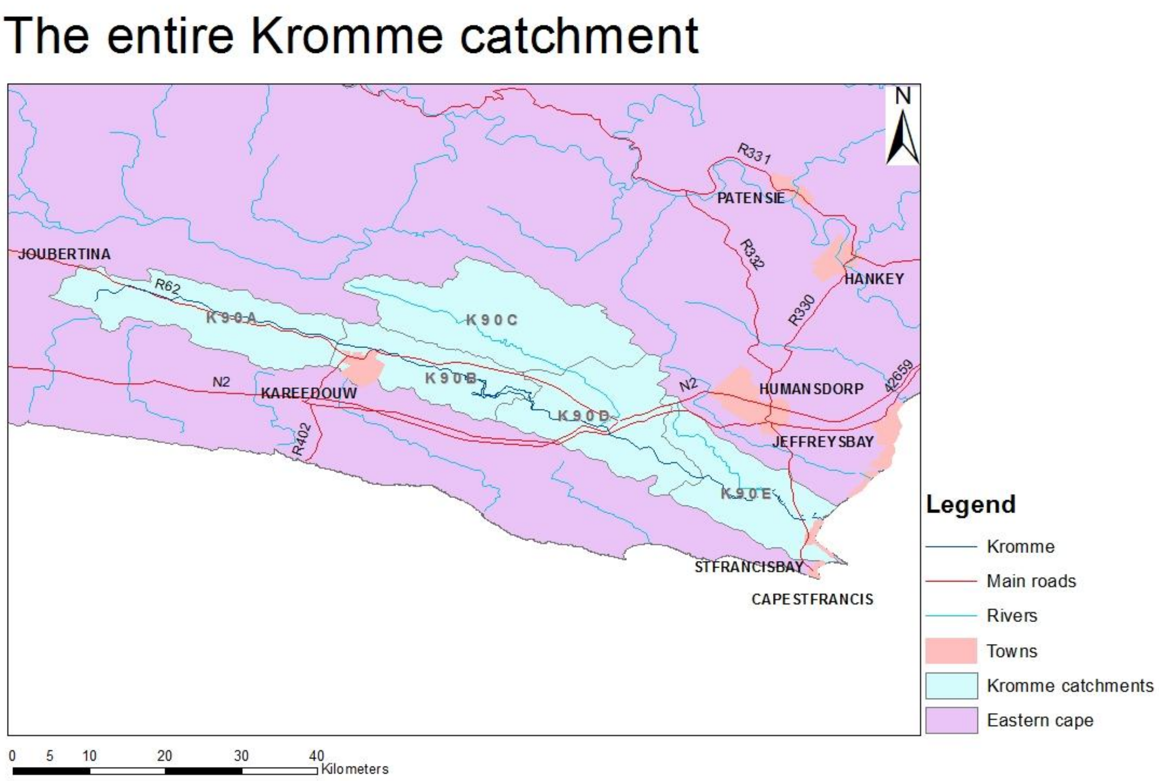

Figure 7: Kromme Catchment
Source: (Author's work)

On the next page, figure 8 presents a map with mean annual evaporation and precipitation. (IWR, 2005)The mean annual evaporation is 1500 millimeters in the Kromme catchment. The differences in amounts of rainfall are quite large because of the mountain ranges. The amounts of precipitation varies from less than 400 millimeters in a year in the driest parts till 800 millimeters in the wettest part of the catchment. In general, it can be concluded that the driest parts of the catchment are the most inland. Furthermore, annual rainfall varies a lot from year to year and from season to season. During the wettest year 1081,8 millimeters was received, but during the driest years only 285,5 millimeters. The month May is the wettest month of the year with 53,07 millimeters and the month January is the driest with only 32,91 millimeters. (IWR, 2005) Extremes of climate are frequently experienced. For instance, the decade of 1980 was very dry early in the decade, but during June, August, and November 1981, 3 major floods came down. Regularly, destructive floods took place in a wider area of the Langkloof. (E.H. Haigh et al, 2002)

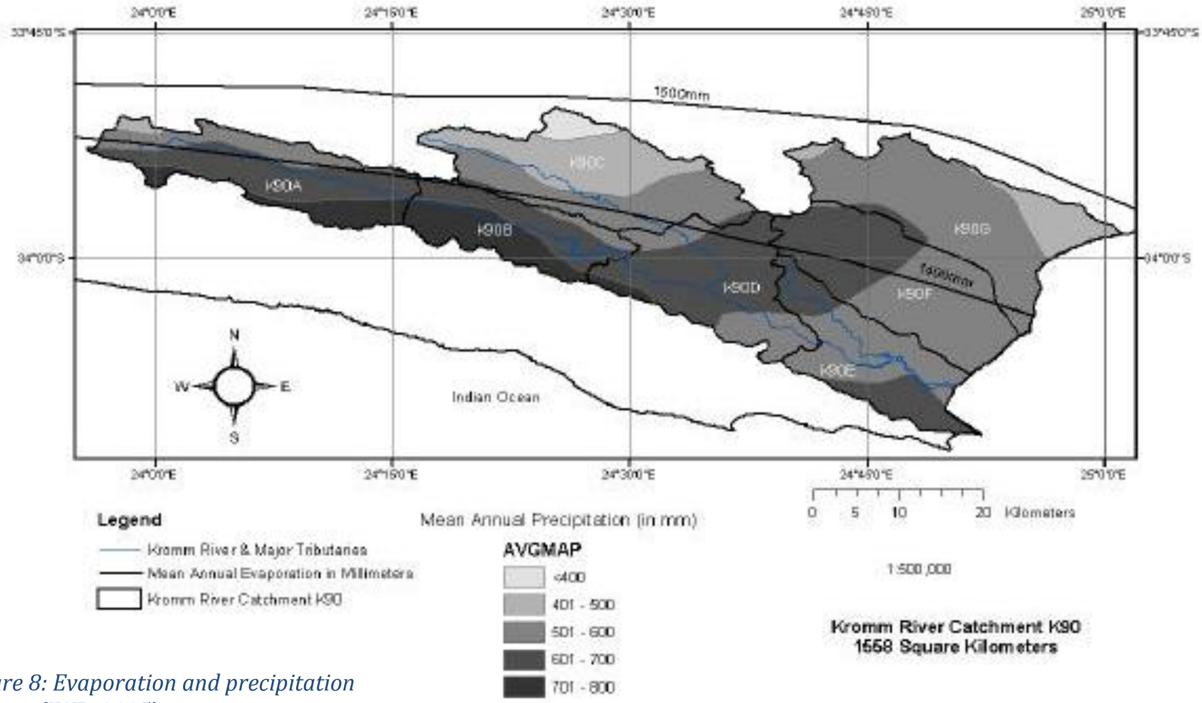

Figure 8: Evaporation and precipitation
Source: (IWR, 2005)

The Kromme river, with the Impofu Dam and the the Churchill dam, is a very important water resource for the Nelson Mandela Metropole. The Churchill dam is delivering 25234 mega liters water and the Impofu dam is delivering 10314 mega liters water each year. This constitutes about 55% of the entire water demand of this Metropole. (Dan Baird, 2006) However, the two dams also cause high alterations to the river flow. (IWR, 2005)

Looking to the recent past, the Kromme catchment supposed to be characterized by large Palmiet dominated wetlands. This is a specific wetland mainly covered by the plant Palmiet. The peat layers and the vegetation, in particular Palmiet, are very important in terms of flood protection, water purification and the storage of water. Moreover, these wetlands are creating unique and rich ecosystems. Unfortunately, most of the wetlands are disappearing or have already been disappeared due to loss of natural vegetation and erosion processes in this high energy water system. (Mr Japie Buckle et al, undated)

2.5 Water quality

The water quality of the Kromme river varies from place to place in the catchment. The water in the area is acidic and fairly corrosive. The table below shows the alkalinity and conductivity of the water. Based on the alkalinity and the conductivity of the water the suitability for agricultural use is given. The project area encloses the either areas Krugersland and Companjesdrift. (Mrs. E.H. Haigh et al, 2002)

Site	Alaklinity	Conductivity	Suitability
Krugerland	pH 6,6 pHs 9,89	15 mSm	Class 2 irrigation, corrosive
Companjesdrift	pH 6,33 pHs 10,18	15 mSm	Very corrosive, high boron. Not suitable for domestic use

Figure 9: water quality Upper Peatland Basin
Source: (E.H. Haigh et al, 2002)

2.6 Flora and Fauna

The region of the wetland and its surrounding area are enriched with both rare and common species of plants and animals. A lot of endemic species are to be found in or around the Upper Peatland Basin. This paragraph is split in two sub-paragraphs. The first one is about flora, the second paragraph is about fauna.

2.6.1 *Flora*

The project area is characterized by a lot of different fynbos species. The slopes are covered with a mix of fynbos species. The fynbos species Palmiet performs as an important plant in the wetland. This plant is accompanied by a mixture of bulrushes. Alien invasive plants like Black Wattle and Kikuyu are scattered around in the Upper Kromme Catchment. Figure 11 shows a global view of the wetland vegetation.

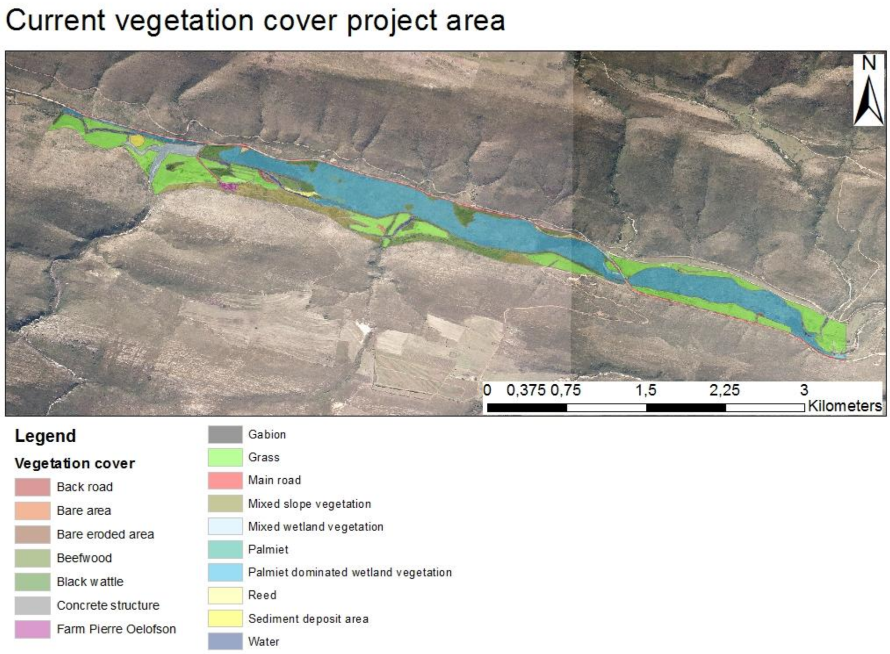

Figure 10: Current vegetation cover project area
Source: Author's work

2.6.1.1 Fynbos

As shown in figure 11, natural vegetation grows in the biggest part of the project area. Fynbos covers the mountains, valleys and coastal plains in a very big part of South-Africa. It grows in the area of Port Elizabeth, Mossel Bay, Cape Town, Lamberts Bay and Niewoudtville, as can be seen in figure 13. In the project area, fynbos is found on the slopes and in the wetland.

Figure 11: Ericoid Leaves source: (Maneveldt, sd)

Fynbos plants are recognized by the small, hard, tough and leathery leaves (ericoid leaves, figure 12). Fynbos contains members of seven plant families found nowhere else in the world. Over 7700 plant species are found in fynbos, from which 69 percent are endemic to the area. This means, 69% of the plants in fynbos can be found nowhere else in the world. (Maneveldt, sd)

Despite their capability to survive very wet and dry conditions by making their leaves whether bigger or smaller and their capability to survive fires, many of the fynbos species are threatened with extinction. (personal comment Japie Buckle, May 22nd 2014) Alien invasive plants, agricultural practices and man-made fires are the main threats to fynbos.

The impact of alien invasive plants on species that are extremely localized in their distribution is severe. Fynbos has a lot of localized species, so alien species are the major threat to fynbos vegetation and its plant diversity. The other threat to fynbos are the impact from agricultural practices, like groundwater table lowering by digging drains. The last main threat are the increased frequency of fires for agriculture purposes. Fynbos must burn from time to time to stay healthy, because fire is a major influence on fynbos community processes. (South African National Biodiversity Institute, undated)Fynbos should burn once in every 10-14 years to stay as healthy and divers as possible. (fynbos and fire, 2011)Many species store their fruit in fire-safe cones for release after a fire, and ants are enticed to bury fruit where they are safe from rodents and fire. Without fire, fynbos becomes old and weaker, and forest and thicket elements begin invading. However, too many fires in a short period or fires in the wrong season can eliminate species. (South African National Biodiversity Institute, undated)

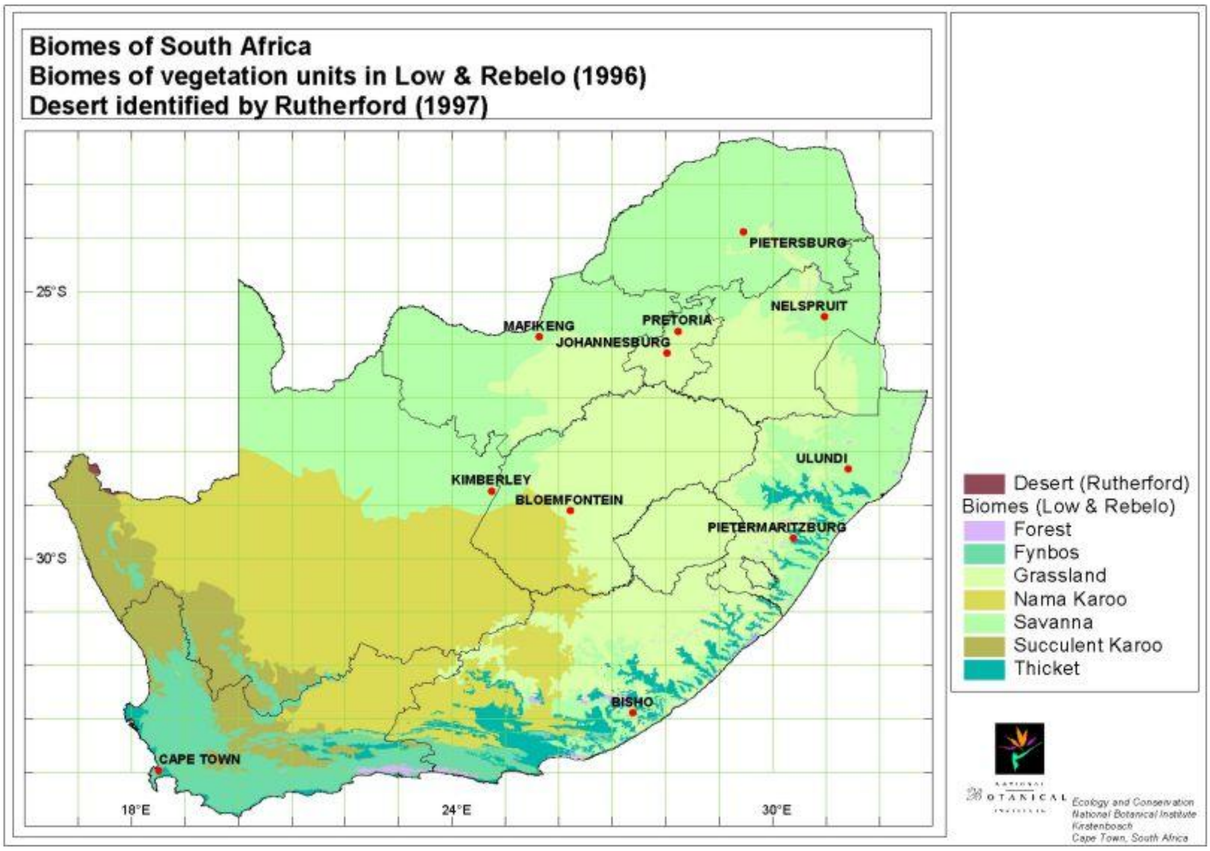

Figure 12: Biomes of South Africa
Source: (Xaba, 2005)

2.6.1.2 Palmiet

Palmiet is a fynbos species and occurs from the Western Cape province to the south of the Kwa-Zulu Natal province. It is found in marshy areas, streams, rivers and riverbanks. (Xaba, 2005) The wetland is dominated with this fynbos species.

Palmiet is a robust, evergreen, semi-aquatic shrub that grows up to 2 meters high. The main stem is 50-100 millimeters in diameter and is usually covered with the dark brown remains of old leaves. The leaves are stiff, leathery and pale grey-green with toothed edges. The flowers are small and brown and occur from September to February. (Xaba, 2005) Underground, the Palmiet plant has a dense network of fibrous roots that extend far deeper than any other wetland plant occurring in its habitat. This network of roots extents up to 5 meter into the peatland. (Sieben, 2012)

Wet conditions, nutrient poor soil and an open environment to catch enough sunlight are necessary for conservation and growth of this species.

Since Palmiet is able to grow in flowing water it can 'choke' the river leading to inundation of large areas of the valley. This will cause peat to form, and the Palmiet will be able to expand further in the area that it occupies. Another special feature of this plant is its capability to grow in areas with a gradient up to three percent. All these capabilities are contributing to a habitat which is created entirely by the Palmiet plants themselves. (Sieben, 2012)

2.6.1.3 Kikuyu

Kikuyu grass is a common grass in the wetlands of the Kromme. It is not native to South Africa, it has is origins in Central Africa, near the equator. The grass is now all over Africa, in tropical Asia, many parts of the continent of America and in Australia and New Zealand. Kikuyu is appropriate for grazing purposes and therefore a common vegetation species in the Upper Kromme Catchment. (Personal comment Japie Buckle, May 22nd, 2014)

Kikuyu grass grows about 30 or 40 centimeters tall, forming turf when dropping its leaves. The leaf blade is linear, up to 30 centimeters long and 0.7 centimeters wide. The kikuyu grass grows best on high fertility soils of loam or clay. It tolerates a pH down to 4.5 and prefers at least moderately drained soils.

Kikuyu has its origins in areas with an rainfall of 1000-1600 mm/year, but now it also grows in environments with a dry season of five months. Where soils are suitable, it grows in areas with annual rainfall down to 800 millimeters or up to 3000 millimeters. Under irrigation it can even perform well in lower rainfall areas. The grass is relatively drought-proof because it has a deep root system, up to three meters deep. It is often found along water courses, and can tolerate ten days of inundation. It grows best during periods of high humidity. The Kikuyu grass can survive moderate shade, but will not grow well in heavy shade. When the soil is suitable for the grass, it will spread very quickly. (forages, sd)

2.6.1.4 Black Wattle

The Black Wattle tree is an invader from South-eastern Australia and Tasmania, and is now a problem in the Western Cape, the Eastern Cape, Kwa-Zulu Natal, Mpumalanga and Gauteng. (Invasives, sd). As to be seen in figure 11, Black Wattle is scattered all over the area, including the wetlands.

The Black Wattle is an evergreen tree which grows up to ten meter high. The leaves are dark olive-green with finely haired pods. (Invasives, sd) The roots of the Black Wattle are sparse.

Because of the roots, this tree is not able to keep the soil together as good as Palmiet during floods. Furthermore, this tree replaces the original and natural species. (Invasives, sd). The governmental program Working for Water wants to get rid of this alien by cutting it down.(Personal comment Japie Buckle, May 22nd, 2014)

Figure 13 : Palmiet
Source: author's work

Figure 14: Black Wattle
source: Author's work

2.6.2 *FAUNA*

In fynbos areas, there is no place for large mammals since the nutrient poor soil on which it grows does not provide enough requirements for large mammals. The large mammals are not able to break the leaves and branches of the fynbos species down. Common small mammals in the fynbos are chacma baboons, klipspringers, grysbok, dassies, mongooses and the striped mouse.

There are not many birds living in fynbos, however there are some endemic bird species that live only in fynbos, like the orange breasted sunbird. This bird is a common bird in fynbos, and plays an important role in pollinating flowers by drinking nectar.

Fynbos is not particularly rich in reptiles and amphibians, but many of the species that are to be found in fynbos are both endemic and threatened. The second rarest tortoise in the world, the geometric tortoise, is found in only a few fynbos areas. In addition to that, there are 62 different kind of frogs in fynbos, from which 29 are endemic.

Lastly, fynbos is home to a lot of fish species. Currently, a few of these fish species are threatened, because the extent of habitat decreased. (Maneveldt, sd) The Cape Galaxias is the most special fish to be found in the wetland.(E. Swartz, 2007)

2.7 HISTORY

Originally, the Kromme Catchment was widely occupied by low impact land users, the indigenous Khoisan. The Kromme valley has experienced higher impact from European occupation since 1775 when Thomas Ferreira occupied Jagersbos. (Mrs E.H. Haighet al, 2002)He was the first farmer to apply for grazing rights. Other settlers occupied the top end of the valley, near the Heights. The coastal towns of Mossel Bay and Plettenburg Bay were both developed as harbors with a lot of trading of indigenous trees and farming development. Around 1790, timber was shipped from the Kromme region to Cape Town by sea. The number of farmers in the Kromme Catchment increased, just as the population in the towns and villages in this area. In 1869 the precursor of the R62 was constructed, the railway line was completed in 1906. This allowed intensification of farming activities. The most common land uses until 1950 were orchards and grazing, but a lot of the orchards disappeared after a major flood in 1931. Many farmers changed to pasture, meat and dairy productions. (Kotze DC, 2009) From 1935 onward farmers started planting Kikuyu as a suitable pasture grass on the floodplain. (Mrs E.H. Haighet al, 2002)On the former wetlands that became fertile floodplains, soft-fruit orchards were planted between 1930 and 1940. To make matters worse, after the big flood of 1931 Black Wattle trees appeared in greater numbers all along the course of the Kromme River. After 1945, Black Wattle was harvested to use the bark in the tannery in the town of George. (Kotze DC, 2009) However, since the middle of the twentieth century the practices fell away, and Black Wattle has become a major environmental threat to the water course and to natural vegetation. (Mrs E.H. Haigh et al, 2002)

3. THE UTILITY OF THE WETLAND IN ITS ENVIRONMENT

Peatland wetlands have a great influence on the surrounding area. Especially downstream of the wetland, the consequences of rainfalls or even droughts are entirely different if there is a wetland like the Upper Peatland Basin to store water. This chapter is firstly about the way wetlands are created, and secondly about the functions of the wetland and the effects it has on the surrounding area.

3.1 CREATION OF THE WETLAND

The floodplain of the Kromme situated upstream from the Churchill Dam is supposed to be one large Palmiet-dominated wetland. Palmiet is especially found in relatively high energy systems, such as the Kromme catchment with steep slopes, causing a high run off. (Personal comment Japie Buckle) The peat complex in the area is formed by Palmiet, and can be characterized as a valley bottom fen. The peat layer is formed over a period of approximately 5000 year as a result of sedimentary activity of the steep narrow Cape fold valley. The peatlands are formed upstream from key points where tributaries have deposited sediment in the Kromme riverbed. (E.H.Haigh et al. 2002) These key points are called alluvial fans, which are wide ranges of sediment deposited by the river. (Personal comment Japie Buckle, May 22nd, 2014) The alluvial fans function as natural dams to trap new sediment out of the Kromme. The washed out and therefore poor white soil in combination with the wet environment create good conditions for Palmiet to grow. The area of sediment in the floodplain of the Kromme river is soon covered by dense grown Palmiet and perform, due to a deep and dense network of fibrous roots, as an excellent block against floods. Now, different types of bulrushes are also able to grow in the sediment trapped area. River water is distributed over a large floodplain and infiltrates in new created peat layers. The wetland abstracts a lot of energy out of the high energy water system of the Kromme catchment and prevents the area from degredation.

3.2 THE IMPORTANCE OF THE WETLAND

The floodplain of the Kromme river used to be one big Palmiet-dominated wetland. The determination of the different grain size in the granular material is indicative of fluctuating flow velocities during the deposition of the sediments. The peat profile presents relatively stable river discharge amounts over the past 5000 to 6000 years before present. Pollen profiles and peat show locally variable conditions. (Mrs E.H.Haigh et al. 2002) Overall, it can be considered that all the Palmiet wetlands played and still play a very important role in purification, the storage of water, flood breaking and creation of unique and rich ecosystems.

3.2.1 PURIFICATION

Wetlands are world's most effective water purification mechanisms. (Japie Buckle, undated) The vegetation of the wetland spread the water out of an large area. This makes the exchanges of pollutants between water and soil very effective.(Mondi Wetlands Programme, undated) The bulrushes are important for purification of the water by trapping polluted sediments. (Mr. Japie Buckle et al. undated) Many different chemical processes take place in the peat layers to remove pollutants as for example the excess of heavy metals, nutrients, disease causing bacteria and viruses and synthesized organic pollutants such as pesticides. Denitrification is one of these chemical processes and a common process in the wetlands because of the anaerobic and aerobic soil zones which are found close together. The conversion of these nitrates is very important, because otherwise the nitrates could pollute the water (Mondi Wetlands Programme, undated)

3.2.2 *STORAGE OF WATER*

Storage of water in the thick peat beds causes a more constant river flow. Palmiet builds op very fine peat, with an accumulation rate of 0,3 to 0,7 mm depth a year. Every cubic meter soil of which 70% is carbon peat can store 700 liters of water. (Personal comment Japie Buckle, May 22nd, 2014) The peatland works as a natural sponge, by storing rainwater and releasing it steadily over time. (Czeglédi, 2013) After approximately four dry years in the Upper Peatland Basin, three heavy rain events were needed to make a little bit of water flowing out of the wetland. (Personal comment Japie Buckle, May 22nd, 2014) The great water storage capacity of peat is a very important result of a Palmiet wetland. Because of this capability, the river downstream is less likely to overflow. The wave of water from a heavy rainfall will be longer but flatter. In the situation of the Upper Peatland Basin, this will make the Churchill dam less likely to overflow, which will save a lot of fresh water. Therefore, it is very important to maintain Palmiet in order to maintain wetlands.

Figure 15: A simple model of a wetland
Source: Author's work

3.2.3 *FLOOD PROTECTION*

All the wetlands in the Kromme are very important for protecting the dams against sedimentation and flooding. Wetlands, like the Upper Peatland Basin, are natural buffers against flood damage. In fact, they are the "glue" that keeps the soil together and prevents erosion processes. Figure 18 and figure 19 show why Palmiet is very capable in keeping the soil together. Figure 18 shows the roots of Palmiet, figure 19 shows a leaf of Palmiet. Because of this dense structure of the Palmiet, they are adapted to break the floods. They slow down the runoff, which provides time for infiltration. On the next page, figure 20 shows the hydrologic buffering effect of the wetlands on the high river flow peaks. (Mr. Japie Buckle et al. undated)

Figure 16: Roots Palmiet
Source: Author's work

Figure 17: Leaf Palmiet
Source: Author's work

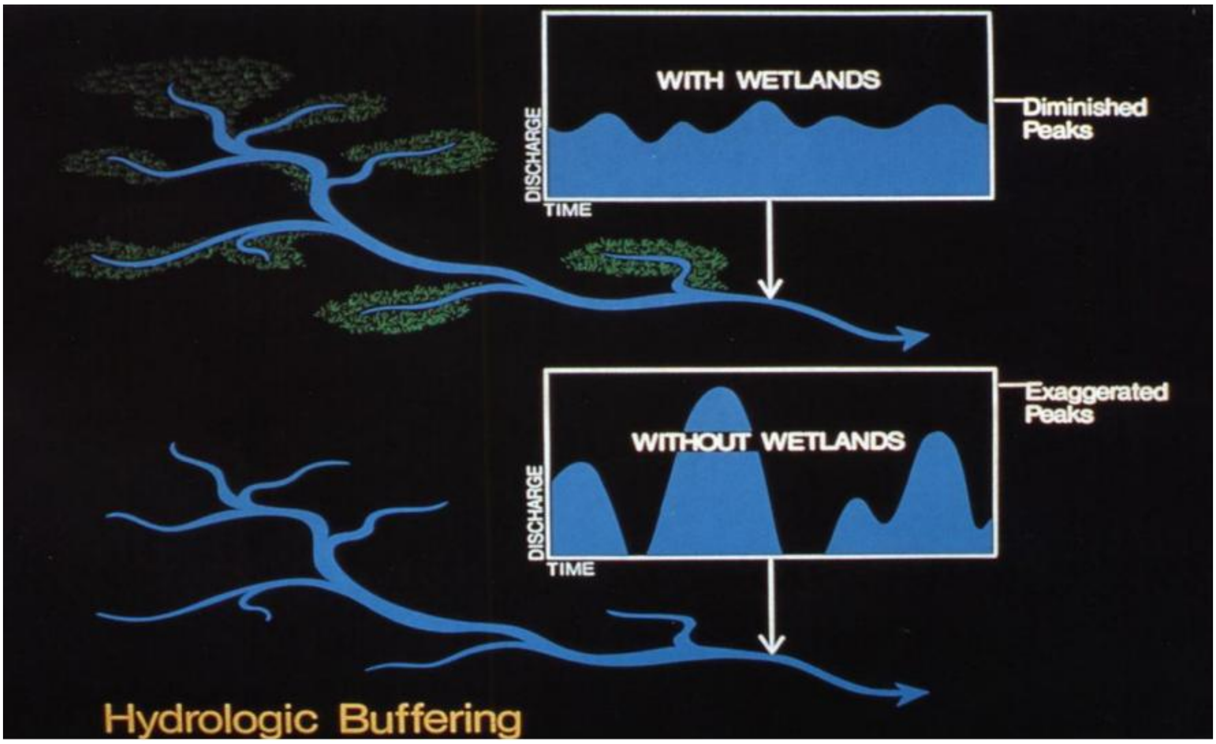

Figure 18: Hydraulic Buffering Effect of Wetlands
Source: (J. Buckle, undated)

3.2.4 RICH AND UNIQUE ECOSYSTEM

Palmiet is marked as an bio engineering plant because of its capabilities. This plant species could create its own environment, a rich and unique ecosystem with a lot of endemic species.

One of those special capabilities is the ability to grow on very poor soil, dominated by quartzite particles.

Another feature are the fibrous deep roots which give this plant the right equipment to survive big floods.

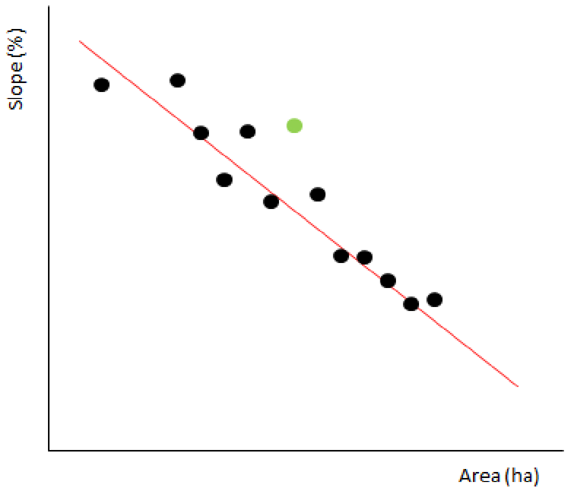

Figure 19: Correlation slope/area wetland
Source: Personal comment Fred Ellery, author's work

Moreover, this plant can grow in areas with a gradient up to three percent, which is extraordinary for wetland plants. Figure 14 presents the correlation between the slope in a particular area and the area of the wetland. The gradient of an area is negative correlated to the area of wetland. The steeper the slope, the smaller the area of the wetland. Dots above the red line are areas in which gullies and other erosion processes occur. In this case the wetland cannot handle the high water energy generated by the steep slope. One exception to this negative relationship are the Palmiet wetlands, shown as the green dot in the graph. Those specific wetlands are able to counter erosion processes due to

Palmiet vegetation, while other wetlands without Palmiet but with the same slope gradient have been eroded already. This feature makes Palmiet-dominated wetlands unique in the world. (Personal comment Fred Ellery, June 19th , 2014)

Lastly, the dense grown Palmiet forces the river to flow over a large area of the floodplain instead of a river channel. In this case, a large area is suitable or becomes suitable for Palmiet. (Personal comment Japie Buckle, May 22nd, 2014) The wetland in this state is host for a variety of living organisms, water plants and a plants on the riverbanks, fresh water fishes, frog species and indigenous bird species. (Japie Buckle et al, undated)

4. Change in extent of wetland

In the 20th and the 21st century, the Upper Peatland Basin decreased rapidly. This is the result of a combination of events. Some of them are caused by human interferences, others are natural. This chapter describes the decrease of the area of the wetland in the past, and the threats that can cause the wetland to decrease.

4.1 Decrease of area wetland

The main reasons for the degradation of the Upper Peatland Basin were the construction of the old R62 and bridges, the commercial mixed cultivation and the invasion of alien plants, especially the Black Wattle. Bridge and road construction had impact on the environment by causing erosion gullies, and at some places increased sedimentation. (Kotze DC, 2009)

The first aerial photos that could be used to determine how the wetland has transformed were made in 1942. At that point, the floodplains had already been transformed on some places. However, since the first useful photo’s where made in 1942, this year is often used as baseline against later observations. After 1942, agricultural activities increasingly moved towards the production of soft-fruit and vegetables. (Kotze DC, 2009) Figure 21 shows the difference in total area wetland between 1942 and 1999. (E. H. Haigh et al, 2002)

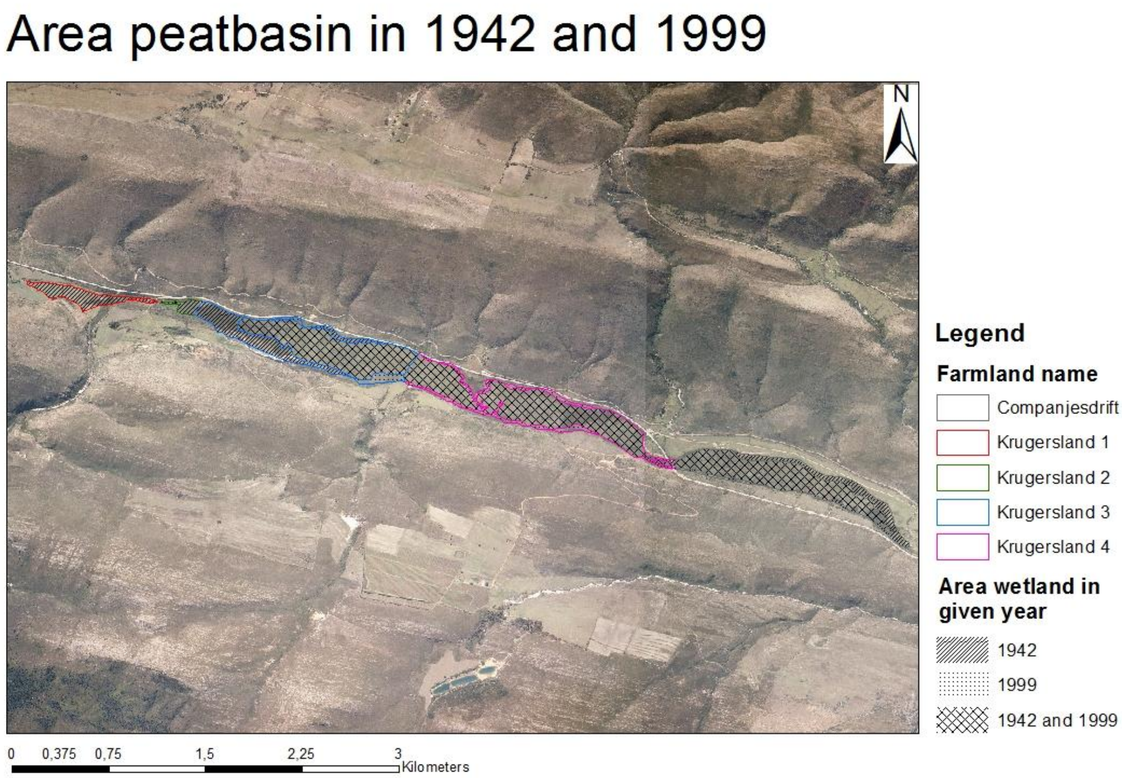

Figure 20: Area Upper Peat Basin in 1942 and 1999
Source: Author’s work

Figure 22 presents the percentage of decrease or increase of the wetland area between the years 1942 and 1999. Especially the western part of the wetland, Krugersland 1 and Krugersland 2, where almost totally destroyed in 1999.

Peat basin	Size in 1942	size in 1999	Increase or decrease wetland area
Krugersland 1	5.98 ha	0 ha.	100 % destroyed
Krugersland 2	1.49 ha.	0.04 ha.	99 % destroyed
Krugersland 3	35.50 ha.	26.27 ha.	25 % destroyed
Krugersland 4	34.71 ha.	36.41 ha.	5 % increased
Companjesdrift	30.65 ha.	25.55 ha.	16 % destroyed
Total	108 ha.	88 ha.	19 % destroyed

Figure 21: Table decrease Peatland Basin from 1942 to 1999
Source: (Lil Haigh P. I., 2008)

4.2 ACTUAL THREATS TO THE WETLAND

Both climate change and human interference like overgrazing, infrastructure, agricultural practices, mining, water abstraction, fires and alien vegetation are transforming the current environment in the Upper Kromme catchment. It is still not clear whether human interference or climate change has the most impact in this area. In this paragraph, all the threats and their impacts are one by one explained.

4.2.1 OVERGRAZING

Overgrazing does not pose a direct threat to the peatland complex at the moment. However, the reduced vegetation cover make the slopes more erodible and the tributaries will discharge more sediment. This sediment will be trapped in the peat basin and raise the level of the banks. Effectively, the water table lowers and new facultative wetland plants and invasive aliens will appear. The invasive aliens reduce usable land for grazing and cultivation. Moreover, they out-compete indigenous plants. Especially wetland plants, including Palmiet, disappear. In turn, the vulnerability to erosion in the area increases. (E. H. Haigh et al, 2002)

4.2.2 INFRASTRUCTURE

Bridges and causeways that are more narrow than the riverbed causes acceleration of floodwater through the narrowed aperture. The increased force of the water causes erosion of both the riverbed and the channel floor. The channel incision results in an higher discharge peak of water and sediment during heavy rainfall events . Areas downstream will be threatened by floods. In periods of a low surface water level, the peatland downstream will be threatened by dehydration.

4.2.3 AGRICULTURAL PRACTICES

Wetlands are often used for agricultural practices because of the flat area and the opportunities for irrigation. Especially in the early stages of agricultural land use in a new wetland, the composition of the soil is quite good. However, the water table lowers after draining, ploughing, and planting riverbanks and floodplains for commercial agriculture. The peat will oxidize and a white, poor soil remains. Farmers regularly have to fertilize their farmlands to keep it appropriate for agriculture. Furthermore, the disappearing of the wetlands upstream causes increase of the water velocity and erosion. More downstream, new problems occur for the farmers. The sediment will get stuck in their pumps en the sharp particles will damage the pipelines. (Japie Buckle, May 22nd, 2014)

Man-made drains with the purpose to lower the water table in the wetland are an attempt to make it appropriate for agricultural land use. In this case, the drain channels lower the water table and in turn the peat bed oxidize. (E. H. Haigh et al, 2002) The volume of peat bed for storage of water will decrease until the wetland dries out, and important wetland plants to keep the soil together, as for instance Palmiet, will disappear.

4.2.4 MINING

Mining activities may have impact on wetlands either in a physical or a chemical way. The physical impacts of mining on wetlands include inundation and siltation. The effectiveness of a wetland is reduced when it is inundated for a long period, which can be a result of mining. As discussed before, a wetland can be compared with a sponge. A sponge that is always wet does not work properly anymore, since it is full an cannot store additional water. The wetland needs a period of time for regeneration, to lose the water earned by floods. Furthermore, water discharged from a mine often carries a lot of sediment, which may result in siltation of streams. This can be the cause the wetland to disappear, since the large quantities of poor-quality, non-fertile silt enter the system. Thus, discharge water from mining activities diminishes both the pollution cleaning process and the storage capacity of a wetland. (Gauteng Department of Agriculture, 2008)

There are no mining activities in the Upper Peatland Basin in the Kromme catchment. Wetlands are protected by environmental laws, and so is the Upper Peatland Basin. Permission to mine should always be requested by governmental instances.

4.2.5 WATER ABSTRACTION

Water abstraction can have a significant role in lowering the water table. Water can be abstracted in large amount, in order for example the watering of an orchard next to the wetland. Farmers need a lot of water for irrigating large fields of trees. When they extract it from the wetland, the water table of the wetland will drop. Therefore the top peat layer gets dry, and wetland plants dependent on water will dry up. Black Wattle is able to get water from deeper in the ground, and will take over from the wetland plants. The area will change in a dry, eroded area. Thus, it is very important to reduce the abstraction of water from the wetland as much as possible. In the Upper Peatland Basin no one is allowed to abstract large amount of water. For that, the problem of water abstraction is not applicable to the Upper Peatland Basin as long as no one is allowed to abstract water.

4.2.6 FIRES

Fires have always been a natural threat to the wetland in the Kromme Catchment, at least for the past 4000 years BP. However, manmade fires for grazing may reduce the time interval between fires or increase their intensity by burning the alien trees and other vegetation for grazing. After the fires, the hill slopes are bare and water will flow more rapidly down from the wetlands with a risk of flooding downstream. Moreover, the sedimentation from the catchment hill slopes will occur and could cause dehydration of the top layers of the peat bed. The burning of chopped Black Wattle trees could cause ignition of the peat beds (E. H. Haigh et al, 2002)

4.2.7 *ALIEN VEGETATION*

The Upper Peatland Basin has been invaded by the Australian Black Wattle (Acacia mearnsii). This tree requires a lot of water and is especially found in wetland areas. (Personal comment Personal comment Japie Buckle, May 22nd, 2014) Unlike Palmiet the roots of the Black Wattle are sparse, which makes them unable to keep the soil together during floods. The Black Wattle will rip out the riverbanks and leave holes in the riverbanks. The banks get more and more unstable and erosion will occur. The lack of vegetation, and so the block against the flowing water, assures that the velocity of the water flow will increase. All the water of the river follows the same course with the least friction. Nothing is holding the soil particles together anymore and they flush away. The river gets deeper and more narrow. To make matters worse, the ripped Black Wattle trees are flushing away and start to accumulate on a certain place. In this case, a congestion makes the river more narrow. Therefore, new erosion processes take place and the area deteriorates. (E.H. Haigh et al,2002) Furthermore, Black Wattle on the slopes make the area more sensitive for land degradation. The tributaries contribute to the spreading of the Black Wattle seeds. (E.H. Haigh et al,2002) Black Wattle is an important cause for the disappearing of Palmiet. Palmiet needs sunshine for conservation and growing. Unfortunately, the Black Wattle tree creates a lot of shade and in turn Palmiet disappears. Moreover, Black Wattle trees are self-sufficient due to nitrogen fixing root nodules, and therefore it can grow on poor soil. However, Palmiet is growing well on poor soils and dislikes the fixed nitrogen from the Black Wattle tree. It is almost impossible to get rid of this alien tree. Black wattle was brought in quarantine, so there are no natural enemies for it in South Africa. Furthermore, fires seems to be no problem for this tree, because of the great number of tough, heat resistant seeds. After a fire or a clearing program this tree will quickly start growing again. It can grow up to 4 meters within 4 years. (Personal comment Japie Buckle, May 22nd , 2014)

Another invasive in the riverbank is Kikuyu grass. This grass is very competitive and generally incompatible with other grasses. However, for other plant species like weeds, reeds and Palmiet the Kikuyu grass is no threat (forages, sd). For the wetland it does not matter if the natural grass or the Kikuyu grass is growing, so for the wetland Kikuyu is not a threat.

4.2.8 *CLIMATE CHANGE*

Climate change is a controversial topic when it comes to threats to a wetland. It cannot certainly be said whether climate change or human interference is the biggest threat to the wetland. Pierre Oelofsen noticed the climate is changing in the area. Rain showers supply new water less regular, but they provide more water due to higher intensity. (Personal comment Pierre Oelofsen, June 19th , 2014) The natural system of the Kromme catchment in current state is not used to this changing type of climate. In the last Ice Age this area was characterized by approximately 350 – 400 millimeters rainfall each year. The environment with wetlands could handle this amount of water. Now, with approximately 600 millimeters rainfall each year and higher temperatures, the energy in water is higher and erosion processes start to occur in the whole catchment. This process is sped up by human interference, and processes that naturally should probably occur about a century later are already starting. (Personal comment Damian Walters, June 26th , 2014)

5. STAKEHOLDERS

When making a rehabilitation plan, one must not only look at the threats and natural needs, it is also necessary to look at what the interests are from all the people who have something to do with the wetland, the river or the area. Land owners have ideas about what they want with their lands, and the inhabitants of the Nelson Mandela Bay Municipality use the water from the Kromme. In addition to that, there is a national policy on wetlands and the government formed programmes to improve the state of inter alia wetlands. This chapter is firstly about the policy and laws of the wetland, and secondly about the interests of the farmers, the inhabitants of the downstream cities, and the companies that use water from the Kromme.

5.1 GOVERNMENT

This paragraph is about the policy and laws applicable to wetlands. The first sub-paragraph contains information about the national policy on wetlands, the second sub- paragraph tells about laws the government made for wetlands.

5.1.1 NATIONAL POLICY ON WETLANDS

Wetlands represent some of South Africa's most threatened ecosystems, as such their conservation and sustainable use is a crucial component of the National Policy of Wetlands. Insufficient attention to secure the effective management of wetlands has been given in the past. Nowadays, the wetland management takes place in an integrated manner, in accordance with the objective of conserving and using biological resources sustainably, and minimizing impacts on aquatic biodiversity. The government will wherever possible and appropriate:

- Support the principle that basic domestic needs and environmental needs will enjoy priority use of water. The quantity, quality and reliability of water required to maintain natural flow regimes and ecosystems must be reserved.
- Appropriate laws must be developed to secure the wetlands and their ecological and socio-economic functions.
- Promote the establishment of National System of Protected Wetlands as part of the protected area system.
- Prevent inappropriate activities and development around wetlands.
- Ensure that considerations relating to the biodiversity of aquatic areas and wetlands are adequately incorporated into the national policy on integrated pollution control and waste management.
- Strongly promote the development of catchment-specific partnerships and joint management plans between the range of institutions, organizations and individuals engaged in managing and using wetlands.
- Provide leadership in international wetland conservation efforts in southern Africa. (Department of Environmetnal Affairs and Tourism, 2003)

Because the complexity of a wetland is quite high, multiple policies, organizations, and stakeholders are often concerned with a particular wetland. (Kotze DC, 2009) the reasons for the complexity of a wetland are listed on the next page.

- Wetlands are typically located in transition between terrestrial and aquatic systems, resulting in wetlands being of relevance to both land and water management.

- The functioning of wetlands in influenced by processes locally at the wetland, for example grazing of wetland vegetation. Furthermore, wetlands are influenced by processes operating at broader scales like pollution of water upstream the wetland.
- Wetlands supply ecosystems both locally (harvesting reeds and water supply) and at distant beneficiaries (improved water quality downstream).
- Wetlands deliver a broad spectrum of ecosystem services.
- Wetlands are often subject to conflicting land-use demands. They are important downstream, have a high biodiversity and are fertile for cultivation. (especially for farmers lacking resources for irrigation and fertilizers)

Key-policy elements around wetland conservation are found in the National Water Act and the Policy on the Conservation and Sustainable Use of South Africa's Biological Diversity. Thus, there is policy about wetlands, however there is no national strategy for the conservation and wise use of wetlands.

There are three national government departments that are directly mandated with regulating the use and management of wetlands. These are:

- Department of Environmental Affairs and Tourism (DEAT)
- National Department of Agriculture (NDA)
- Department of Water Affairs and Forestry (DWAF)

Those three departments are all responsible for acts with measures to protect wetlands. Those are the Environmental Conservation Act, the National Environmental Act, the Conservation of Agricultural Resources Act and the National Water Act.

The following national programmes are administered by the departments:

- Working for Water, a large-scale public works programme with a poverty-relief focus for the control of invasive alien plants.
- Working for Wetlands, a public works programme that implements wetland rehabilitation projects using an approach focused on poverty relief. Working for Wetlands main goals are reducing erosion and desiccation from drains and gullies, and to promote the sustainable use of wetland resources.
- LandCareProgramme promotes sustainable agricultural land-use practices, food security and poverty relief. The LCP mainly works in communal rural areas.

Furthermore, there are two big national Non-Government Organizations:

- Mondi Wetlands Project (MWP) has the greatest NGO involvement in wetland management and development issues at national level. The primary focus of the MWP is the wise use of wetlands in rural areas and supporting government departments in fulfilling their mandates in relation to wetlands.
- The Endangered Wildlife Trust (EWT) has primarily been involved in the promotion and of the conservation of crane species and the wetland habitats on which the cranes depend. They focus on problems with dams and fires, and work especially in wetlands supporting breeding cranes. (Kotze DC, 2009)

Clearing the wetland from black wattle is the task of the multi-departmental programme Working for Water. The overall purposes of this programme are to recover water being lost to invading alien plants, to create jobs, empower individuals and build communities, and to conserve biological diversity, ecological integrity and catchment stability. (Kotze DC, 2009) Most of these goals can be achieved by getting rid of black wattle in the Upper Peatland Basin. This project is good for jobs, stakeholders, and the biodiversity and ecological state of the wetland.

Working for Wetlands established rehabilitation structures in the river, in order to save and rehabilitate the Upper Peatland Basin. In other places, where the wetland has been completely destructed years ago, Working for Wetlands is planting Palmiet and other wetland vegetation in and around the river. That combined with rehabilitation structures makes it possible for more wetland vegetation to grow.

5.1.2 *SOUTH AFRICAN LAWS APPLICABLE TO WETLANDS*

In South Africa, a lot of destruction of the environment has taken place because of poorly development. That's why an Integrated Environmental Management (IEM) procedure has been developed in South Africa. This procedure follows the underlying principles:

- Development is sustainable end equitable;
- Decision making is informed, accountable, and open, involving the relevant authorities and stakeholders;
- Alternative options are considered;
- The environment is considered in the broadest sense, including physical, biological, social, cultural and economic factors.

Furthermore, land users are forbidden (without successfully obtaining the necessary permission) to drain or cultivate any marsh or water sponge or portion thereof on their land or to cultivate any land within the flood area of a water course. (Conservation of Agricultural Resources Act, No. 43 of 1983)

As mentioned before, another act regarding wetlands is the National Water Act. Water Law is one of the most complicated fields of law. The key principles of particular relevance to wetlands are given below.

- In a relatively arid country such as South Africa, it is necessary to recognize the unity of the water cycle and the impact of its elements amongst each other. Evaporation, clouds and rainfall are linked to underground water, rivers, lakes, wetland areas and the sea.
- The variable, uneven and unpredictable distribution of water in the water cycle should be acknowledged
- All water, wherever it occurs in the water cycle, is a resource common to all. The use of this water should be a subject to national control.
- There shall be no ownership of water but only a right to its use.
- The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend should be reserved, so that the human use of water does not individually or cumulatively compromise the long term sustainability of aquatic and associated ecosystems, such as wetlands.

Last but not least, the Mountain Catchment Areas Act emphasizes that any wetland within mountain catchment areas are protected under provisions of this act. (Department of Environmetnal Affairs and Tourism, 2003)

This means, the Upper Peatland Basin is watched closely by the national authority. The owners of the land have to ask for permission when they want to do something with their wetland. The water in the wetland is a subject to national control, the ecological functions should be reserved and the importance of the water and the wetland itself should be acknowledged. Thus, landowners are by law prohibited to change anything about their wetland without asking permission to the national authority. Furthermore, the governmental programme Working for Water has taken responsibility for getting rid of the Black Wattle.

5.2 LAND OWNERS

This paragraph is about the two land owners of the Upper Peatland Basin and the landowners more downstream. Their involvement in and their view on the wetland is very important, because they live in the area. Even more important, they are the first people who have to deal with changes in the Kromme Catchment.

5.2.1 PIERRE OELOFSEN

The main stakeholder is Pierre Oelofsen. As mentioned before, he is the owner of the Krugersland, which covers the biggest part of the Upper Peatland Basin. He has been the owner of this land for 40 years now. Since the Upper Peatland Basin is the biggest wetland with significance value for a very large area, Pierre Oelofsen owns a very important piece of land for a lot of people. However, Mr. Oelofsen is not allowed to use his wetland as a farm whatsoever. The future of the wetland does not look promising regarding to commercial purposes. However, Mr. Oelofsen wants to sell his wetland for a good price. A lot of people and water consuming companies make good use of the water that flows slowly through his land. Furthermore, the rare flora and fauna in the area are good reasons for the government to name it a protective area. There are a lot of organizations using their money to invest in special areas, such as wetlands. To conclude, Pierre Oelofsen hopes to sell his wetland to one organization or another, so he gets compensation for his restricted land and so he does not have to take care for it anymore.

5.2.2 DENNIS FERREIRA

Dennis Ferreira is the owner of Companjesdrift. The eastern part of the wetland is part of his land. Companjesdrift does have a lot of soil which is suitable for farming. Mr. Ferreira uses his land to produce apples, pears, honey and tee. Furthermore, he has cattle grazing on his lands, they drink water from the wetland. Working for Water did not place a fence, so the cattle in Dennis Ferreira will go to the wetland whenever they want to. The animals are around the wetland quite often, because it is the only place for them to drink fresh water. Thus, for Dennis Ferreira it would be good if Working for Water would place a fence next to the wetland, and then arrange a new drinking place for his cattle. Furthermore, Dennis Ferreira states that the Black Wattle trees that are cut down are not always cleared. This does not only makes a mess of his land, it also increases the effect of erosion.

5.2.3 FARMERS

Farmers downstream the wetland notice the effect of the wetland for two reasons. The first reason is the improved water quality. Directly downstream a wetland, water is clean enough for humans to drink from. Most farmers will appreciate the second reason even more though. Since the wetland works as a sponge on water, the river is less likely to overflow during heavy rainfall. This means less erosion on their riverbanks and less destruction of their crops and orchards. Farmers downstream the wetland are aided when the Upper Peatland Basin rehabilitates.

5.3 Population Nelson Mandela Bay Municipality

The inhabitants of the Nelson Mandela Bay Municipality make good use of the water from the Kromme River. 55% of the total water demand, which is 34 million m^3, for about 1.1 million inhabitants of the Nelson Mandela Bay Municipality is delivered by the Kromme system.(M. Mander, 2010) All this water has a great value, since water is scarce in South Africa. Because the wetland cleans the river from pollutants, it can reduce the costs of water treatment plants. There are more wetlands required downstream for that though, because the water gets polluted downstream the wetland right away. In addition to that, without the wetland there would be more overflowing water, which means less drinking water for the inhabitants of the cities.

5.4 Companies in Langkloof

Multiple companies make use of the water of the Kromme. Nestlé is one of the organisations using water from the River Catchment. They are settled in Kareedouw. The factory itself does not use a lot of water from the Kromme, but the dairy farms that deliver the milk to the factory do. The cows drink from the water from the Kromme or its tributaries. Nestlé invests in those farmers so they use the river with responsibility. By doing this, the Kromme River does not degrade further by their doing, which means they have a good, sustainable water source close by. Other companies may follow, some are already investing in the health of the river, just like Nestlé.

As a result of the large flood damage over the past decades, insurance companies lost a lot of money. In particular areas downstream are regularly victim of high damage through the floods. The claims for restoring are very high, so insurance companies cannot offer insurance because it is not profitable anymore. (Personal comment Thekla Teunis, June 8th, 2014) Insurance company Santam is currently putting effort into a few local municipalities to help determine the risks associated with climate change. Insurance claims can be reduced through these partnerships, these risks can be mitigated pro-actively. (personal comment, Francois Adriaan, head Group Corporate Affairs, June 17th, 2014)

6. Wetland rehabilitation

In this chapter, the implementation plan and maintenance plan are described. The first paragraph is a proposal for the implementation plan for the Upper Peatland Basin, the proposal for the maintenance plan is written in paragraph 6.2.

6.1 Implementation plan

To get a good view of the issues described in the implementation plan, every point of interest is shown in a map of the Upper Peatland Basin in figure 23. This paragraph describes what to do with the points of interest.

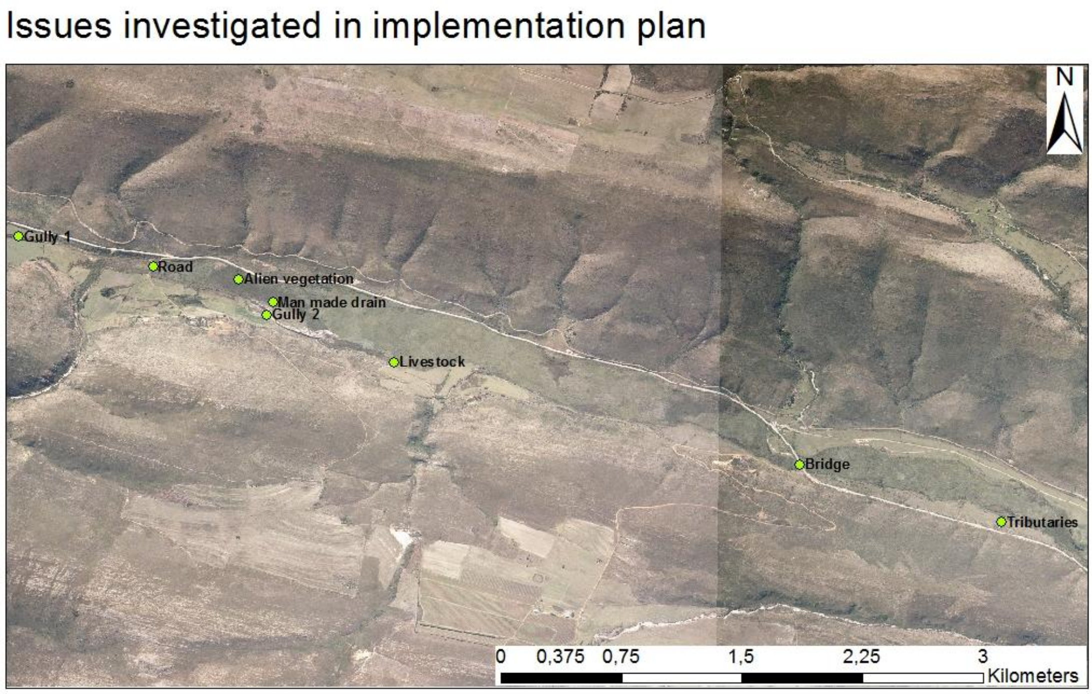

Figure 22: Issues investigated in Implementation Plan
Source: Author's work

6.1.1 Gullies

The wetland counts two big gullies which could have a draining effect in the wetland. It can be discussed to which extent these gullies result, from either human activities or natural processes. In case of gully creation, the natural balance is already disturbed because the gradient is too high. Gullies are a natural way to reduce this gradient until the natural balance is restored between water energy in velocity and the soil energy in keeping grains on its place. Based on this information it can be concluded gullies are part of natural process to keep balance.

Moreover, the dynamics of wetlands in changing the course of water over time is normal. For example, say most of the water flows on the left hand side from the wetland. Sooner or later, most of the sediment will be trapped on that side and the surface level will rise in comparison with the other side of the wetland. This process will go on till water find an easier way to flow, on the right hand side of the wetland. The course of most of the water will change to that side and the left hand side of the wetland will get drier.

6.1.1.1 Gully 1

Gully 1 is located in the most western part of the wetland. Figure 24 presents the exact location and some pictures from the gully. The gully is surrounded by pastures, but close to the main- and back road by bushes and bulrushes. In 1942 this area was still part of the wetland in terms of vegetation, soil and hydrology. A big flood and agricultural practices more upstream are probably causes for the channel marked as gully 1. Later on, Black Wattle began to overtake the wetland vegetation. When they cut down the Black Wattle, the area became suitable for orchards and pastures. (Personal comment farmer Pierre Oelofsen, June 19th 2014) In the last approximately 70 years, the original Palmiet dominated wetland totally disappeared in this area and changed to farmland with drains and gullies. The gully was lengthening upstream until the moment a structure was built to stop the headcut from moving. (A headcut is the sudden change in elevation or knick point at the leading edge of a gully. (Agricultural Research Service, 2013) Too much water energy at this certain point starts erosion and makes the headcut move upstream. Then the gully will expand, resulting in damage over an increasing area.) The concrete structure that is built to stop the headcut of gully 1 is marked with a purple outline in figure 25.

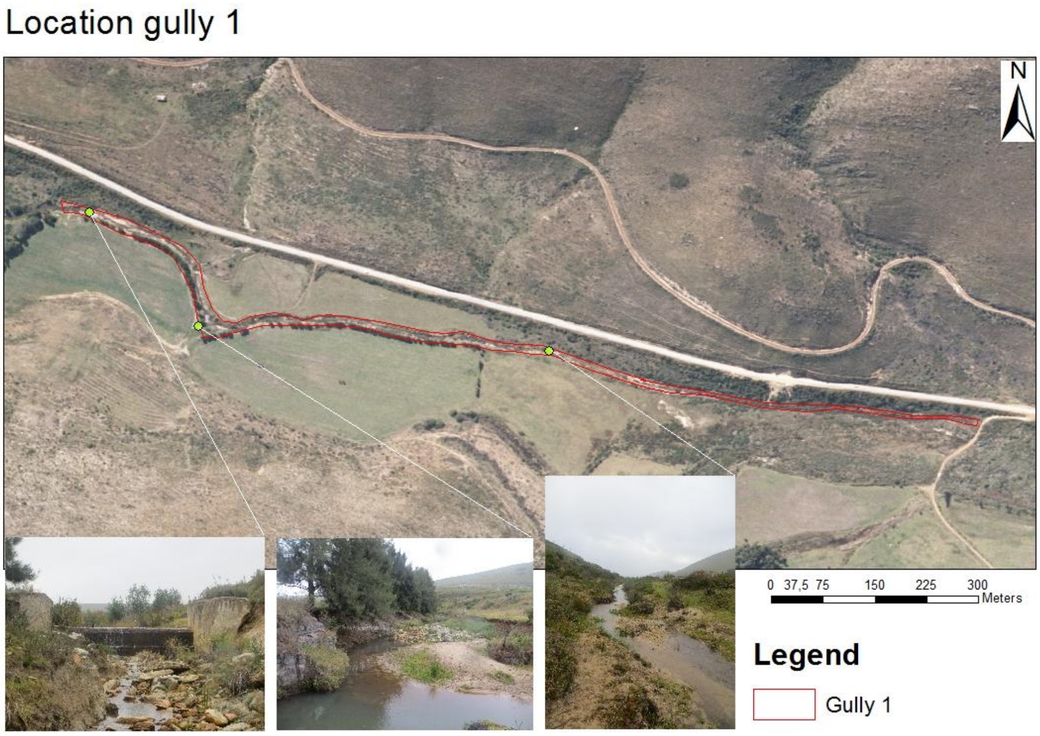

Figure 23: Location Gully 1
Source: Author's work

Despite the fact that the headcut of gully 1 stopped moving, this western area of the wetland still does not work as a healthy wetland, like it once did. Transforming this area back to a Palmiet dominated wetland might be realized by building another hydraulic structure in the flood plain. A hydraulic structure should rise the water table and force the water to flow over the whole flood plain instead of only flowing in the current channels. The green circle in figure 25 shows a potential suitable location for a structure. Water from the tributary and the Kromme itself should be dammed when a structure is placed in the green circle. The water level will rise and could create new appropriate conditions for wetland vegetation. Furthermore, the structure traps sediment, which will slowly fill up gully 1. Lack of bed rock as solid foundation is the reason a flexible structure instead of a concrete structure will be the most proper solution to realize a new wetland environment in this area.

Potential location for structure to rehabilitate the western part of the wetland

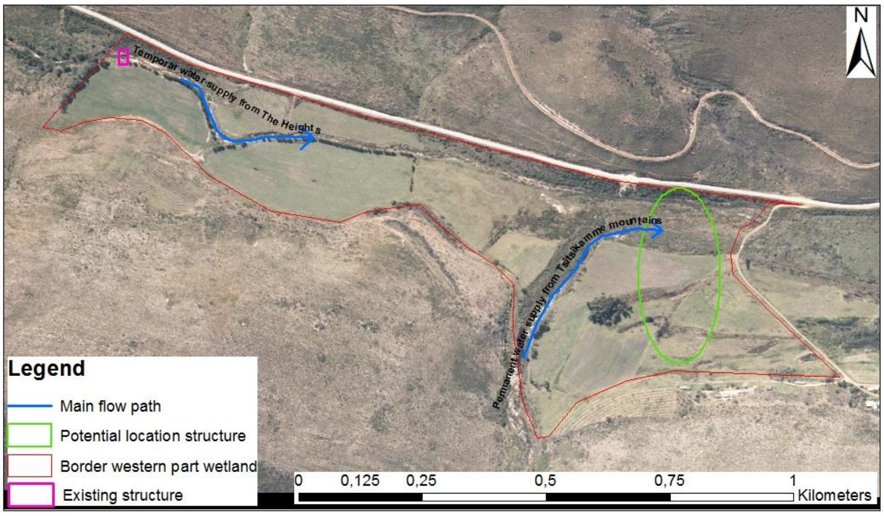

Figure 24: Potential location structure western wetland
Source: Author's work

The most obvious hydraulic flexible structure to build for the rehabilitation is the gabion. A gabion is a structure build up by cages filled with builders. The main goal from the gabions in the Upper Kromme Catchment is to stop headcuts and therefore the control of gully erosion. The headcut just upstream from the gabion structure will fill itself with water, as can be seen in figure 26 on the next page.

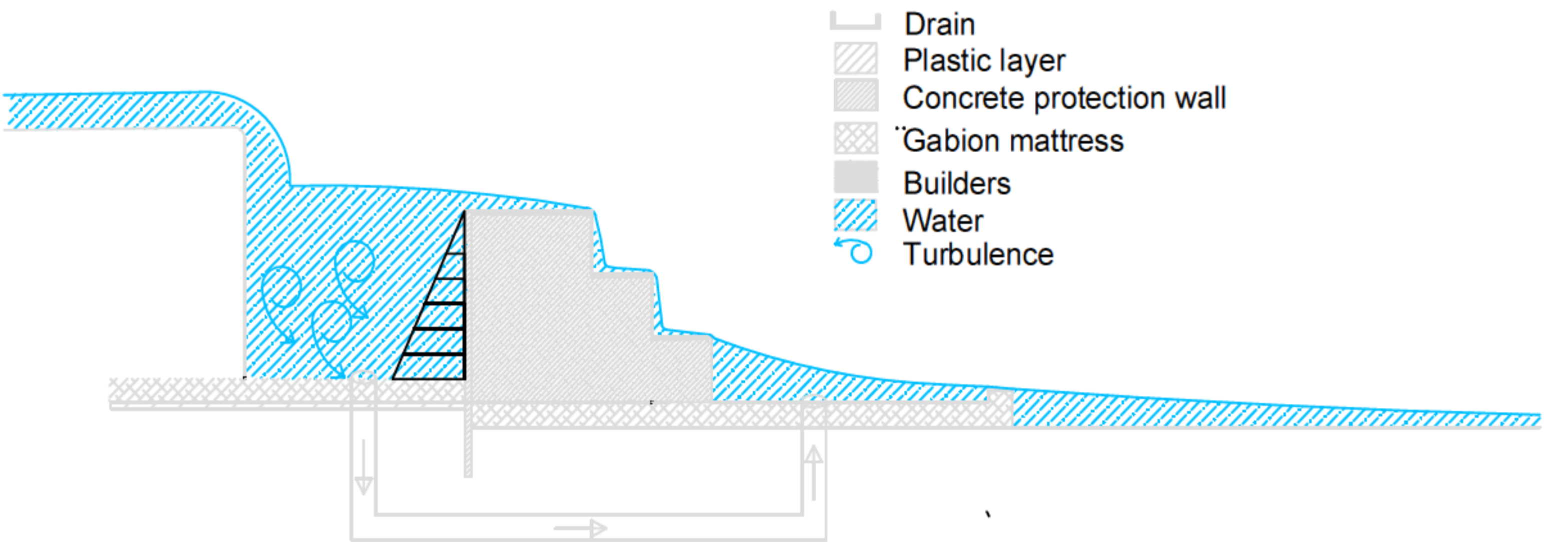

Figure 25: Gabion
Source: Author's work

The gabion slowly removes the headcut by causing sedimentation. In the headcut, water will slow down and lose energy. The water is no longer available to hold the soil together, and this soil will settle down in the bottom of the headcut. This process will counter the process that created the headcut, and in time the wetland is able to restore itself.

Besides the prevention of head cut erosion, gabions could be applied to raise the water level as well. Since the head cut is already stopped from moving in this area the gabion is only needed to raise the water level and to spread the water over the whole floodplain.

Gabions are relatively cheap, simple to build structures. The main part of the structure exists of the builders in a cage made from wire. To prevent the structure from being eroded by water, a concrete protection wall should be attached to the vulnerable parts of the gabion. As can be seen in figure 26, there is a lot of hydrostatic water pressure exerted on the bottom of the water basin. This pressure will make the water find a way to flow underneath the structure, removing the foundation of the structure in this process. This event is called piping. Especially when the structure is built on vulnerable layers as for instance sand layers, the risk of piping is high. To prevent this from happening, a mattress with geo textile could be placed just upstream from the gabion. To remove the massive amount of hydrostatic pressure, pipelines are usually used to let water flow from the one side of the gabion to the other. A gabion structure including these pipelines is presented in figure 28. The black outline in figure 28 shows water coming out of a pipeline and reach the surface as result of the hydrostatic pressure.

Figure 26: Piping
Source: Author's work

Building a gabion structure should be possible in the area marked with a green circle in figure 25. However, to prevent the structure from erosion around it, the whole structure including the concrete protection wall should be built over a wide area since the flood plain is broad here. A structure with a length of at least 150 meter is needed to expand the current area of wetland with approximately 20 percent. Over the past twelve years, 11 large gabions and structures have been built at a total cost of more than ten million South African Rand. (Rejoice Mabudfhasi, 9th November 2013) A rough estimation revealed that a gabion could be built for approximately one million South African Rand in the Kromme. The suggested gabion for the western part of the study area has to be big, because of the wide floodplain. The total costs for building it would probably be at least one million South African Rand. This expensive investment should create a large area of new wetland. Figure 29 presents a similar situation with another gabion closer to the Churchill Dam, and the created potential area of new wetland upstream of that gabion. In the same figure, the potential area of new wetland that would be created by building a gabion in the western part of the assessment area is contoured red. The big difference in area makes clear how little impact the gabion will have in the western part of the study area. Only a small area is suitable for new wetland in this area, because of the small distance between the new gabion and the already existing concrete structure. Financially is it not feasible to rehabilitate such a small area. There is no other area suitable for building the structure, because the road is directly located downstream of the dam and the tributary is directly located upstream.

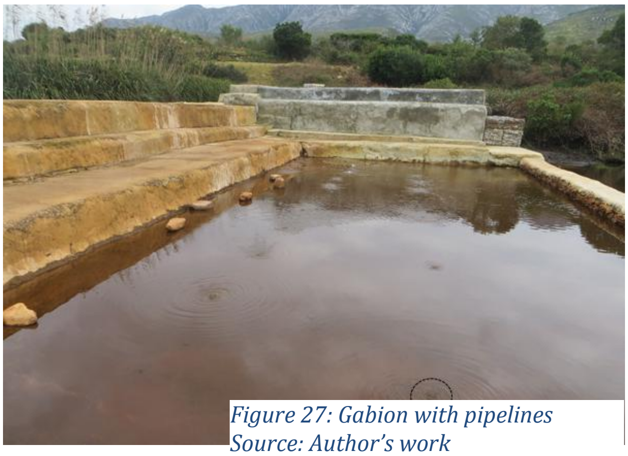

Figure 27: Gabion with pipelines
Source: Author's work

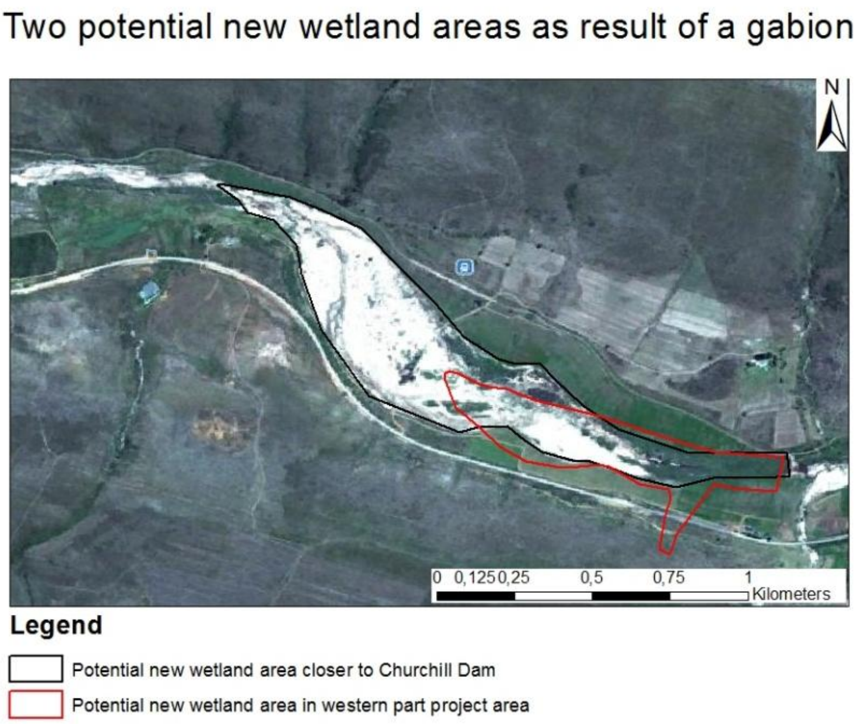

Figure 38: Potential new wetland areas as result of a gabion
Source: Author's work

6.1.1.2 Gully 2

Gully 2 is a heavily eroded area just east of the house of Pierre Oelofsen. For years the river has flowed over a large floodplain and the river deposited sediment in this area due to the vegetation. It is not totally clear whether vegetation loss or climate change might have influenced the amount of sediment in the past. However, it is obviously the building up of sediment in the northern part of the wetland that changed the river course to the south and started the erosion in this part of the wetland. Moreover, the alluvial fan located west of the gully could have steepened the slope in the area of gully 2. Natural reaction is to create a new balance, by reducing the gradient by incising. The last ten years, the gully expanded and moved in southern direction.

The expansion of the gully should be stopped, because an increasing area of wetland will be drained when the headcut moves further upstream. Building a gabion could be a solution, but this situation is comparable with the situation of gully 1. The gabion ought to be built over a large area and the effect of the gabion will not outweigh the costs for building it. Nevertheless, something must be done to stop the headcut from moving. An alternative is to stabilize the slopes of the headcuts in the area within the black circle, presented in figure 30. This option will be less effective, but it is a lot cheaper and with regular monitoring the erosion process could be countered. New vegetation cover on these stabilized banks keeps the soil together. To improve the water spreading over a larger area, Palmiet clusters could be planted on the riverbanks of gully 2. Palmiet clusters in the gully are able to grow towards each other and will cover the gully in a relatively short time. Soils stay together well when it is covered with Palmiet, and during a flood new sediment will be trapped. The gully will be filled up with sediment in time. Whether the erosion of gully 2 is natural or not, the pace of the expansion of eroded areas could certainly be identified as a big threat for the remained wetland area. Stabilizing the headcuts and planting Palmiet is a cheap way to stop this area from further degrading.

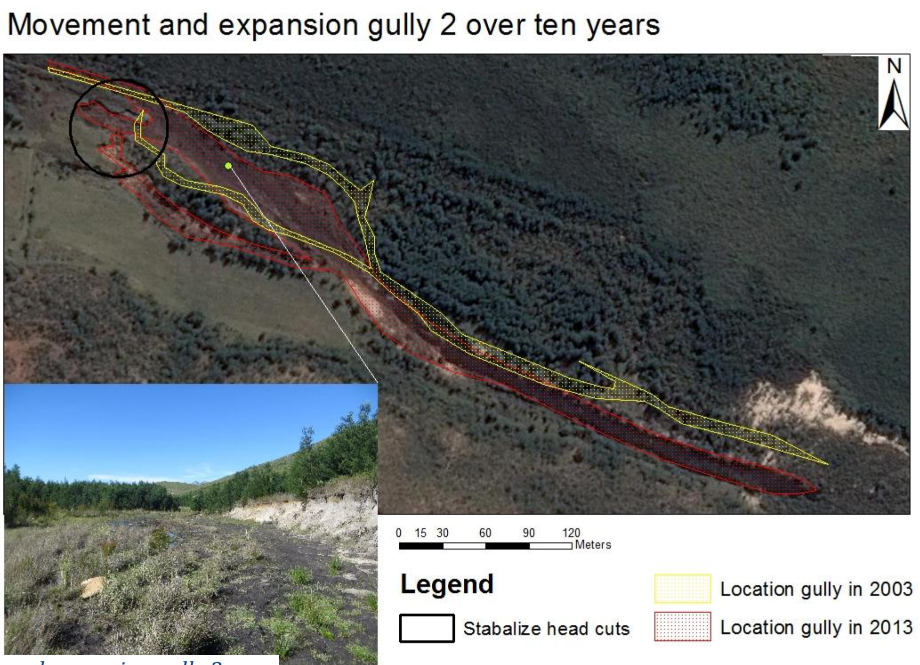

Figure 29: Movement and expansion gully 2
Source: Author's work

6.1.2 ROAD

The back road to Pierre Oelofsen's house crosses the wetland. In general, crossing roads in a wetland create a narrow flow path for the river. Instead of flowing over the whole floodplain, water has to flow through key points such as culverts and bridges to pass the road. In this case, energy of water will not be dispersed anymore but is concentrated to one or a few places, which causes channel incising. Degrading of the wetland is irreversible because the channel lead to erosion processes and lowering of the water table. Moreover, water with a lot of sediment flows quickly downstream and causes problems in lower parts of the river catchment. However, the crossing back road in the wetland is in terms of land degradation not very dramatic. There is not a big difference between the altitude of the back road and the surrounding wetland. This means, in periods of floods the water is not forced to flow only through the culverts underneath the road. As could be seen in figure 31, a lot of sediment is deposited in the yellow circle. This lower part of the road becomes the flow path of the river when the water level is rising. No major channel incising will occur during floods because of the dispersed water energy in this area. Most time of the year, the base flow is easily passing the road by using the culverts underneath the road. Fortunately, the energy of the base flow is not high enough to start heavy erosion.

Regarding the wetland, water should pass the road by using a larger area of the flood plain then is does now. However, different men-made drains, and gully 1 west of the back road, make this not feasible at the moment . Before starting with the idea to let the water pass the road over the whole flood plain, rehabilitation of the wetland part west of the back road is needed. It is already concluded that it is not worth to rehabilitate this part of wetland out of a financial angle. The current situation in case of the road to Pierre Oelofsen's farm does neither result in an decreasing wetland area, nor poses serious erosion problems. Based on this information it could be concluded adjustments to the road to improve the wetland situation are not needed.

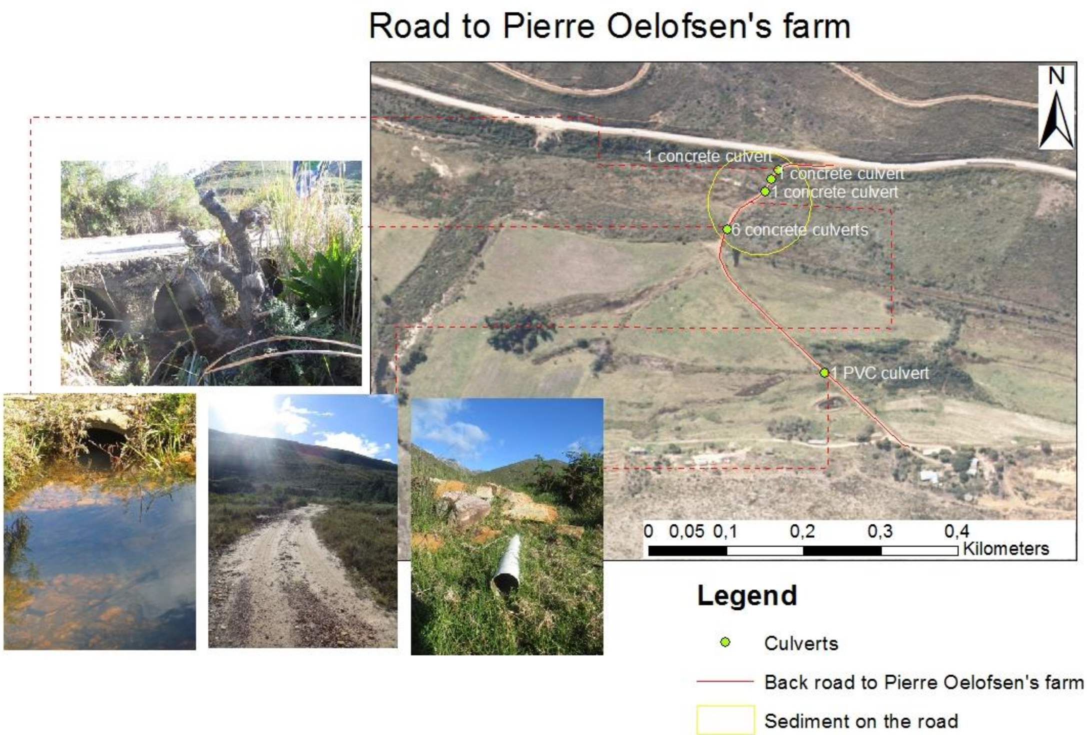

Figure 30: Road to Mr. Oelofsen's farm
Source: Author's work

6.1.3 Alien vegetation

The Upper Peatland Basin is home to three potentially dangerous invasive species. The biggest threat is the Black Wattle tree. Since it is extraordinary fast growing, resistant to fires and able to spread really fast, the Black Wattle is all over the wetland within a few years. The Black Wattle is a problem in a big part of South Africa, and is extremely hard to get rid of.

The only responsible way to get rid of Black Wattle is by cutting them down. Burning them could affect the wetland, and natural enemies of black wattle are only to be found in Australia. Bringing natural enemies to the Upper Peatland Basin would cause new problems, since they have no natural enemies in South-Africa either. When Black wattle is cut down, the remaining stems with roots in the ground have to be sprayed by herbicides to prevent the growing of new sprouts. However, when removing trees, bare ground remains around the stem, because the shadow from the tree prevented other plants from growing. The loose soil that remains is very vulnerable to erosion. Thus, to prevent massive erosion after cutting Black Wattle, it is important to remove only small areas of Black Wattle at a time.

After removal, the bare ground must be filled up by planting new wetland plants directly. This way, the soil is penetrated with roots and erosion will be much less devastating. Furthermore, the branches and stems of Black Wattle are not being removed after cutting it down. Floods will drag the branches and stems downstream where they accumulate somewhere and create some sort of natural dam. However, this dam will not function as a man-made dam, and the water will find a narrow way around the dam of roots and branches, which will cause incising and a drop in the water table. To get rid of all those chopped Black Wattle trees, the wood could for instance be used as firewood for local people. Thus, the three suggested tasks for Working for Water regarding to Black Wattle in the Upper Peatland Basin are:

- Cut all the Black Wattle down, small areas at a time, and spray the remaining stem with herbicides.
- After cutting, remove the roots and branches from the wetland.
- Plant new wetland plants on the empty spots around the old Black Wattle stems.

Another potential threat for the Upper Peatland Basin is Beefwood. Unlike Black Wattle, Beefwood does not grow all over the wetland. Pierre Oelofsen planted Beefwood trees many years ago, next to the river on the eastside of his farm. Back then, experts told him that beefwood was a good tree to keep the soil together and it would be a good idea to plant it. However, about ten years ago Working for Water told him to cut them down in order to restore the wetland. Beefwood might be not as bad as Black Wattle, it still produces a lot of shade and extracts a lot of water. Therefore, Palmiet will not have a chance to grow and the wetland will not be able to restore. Beefwood did not cause the erosion, but its existence will make it impossible to get the wetland back in that part of the Upper Peatland Basin. Beefwood is able to grow in dense groups of Palmiet, but in the Upper Peatland Basin this did not happen yet. To conclude, Beefwood can be a threat, but so far it did not invade the wetland. In order to restore the area where the Beefwood grows, one action would be cutting down Beefwood. However, other measures like planting Palmiet and restoring the riverbank are also needed to restore the wetland there. Since the Beefwood grows in an area which is too expensive to restore (next to gully 1), it is not necessary to cut them down.

Kikuyu grass invaded the wetland by outcompeting indigenous grasses. This replacement causes no problems for the wetland. The farmers are pleased with Kikuyu, since it is a good species for grazing. The Kikuyu grass is very aggressive, but unable to compete with Palmiet or other big wetland plants. Since Kikuyu is not competing with wetland plants in the Upper Peatland Basin, it is not necessary to remove the grass.

6.1.4 MAN-MADE DRAINS

Next to gully 2, a couple of drains and berms are a serious threat to the wetland in especially terms of water lowering. Despite the clayish peat material which makes it hard to lower the groundwater table, these water channels definitely drain the wetland. Furthermore, the drains in combination with the berms start new and worsen already existing erosion processes by concentrating the water energy to one place. Figure 32 shows how the potential flow path of water in times of high water. This figure makes clear the drains lead a large amount of water to only a few drains.

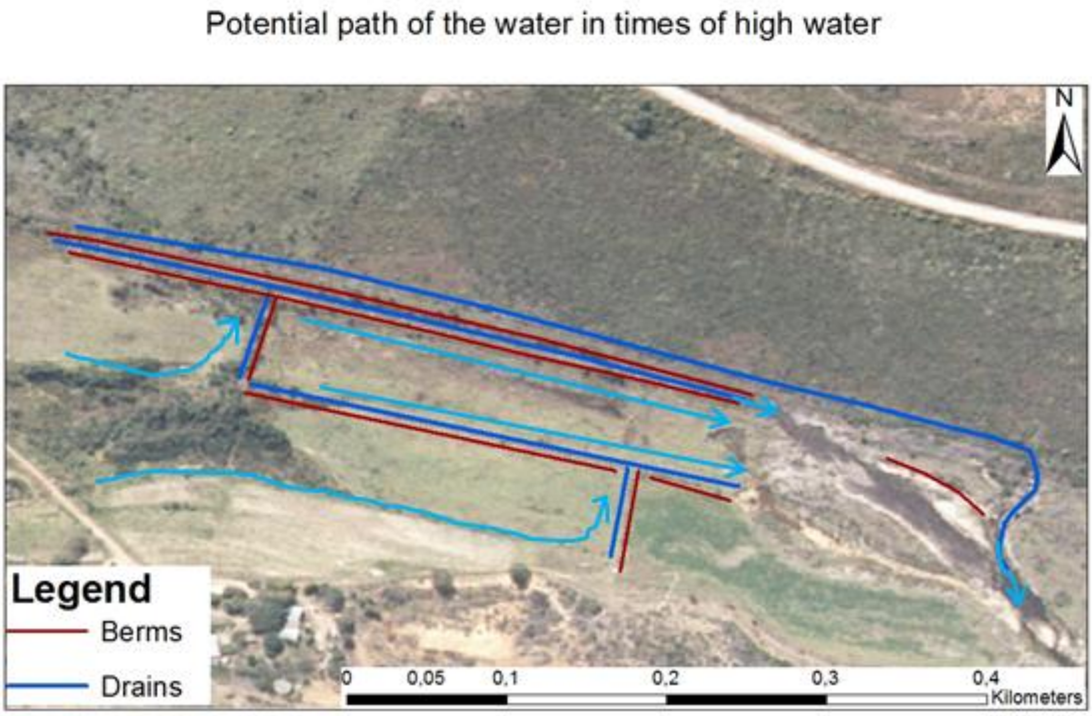

Figure 31: Potential path of the water in times of high water
Source: Author's work

Pictures, depth, width, and the location of the drains and berms are shown in figure 33 and 34. The drains are in general neither deep nor wide. Berms are located next to the drains and can be used to block the drains.

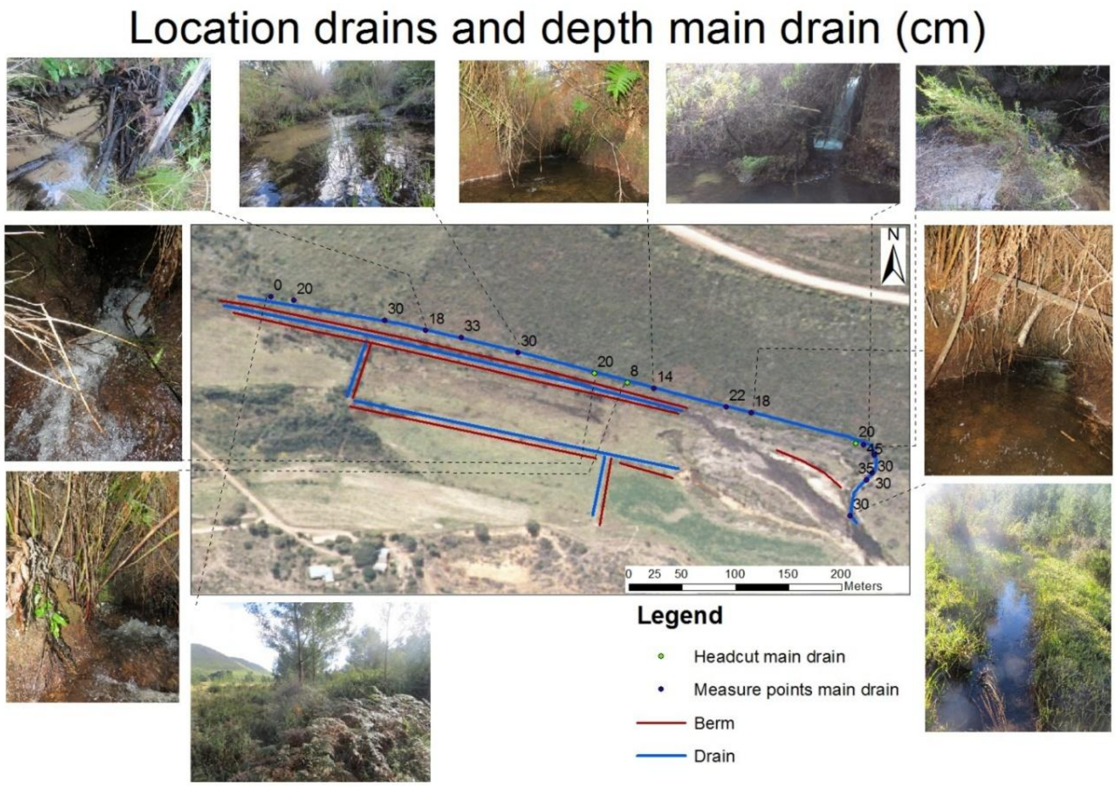

Figure 32: Location drains and depth main drain
Source: Author's work

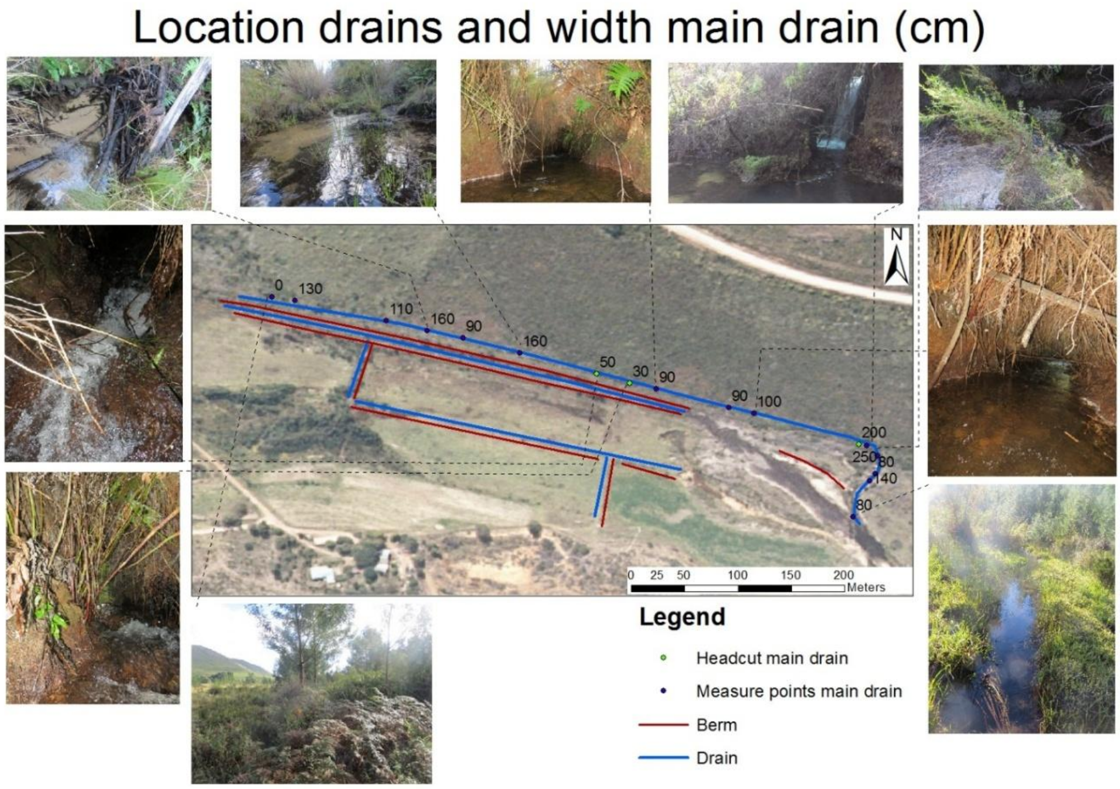

Figure 33: Location drains and width main drain
Source: Author's work

By removing the berms and blocking the drains, the area becomes flatter and water will flow in a braided pattern instead of flow through the drains. The water table should rise, and erosion processes should be countered because of the dispersed water energy. Wetland plants get provided with better environmental conditions and start to take over. A good, cheap way to block drains is by placing ecolocks in the drain. Ecolocks are flexible tubes, wrapped with geotextile and filled with sand. Three of those tubes will be placed at the bottom of the drain, two will be placed upon them and one on top of them. To make this solution effective, an ecolock should be placed every 25-50 meters. See figure 35 for a cross section of ecolocks.

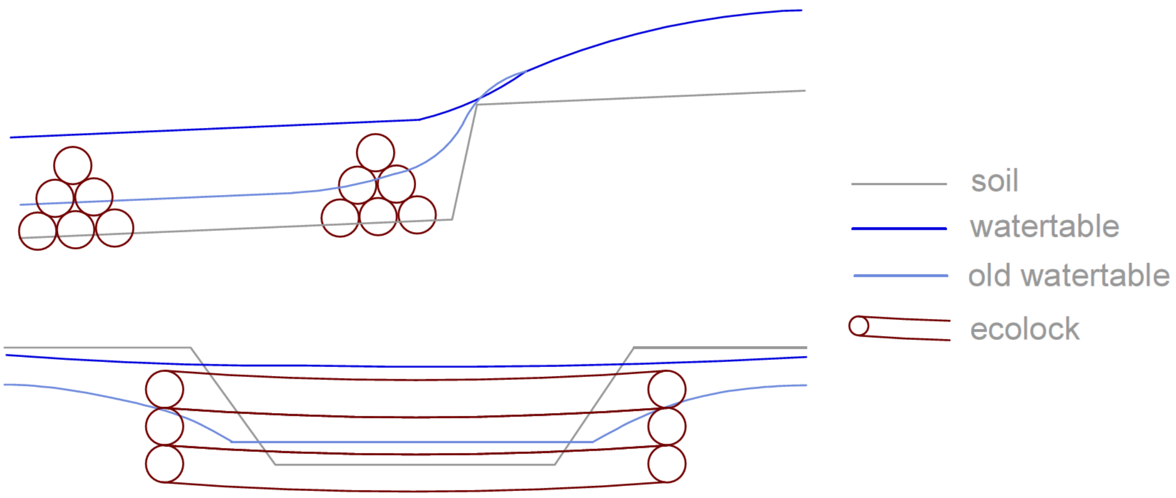

Figure 34: Ecolocks
Source: Author's work

The short distance between the ecolocks prevents headcuts from further erosion. The soil that is extracted by removing berms can be used to fill the ecolocks. The rest of the soil can be used to fill the drains and gullies in the wetland. This is a low-cost, sustainable solution to transfer the wetland from a rough, drained, bubbly area to a smooth one.

6.1.5 LIVESTOCK

Conversations with Pierre Oelofsen and Dennis Ferreira revealed that they are not able to keep the livestock out of the wetland at all times. Despite the law, grazing could still be a cause for wetland deterioration in reality. Moreover, livestock could damage the suggested measures as stabilizing the river banks, planting Palmiet and placing the ecolocks. To prevent the wetlands and the suggested measures like ecolocks from trampling, fences could be placed to keep the livestock away. However, livestock uses the wetland not only for grazing, but also for drinking water. In consultation with Dennis Ferreira and Pierre Oelofsen, a new place for water storage should be dug if necessary. Digging a drinking water spot in the wetland or close to the wetland causes a lowering of the water table, and therefore oxidization of peat layers. It is recommended to point a site for drinking water more uphill and close to a tributary to keep the drink water spot filled with water.

Fences are accumulation points for everything dragged in the water during floods. A lot of force will be applied on those fences due to the high energy in the water, and due to the fact that everything in the water will bump against the fences. To reduce this force as much as possible, the fences should be placed parallel to the water course. Furthermore, to keep the fences on their place, a good foundation high-quality materials are necessary.

Figure 36 shows a suggestion for the location of the fences. If possible, the fences have to be placed parallel to the water course. To make sure the livestock will not enter the wetland again, the fences ought to surround the whole wetland. To save money fences should not be placed in the western part of the project area, because the wetland here completely disappeared and rehabilitation in this area is not feasible.

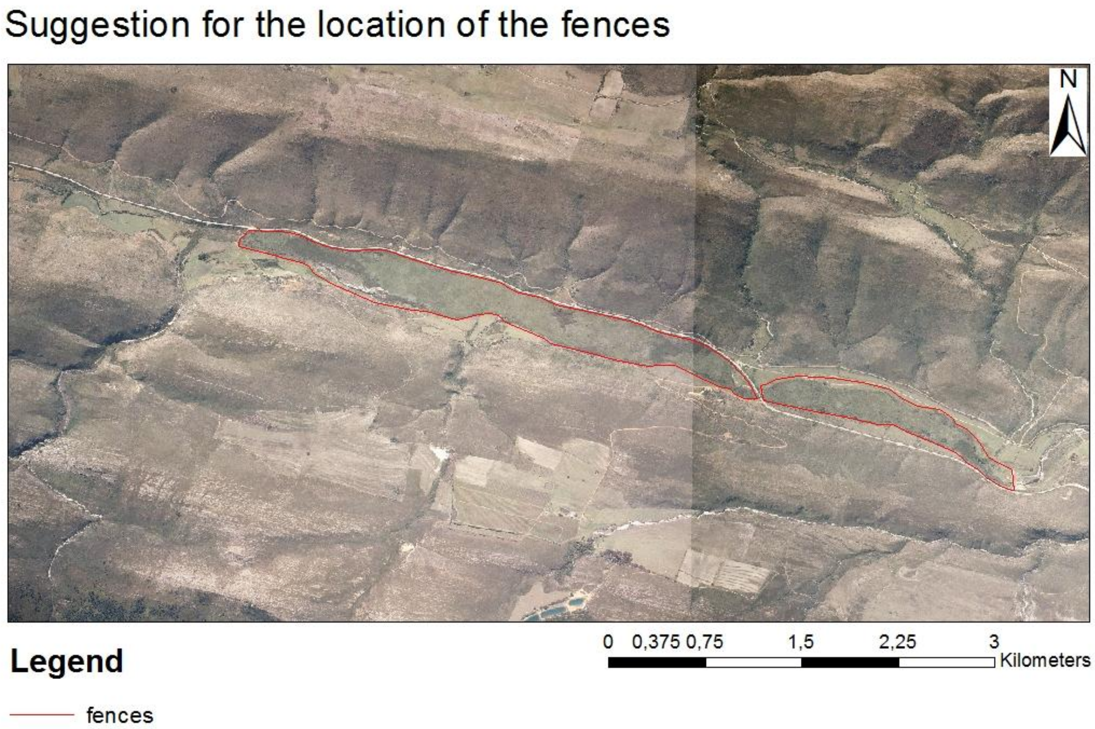

Figure 35: Suggestion location fences
Source: Author's work

6.1.6 BRIDGE

When the bridge was built in the wetland, the wetland became more narrow in the area of the bridge. The map of the wetland shows that the wetland is quite narrow around the bridge, see figure 37. This is of course due to the fact that all the water has to flow beneath the bridge to the other side. However, the wetland is very healthy around the bridge. Palmiet grows in dense groups, and there is no obvious erosion in the area. The only bad part is below the bridge, because there is always shadow. Furthermore, the bridge is part of the R62, an important road for both trade and tourism. The road will remain, because changing its course in order to destroy the bridge is expensive. The area that would be able to transfer into a wetland is quite small, so expensive measures like reconstructing the road will not be taken.

Another option to expand the wetland near the bridge is by placing culverts below the road, so the water can pass the road in multiple streams, instead of only in one stream below the bridge. However, this can cause the foundation of the road to get weaker, which makes the road more vulnerable to crack. To calculate the possibilities of this solution, to build it, and to maintain it is expensive. Thus, the piece of degraded wetland due to the bridge shall remain degraded, because it is very expensive to restore this small area.

Figure 36: Bridge R62
Source: Author's work

6.1.7 TRIBUTARIES

The rainwater from the surrounding mountains flows down into the Kromme River and the Upper Peatland Basin. The steep slopes of the mountains combined with heavy rainfall create a high energy system, which causes erosion. For that, it is expected that the tributaries are heavily eroded when flowing into the wetland. However, the alluvial fans reduced the steepness of the slope by sedimentation, so there is barely any erosion caused by tributaries next to the wetland. This is a natural process, and neither the erosion on the slope nor the sedimentation at the alluvial fans are a threat for the wetland. Figure 38 and figure 39 show the difference between tributaries with a high slope on the hill, and tributaries next to the wetland. Picture 38 is taken next to the R62 and picture second is taken at the border of the wetland.

Figure 37:Tributary on the slope
Source: Authors work

Figure 38: Tributary entering the wetland
Source: Authors work

6.2 MAINTENANCE PLAN

Maintenance is needed to ensure conservation of this wetland. Continue monitoring is necessary to detect new threats to the wetland, and in turn to tackle these threats in an early stage. This paragraph describes recommended maintenance measure to keep a well-performance of the natural functions in the Upper Peatland Basin.

6.2.1 GABIONS AND CONCRETE STRUCTURES

In terms of costs, it is not worth to build new structures in the Upper Peatland Basin because the rehabilitated area would be fairly small. Despite of that, maintenance is important for the already existing concrete structure on the western and eastern border of the project area as well as the gabion on the eastern border of the project area.

At the moment, the three structures are performing very well. To counter the erosion process at the eastern site, a gabion is built. Unfortunatly, the water flowed around and underneath this structure. Therefore, the structure was partly destroyed and it did not counter the erosion proces anymore. As a reaction to the failure of this gabion, a concrete structure is built just upstream from the gabion. The gabion and the concrete structure are both shown in picture 40. The concrete structure took away the high energy of the water, and the two structures combined work perfectly now. There is no headcut upstream from the structures anymore, and the border of the wetland is now exactly where the structures were built. (Personal comment Japie Buckle, May 22nd , 2014) However, it can be concluded that hydrolic structures do not always directly work out the way they should.

Figure 39: Gabion eastern border Upper Peatland Basin
Source: Author's work

The remainings of another gabion, more downstream from those two structures on the eastern border, can be seen in picture 41. This gabion is destroyed by the high energy of the waterflow. At this point in the catchment, the river flows relatively fierce. During a heavy flood, this structure collapsed. The main cause for the collapse was erosion underneath the strucuture, so-called piping. The gabion did not have a mattress below the structure, so the water formed natural pipes below the structure because of the hydrostatic pressure. The ground under the structure flushed away and the structure sank and collaped. (Personal comment, Japie Buckle, June 19th , 2014)

Figure 40: Collapsed gabion
Source: Author's work

Piping underneath these structures as well as erosion around them, are a common problem in the high energy system of the Kromme. Nevertheless, the structure at the western site and the two structures at the eastern site work well at the moment. Maintenance to prevent these structures from piping underneath and erosion around the structure is strictly recommended. It is suggested to monitor the mentioned structures at least once a year. After each flood, a lot of water force is applied on the structures and monitoring will be definitly useful.

Another less common problem which could affect the baskets of the gabion, is the corrosive nature of the water. This could lead to deterioration of the efficiency of the gabion structure. (Mrs. E.H. Haigh et al, 2002)

6.2.2 *ALIEN VEGETATION*

To maintain the wetland, the Black Wattle must be monitored. Black Wattle will always find a way to get back in the wetland, so it is important to destroy the Black Wattle at least once every four years in every part of the wetland. The impact on the wetland vegetation will be reduced in this way.

Until now, the wetland plants in the Upper Peatland Basin did not experience any inconveniences from kikuyu, but it is important to check on the Kikuyu from time to time to make sure it does not take over.

6.2.3 *STABILIZED HEAD CUTS*

A relative cheap but less effective way to stop head cuts from moving is to stabilize the slopes of head cuts. This is an advised manner to tackle the problem of gully 2. Stabilizing those head cuts and keep them appropriate against further erosion is difficult. Continue monitoring and restoring shall be very essential in particular the early stages. Seepage and floods will continue weaken these banks, which will start erosion.

6.2.4 *ECOLOCKS*

It is necessary to monitor the ecolocks to detect piping and other erosion processes in an early stage. Measures could be taken if ecolocks start to collapse.

6.2.5 *LIVESTOCK*

To prevent the executed rehabilitation measures from overgrazing and trampling, fences around the wetland are recommended. Unfortunately, those fences are quickly damaged without any maintenance due to the force of the floods. Material dragged by the water and trapped into the fences should be removed after every big flood.

6.2.6 *AGRICULTURAL PRACTICES*

Palmiet prefers to grow on poor soils, which are washed out of nutrients. In the past fertilizer is used to make the surrounded areas appropriate for orchards. (Farmer Pierre Oelofsen, 19th June 2014) An increasing amount of nitrogen in the soil could have a devastating effect on wetland vegetation and in particular Palmiet. Since all the orchards disappeared, fertilizer was not used anymore. No use of fertilizer in the areas just next to the wetland should have a positive effect to the conservation and the expansion of Palmiet covered spots.

6.2.7 *FIRE*

Fynbos would gradually be replaced by thicket species if it was not for fire. Fire in fynbos is a crucial trigger that resets the fynbos 'successional clock'. Dormant seeds get the opportunity to germinate after a fire, plants in need of sunlight are no longer in shadow of bigger, older plants and are able to grow and flourish. Fynbos should burn once in every 10-14 years to stay as healthy and divers as possible. (fynbos and fire, 2011)The Upper Peatland Basin burns about once every seven years. (Personal comment Pierre Oelofsen, June 19th , 2014) Wetland vegetation is generally sensitive to burning, so the burning frequency has to decrease. However, fires are not easily controlled. At this point, it is important to make sure that no man-made fires invade the wetland.

If the fires are reduced in the future, and there has not been a fire for 14 years, it might be wise to burn the wetland occasionally. However, this should not be happening during late summer or autumn, because then the wetland is very dry and there is small change of flooding. When wetlands are burned in these dry circumstances, recovery takes a long time because fire is more likely to destroy roots and tubers. (S. Holmes, undated) Furthermore, the alien invasive Black Wattle population is very resistant to fire as has been discussed before, so fires will not make the Black Wattle disappear.

As to conclude, it is not recommended to burn the wetland or the area around it to manage the vegetation in wetlands. The wetland already burns too often, it is strongly recommended to try to reduce the fires in the wetland by making it mandatory for everyone to ask permission to appropriate governmental organizations for burning their lands. Only when the wetland has not burned for a long time, one should consider burning the wetland occasionally. Before this happens, wetland experts should be concerned with making this decision.

7 Conclusion

Currently, the function of the Upper Peatland Basin is being threatened. Two gullies are causing oxidization and erosion processes. Heavily eroded tributaries as well as man-made drains and associated berms could threaten the wetland in this way. Another potential problem are the two roads that both cross the wetland. The river is getting a more narrow flow path than it is supposed to have and could be a cause for erosion. To make matters worse, Black Wattle spots are scattered around over the whole area.

All mentioned problems are reducing the well-functioning of the wetland. Feasible rehabilitation should conserve this wetland and improve the implementation and its natural functions. Multiple headcuts should be stopped from moving. The headcuts from gully 2 have to be stabilized to a slope of 1:4 or even more gradual. When new Palmiet spots are planted on these slopes, the chance of collapsing will decrease rapidly. The rehabilitation of this gully will accelerate after tackling the problems caused by the man-made drains and the berms. If the drains are blocked by ecolocks and the berms are bulldozed into the drains, the water will spread over a larger area and the water energy will disperse. Furthermore, a solution still needs to be found for the Black Wattle tree. Chopping a group of Black Wattle trees regularly , spraying the remaining stem with herbicides and removing the chopped parts of the trees is necessary to enhance the wetland's function. In addition to that, new wetland vegetation has to be planted on the bare area around the removed trees. Besides all the suggested measures, it is strictly recommended to protect the wetland against trampling. Fences al around the wetland should keep the livestock away.

Maintenance is needed to make sure this wetland will not disappear and lose its natural functions. One of the suggestions is to monitor the concrete structure on the western border and the two structures on the eastern border of the project area. Piping and erosion around the structures reduced the efficiency of those structures. It is needed to keep monitoring to detect erosion problems as well as degradation of the baskets caused by the slightly corrosive water. The same maintenance could be applied for the ecolocks. The removal of the Black Wattle tree is more labor intensive, because this species always find a way to get back into the area. These trees should be removed at least once every 4 years. Furthermore, It is important to keep monitoring the stabilized headcuts, in order to detect erosion in an early stage. The fences are meant to protect for instance the stabilized head cuts. These fences should be released from all the trapped material dragged by the river. In terms of fynbos conserving, a fire is advised once every 10-14 years. Fires are hard to control, although man-made fires for the aim of grazing can and should be reduced. Monitoring the whole project area after a big flood is certainly recommended, because of the major forces exerted on the wetland.

The mentioned implementation and maintenance measures are not the only option for rehabilitation, but they are strongly recommended for conserving and may be even expanding of the special Upper Peatland Basin in the future.

8 RECOMMENDATIONS

The head cuts in gully 2 are located in a thick peat layer. Before measures will be taken, it is necessary to think about the way these quite solid peat layers can be stabilized. Is it better to add material or to remove peat material for the realization of the required slopes? A ground anchor to keep the stabilized banks on their place is probably necessary.

It is difficult to find the right way of Black Wattle removal. Underneath those trees the ground is bare, because there are no good circumstances for other plants to grow. Cutting all these trees down means that a bare ground remains, which is vulnerable to erosion. More research is necessary to remove the trees in a responsible and effective way.

There should be more knowledge available about the altitudes of the project area, because based on that information more could be said about the current course of the water. In turn, a hypothesis could be established for the effect of particular measures like ecolocks and stabilized head cuts on the course of water. For example, if it is likely that the water from the man- made drains will change its course to gully 2 after realizing the ecolocks, it can be considered not to use these blocks anymore. The aim of the ecolocks is to spread the water over the wetland instead of forcing it into the gully.

A conversation with Dennis Ferreira revealed that his fences could not handle the major forces exerted by floods. Because of those major forces, it is recommended to investigate if it is feasible to place fences in this peat land.

More should be known about the discharges and the water levels of the Kromme river. This information is important to get a better estimation of the water forces applied on the wetland. More effective measures for rehabilitation can be implemented based on this information.

Reflection

It is a pleasure to present this proposal which clarifies the opportunities for rehabilitation of the Upper Peatland Basin. In collaboration with especially Japie Buckle, this plan could be completed. Unfortunately, there was no time left, neither to help the land owner Pierre Oelofsen a lot more with his problem, nor to make the plan even more concrete by the establishment of a cost indication. Besides this, the effort to complete this proposal overlaps the rehabilitation work that is done by the government already.

This project started with the idea to write a proposal for rehabilitation of the Upper Peatland Basin and the idea to help the land owners with their problem. On the one hand, great effort has already been done by writing a proposal for rehabilitation, but on the other hand still a lot of work has to be done to help the land owners of the Upper Peatland Basin. As known, they are not allowed to cultivate or to drain their lands. In other words, Pierre Oelofsen and Dennis Ferreira are not allowed to use their wetland, neither for livestock, nor for agricultural practices. In this case, their own land is not profitable for them in any way anymore. In consultation with Livinglands, landowner Pierre Oelofsen really would like to get help for this problem. Notice, this proposal shows the importance of the wetland and moreover a plan is already finished for rehabilitation. For either organizations or government, it is more attractive to buy this piece of wetland. However, it is not very likely that Pierre Oelofsen will sell his land, since the government is allowed to start and has already started rehabilitation work in this area. Another option could be, to advise him in using his land in a more profitable way by particular farming activities.

A cost indication for the suggested implementation and maintenance measures will make this proposal more concrete. A better view of the different kind of measures and their feasibility will be provided if the costs of implementation and maintenance are known. It will be easier to set priorities if not all measures could be taken from a financial angle. Based on for instance a price-quality ratio, it can be decided whether a measure should be taken or not.

Japie Buckle had investigated the opportunities for rehabilitation in the Upper Peatland basin before the start of this proposal. Despite this, we could make this project more concrete and we could provide Japie Buckle some additional information.

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APPENDICES

- View of the western part of the wetland in current state
- View of the central and eastern part of the wetland in current state
- Kromme River Catchment
- Land use project area
- Vegetation cover project area
- Area Upper Peatland Basin in 1942 and 1999
- Issues investigated in implementation plan
- Location gully 1
- Potential location for structure to rehabilitate the western part of the wetland
- Two potential new wetland areas as result of a gabion
- Movement and expansion gully 2 over ten years
- Road to Pierre Oelofsen's house
- Potential parth of the water in times of high water
- Location drains and depth main drain
- Location drains and width main drain
- Suggestion for the location of the fences

View of the western part of the wetland in current state

Picture in eastern direction

Picture in eastern direction

Picture in eastern direction

Picture in southern direction

Picture in western direction

Picture in western direction

Picture in southern direction

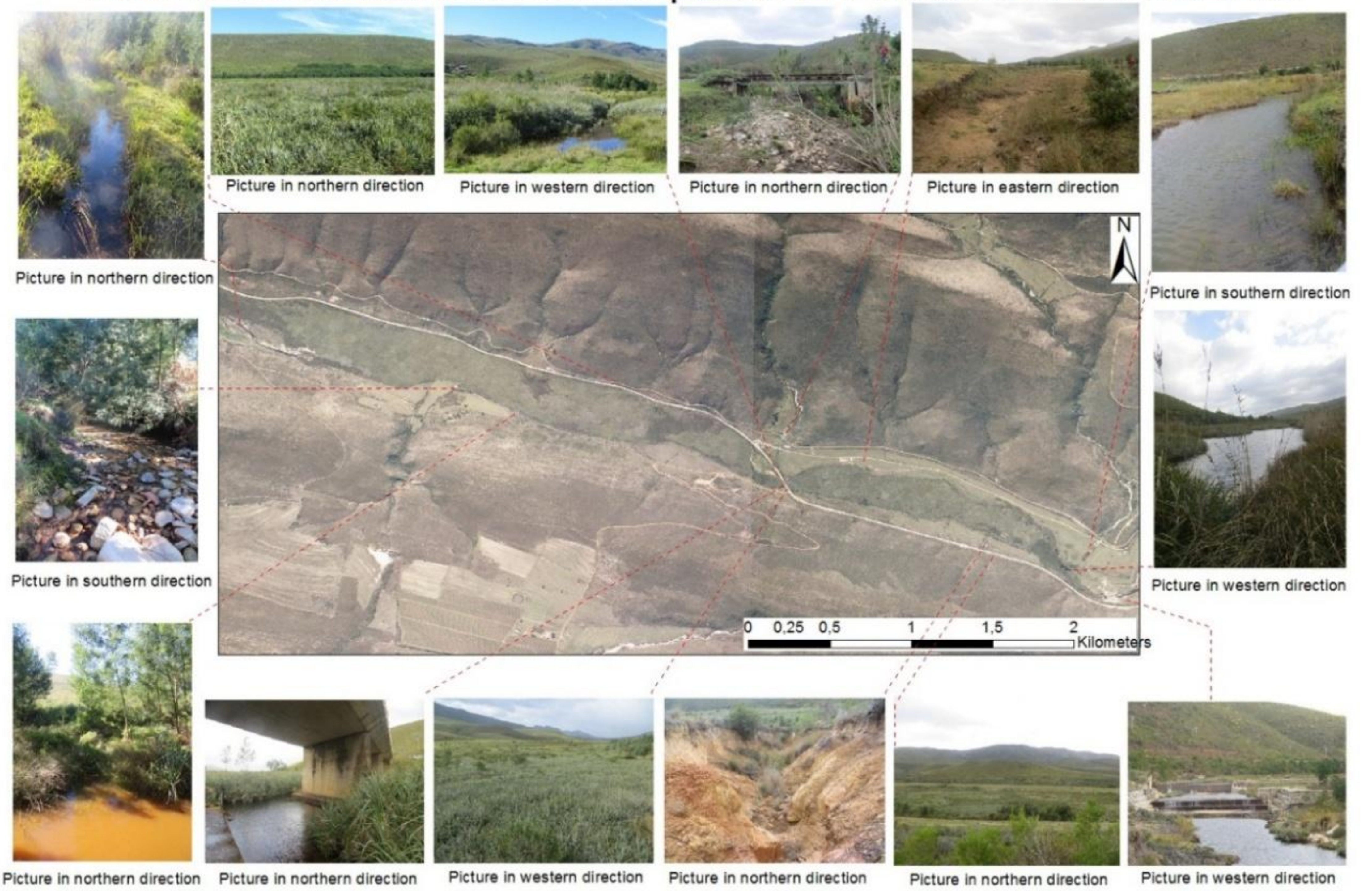
Picture in western direction

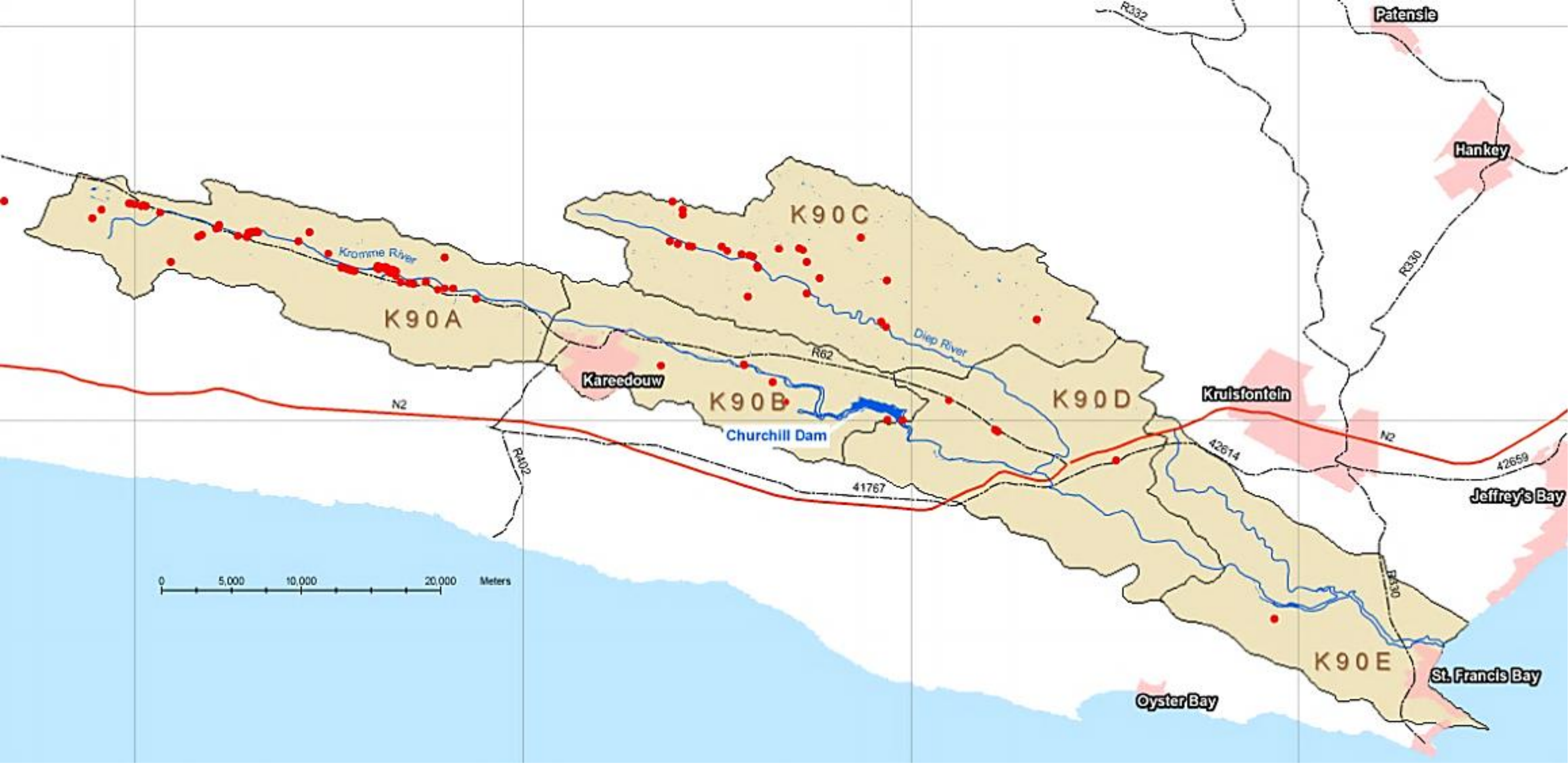
Picture in eastern direction

Picture in eastern direction

Picture in northern direction

View of the central and eastern part of the wetland in current state




Patensie
R332
Hankey
R330
K90C
K90A
K90B
K90D
K90E
Kromme River
Diep River
R62
Kareedouw
Churchill Dam
Kruisfontein
N2
R402
41767
42614
42659
Jeffrey's Bay
St. Francis Bay
Oyster Bay
0
5,000
10,000
20,000
Meters

Current land use project area

Legend

Land use

- Back road
- Concrete structure
- Drain
- Eroded area
- Farm Pierre Oelofsen
- Gabion
- Gully
- High energy water
- Low energy water
- Main road
- Mountain slope
- Pasture
- Sediment deposit
- Tributary
- Water storage
- Wetland

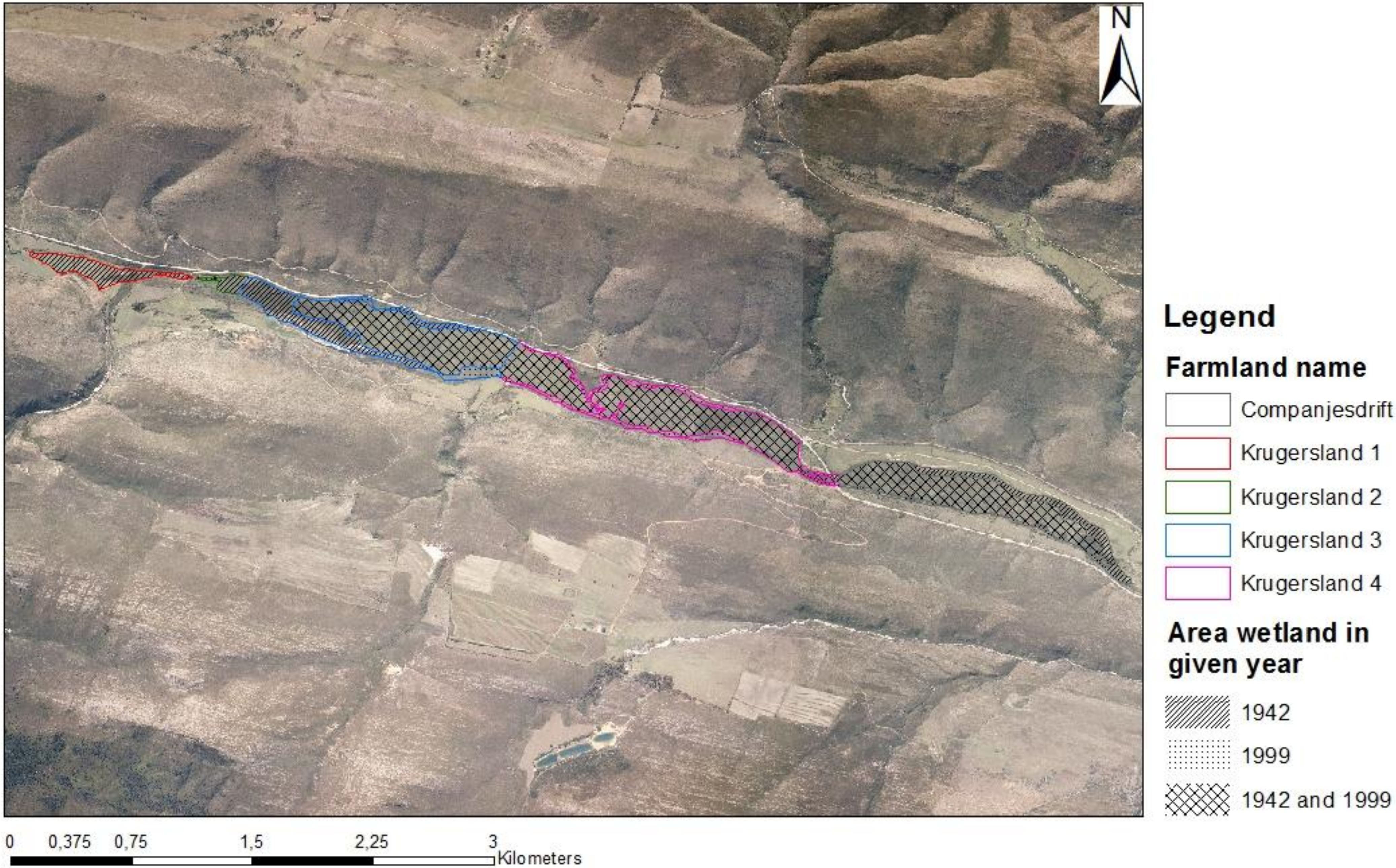
Current vegetation cover project area

Legend

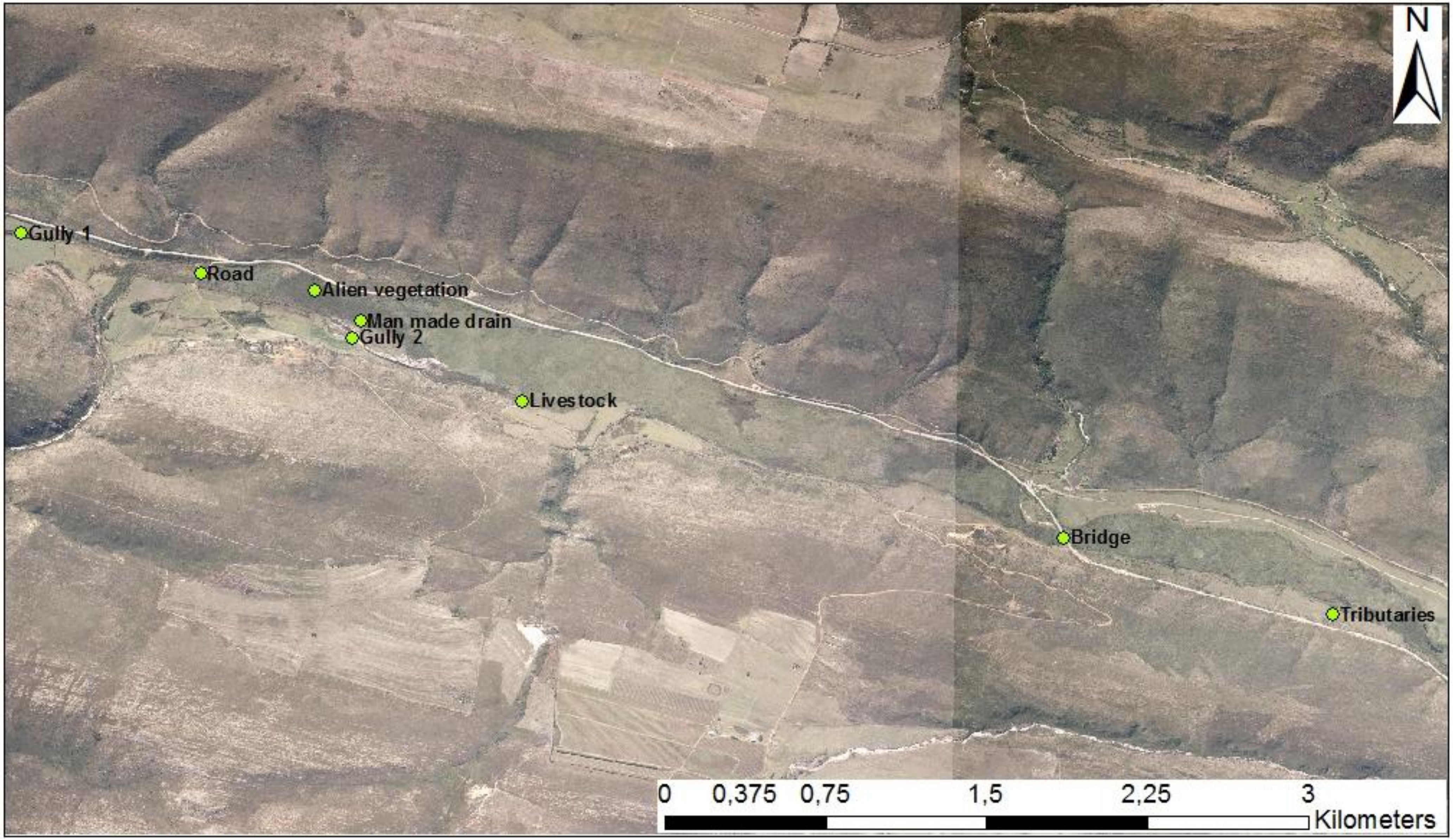
Vegetation cover

- Back road
- Bare area
- Bare eroded area
- Beefwood
- Black wattle
- Concrete structure
- Farm Pierre Oelofson
- Gabion
- Grass
- Main road
- Mixed slope vegetation
- Mixed wetland vegetation
- Palmiet
- Palmiet dominated wetland vegetation
- Reed
- Sediment deposit area
- Water

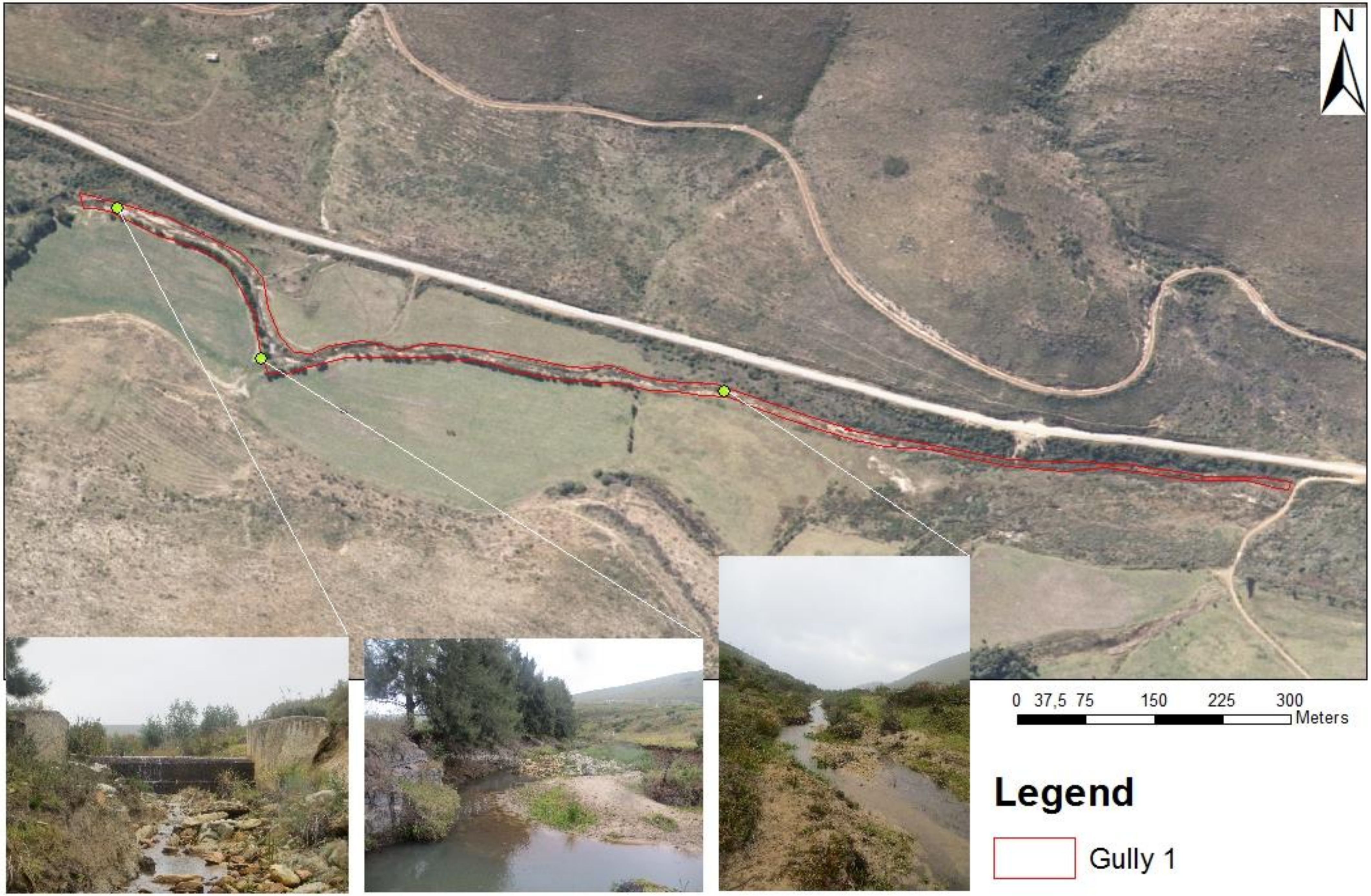
Area peatbasin in 1942 and 1999



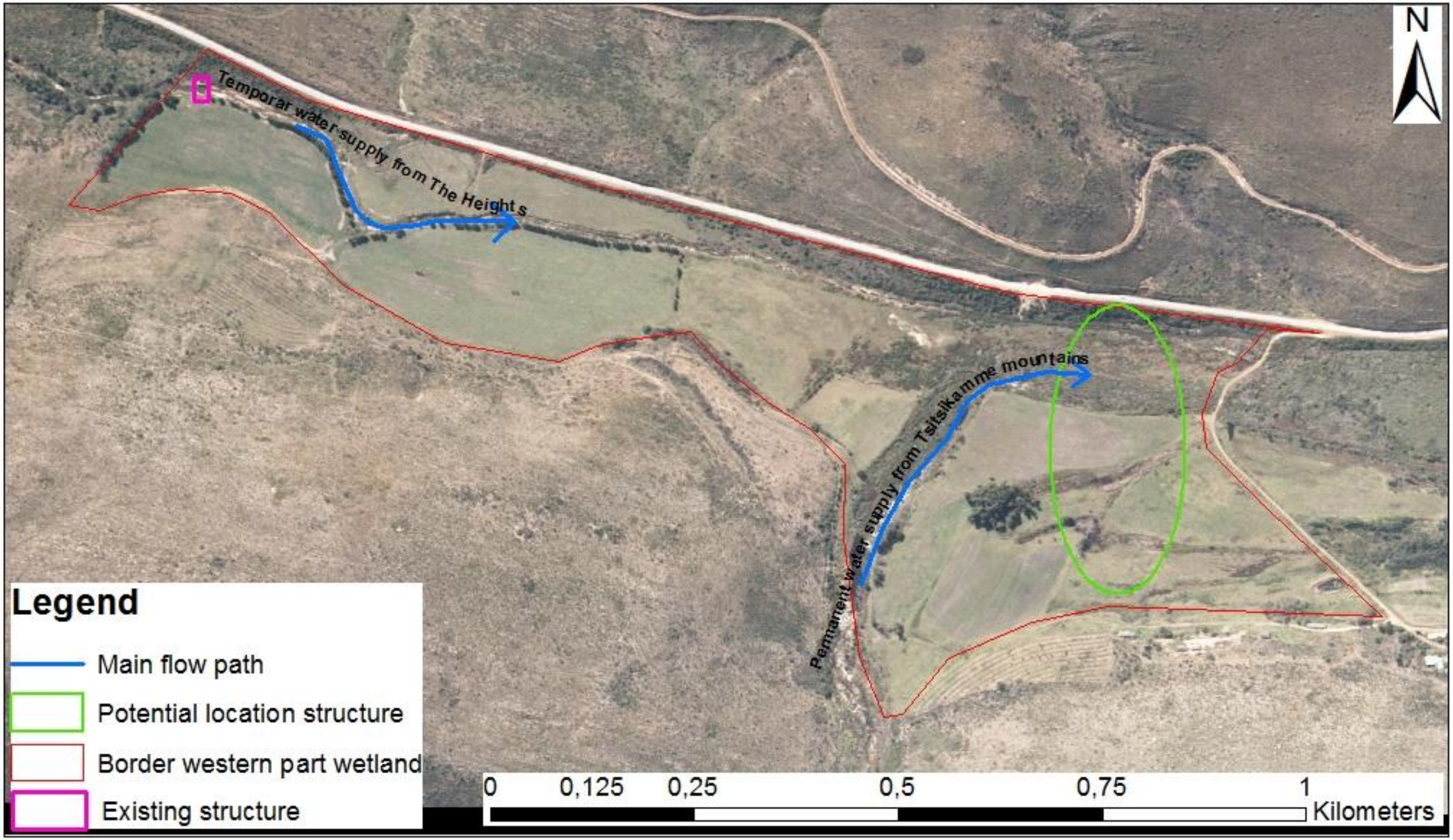
Issues investigated in implementation plan



Location gully 1



Potential location for structure to rehabilitate the western part of the wetland



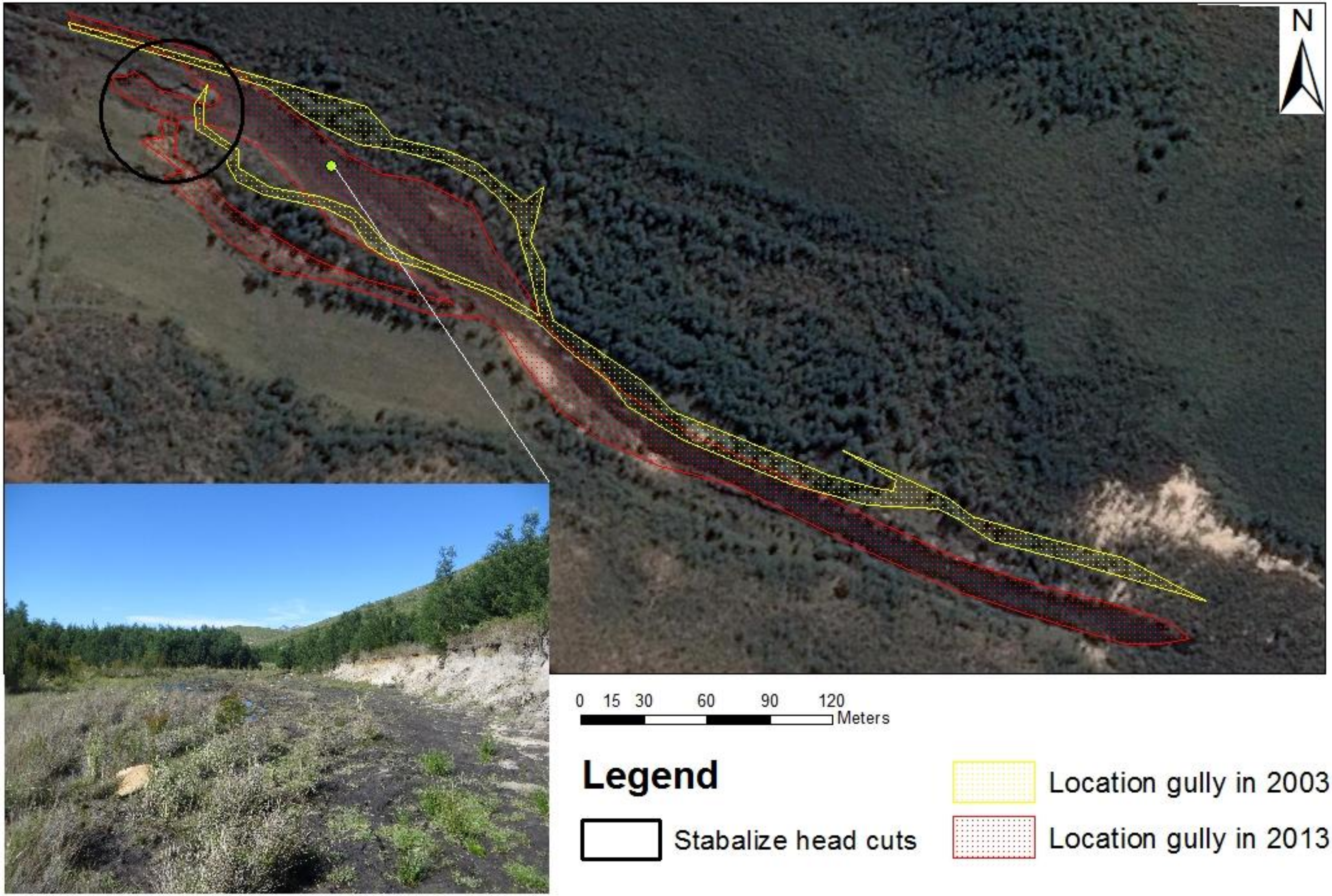
Two potential new wetland areas as result of a gabion

Legend

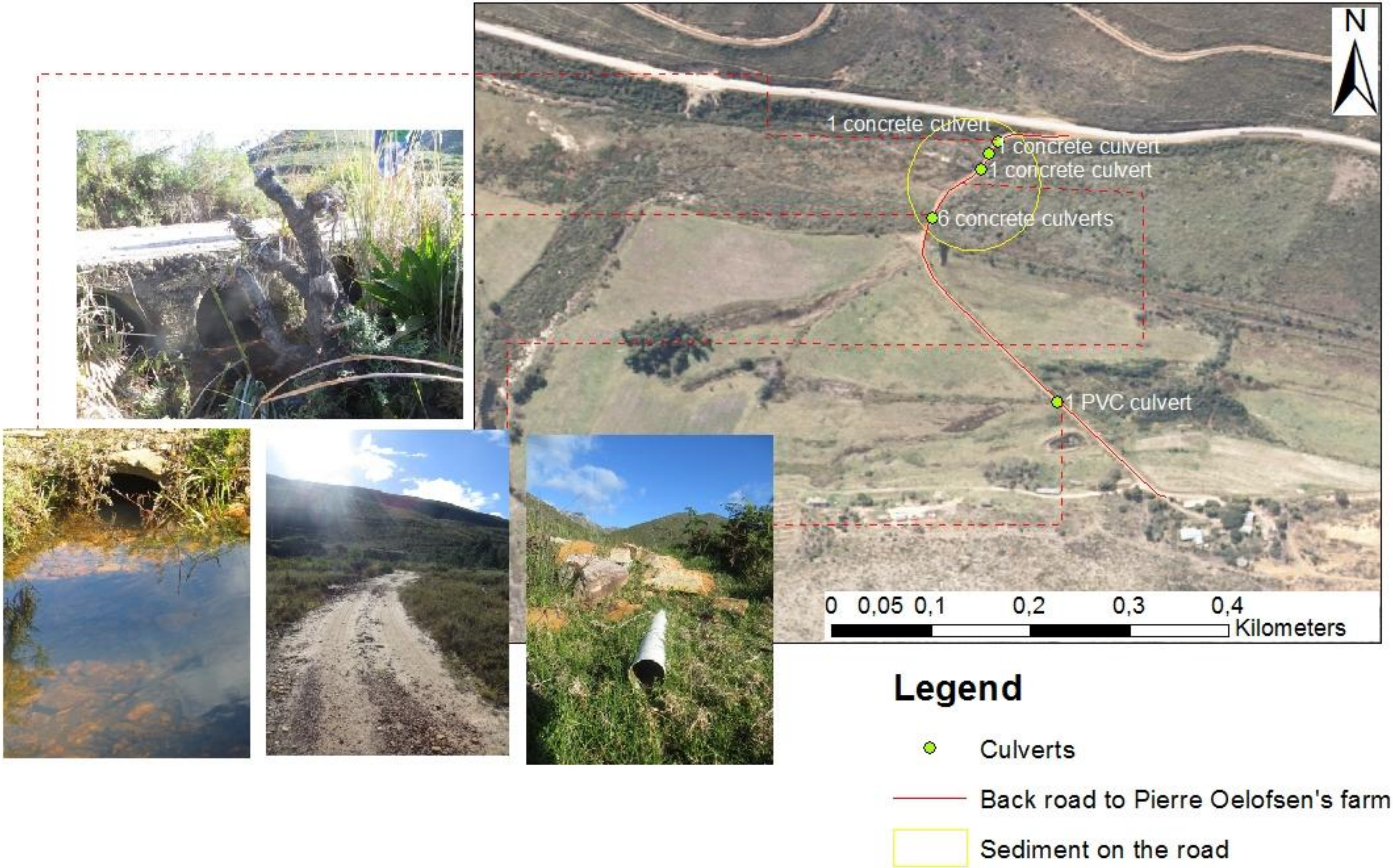
Potential new wetland area closer to Churchill Dam

Potential new wetland area in western part project area

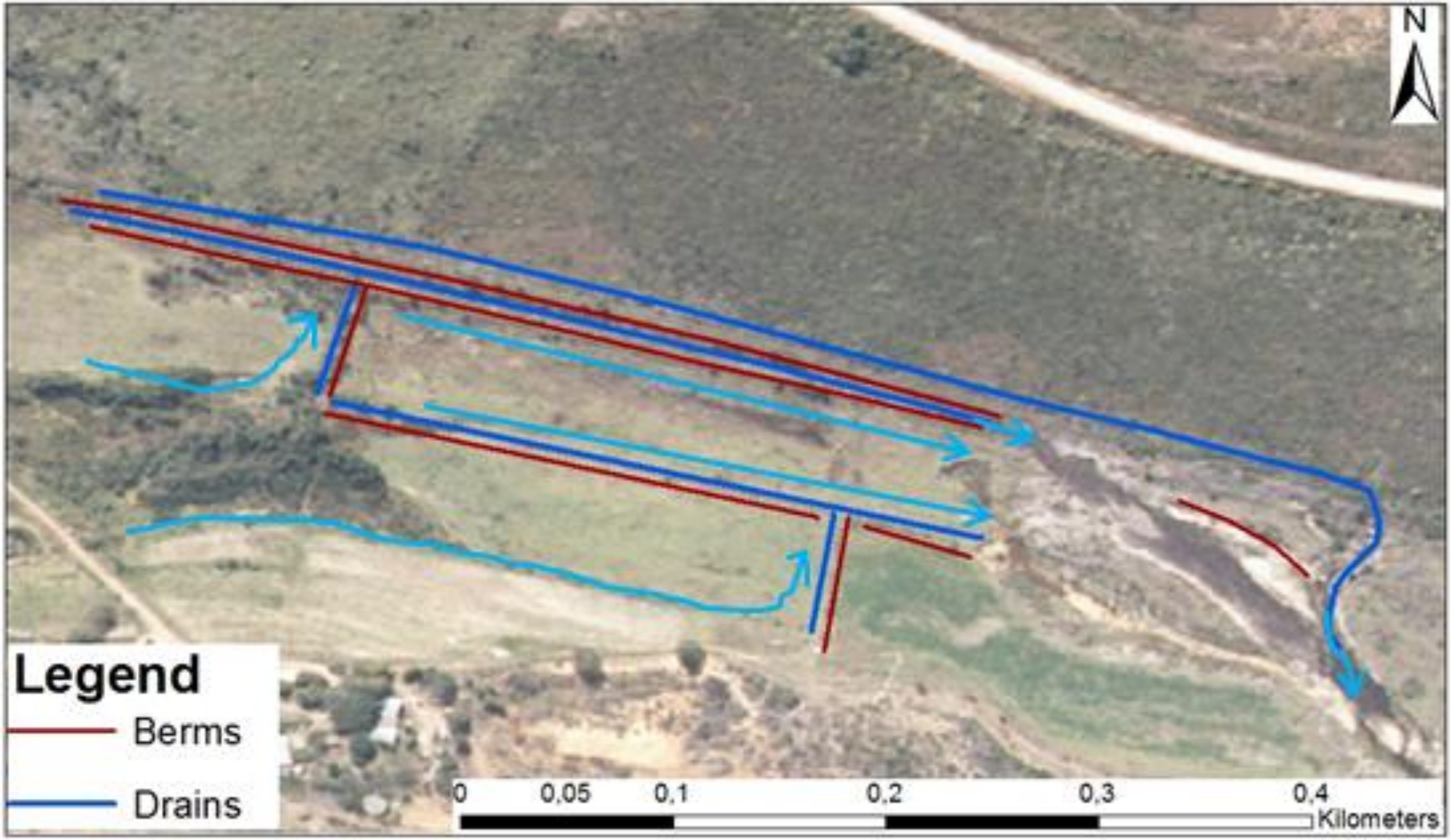
Movement and expansion gully 2 over ten years



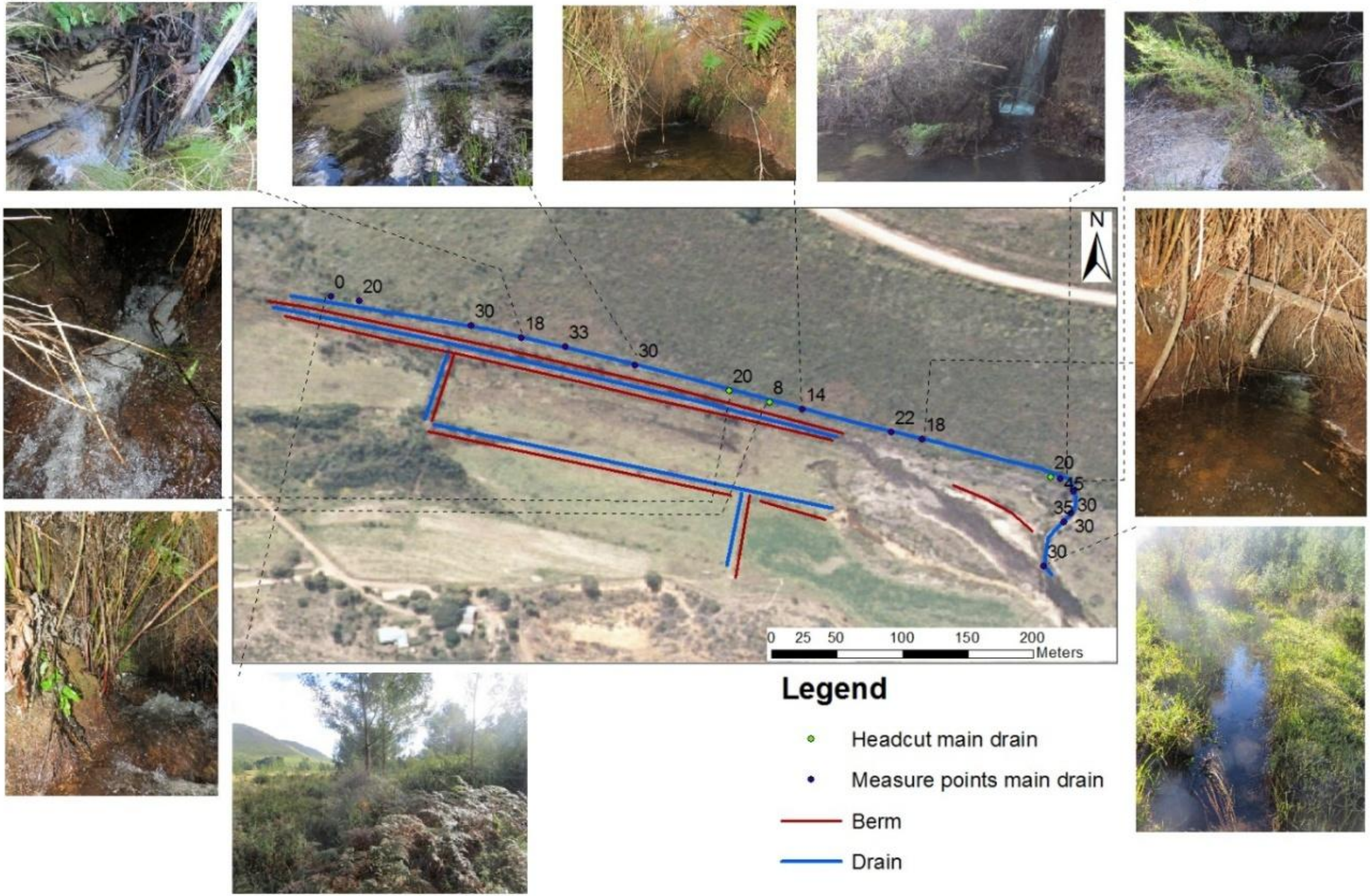
Road to Pierre Oelofsen's farm



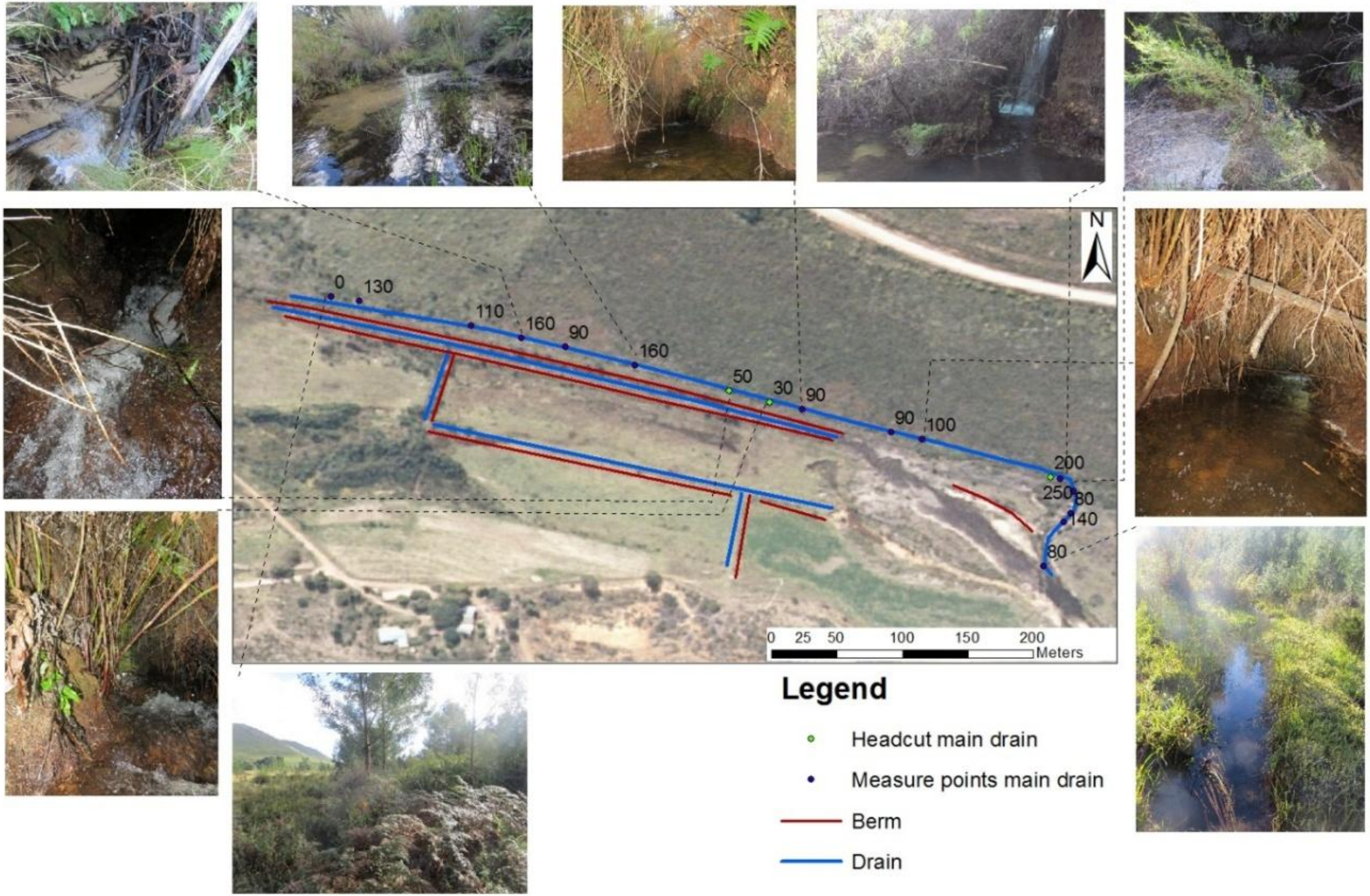
Potential path of the water in times of high water



Location drains and depth main drain (cm)



Location drains and width main drain (cm)



Suggestion for the location of the fences

0 0,375 0,75 1,5 2,25 3 Kilometers

Legend

fences