3.1.2.6 Rietvlei:

i) General description of the wetland site.

The Rietvlei Wetland Rehabilitation project lies within the 3800 ha Rietvlei Nature Reserve near Irene – owned and managed by the City Of Tshwane (Rietvlei Nature Reserve Brochure, 2002). The Rietvlei Dam provides 15% of Pretoria's water and the wetlands on the reserve are regarded as a rare asset (Rietvlei Nature Reserve Brochure, 2002).

The Rietvlei Wetland Complex falls within the Rocky Highveld Grassland zone of the Grassveld Biome, with an average summer rainfall between 600 - 750 mm per annum (Low & Rebelo, 1996). The maximum rainfall for the area occurs during November, December and January (Figure f in Appendix 2) (ARC-ISCW, 2002).

It is underlain by dolomite of the Malmani Subgroup, and it supports (or did historically) various dolomitic springs and with a terrain morphology consisting of undulating plains and pans (Grundling and Marneweck, 2000).

According to Grundling and Marneweck (2000), the peatland complex comprises three distinct sections: the southern and northern peatland basins linked by a central floodplain wetland. Both peatlands can be described as tall emergent (reed-sedge), valley-bottom fens and are located in the catchment of the Sesmyl Spruit.

The Rietvlei peatland complex was dated at 1 290 BP at a depth of 0.23 m and 7 130 BP at a depth of 1.3 m, indicating a peat accumulation rate of about 0.18 mm/year (Scott and Vogel, 1983). The peat can be described as a reed-sedge peat, fibrous to fine grained in texture and with an average pH of 4.5 (ranging from pH 3.5 to pH 8) (Grundling and Marneweck, 2000).

The Rietvlei Dam is located just downstream of the northern portion of the wetland complex and was built during the Great Depression and completed in 1934 (Rietvlei Nature Reserve Brochure, 2002). A smaller dam (the Marais Dam) is located in the central portions and serves as a sludge dam for the Rietvlei dam (Rietvlei Nature Reserve Brochure, 2002). Many smaller seeps and mixed grass / sedge meadows occur in the nature reserve and they feed into the Rietvlei Peatland Complex (Grundling and Marneweck, 2000).

ii) Rehabilitation information.

Grundling (2002) explained the important reasons for rehabilitating the Rietvlei Wetland:

- promotes wastewater purification through the natural systems of reeds and peat;
- addresses the control of alien, invasive plant species;
- protects vital habitats associated with the globally important grasslands biome;
- exemplifies innovation in combating land degradation;
- stems the emission of carbon stored in the peat substrate; and
- creates wetland awareness and education.

This study will only focus on the southern peatland section where the rehabilitation structures have been constructed.

The southern peatland is impacted by:

- infrastructure,
- agriculture,
- sewage outfall,
- peat mining
- water abstraction activities,
- service roads
- power lines
- pipelines

Grundling and Marneweck (2000) documented that *Phragmites australis* and *Carex cernua* are the dominant vegetation species on the southern peatland, and reflect the permanent wet conditions of the peatland. Furthermore they explained that mixed grass / sedge meadows occur on the edges of the peatland and on some of the abandoned peat working surfaces and indicate seasonal to semi-permanent wet conditions (Figure 66).

The grass / sedge meadows on some of the abandoned peat working surfaces suggest that the current vegetation and the distribution thereof may not be a reflection of the historic and natural hydrological regime of the wetland but rather of a system altered and degraded by anthropogenic impacts, especially draining and peat mining, the sewage water outfall and causeways across the peatland (Grundling and Marneweck, 2000). According to a study done by Venter *et al.* (2003), a specific pioneer community dominated by *Persicaria* species established on the rehabilitated ditches and *Cyperus* dominated communities occurred on areas that were mined extensively. These mined areas have not been rehabilitated and no *Phragmites* species occur on them. *Phragmites australis* reed communities, with *Phytolacca octandra*, were prominent on the least disturbed sites (Venter *et al.*, 2003).

Figure 66: The Rietvlei wetland. Previous peat mining activities can be seen in the foreground of the wetland.

Grundling and Marneweck (2000) stated that this wetland was severely degraded by peat mining activities. They furthermore explain the desiccation of the central and southern sector of the peatland as a result of the peat mining and extensive draining of the wetland by a system of drains. The drains, stream diversion and flow concentration have resulted in extensive erosion in the central and downstream section of this peatland (Figure 67) (Grundling and Marneweck, 2000).

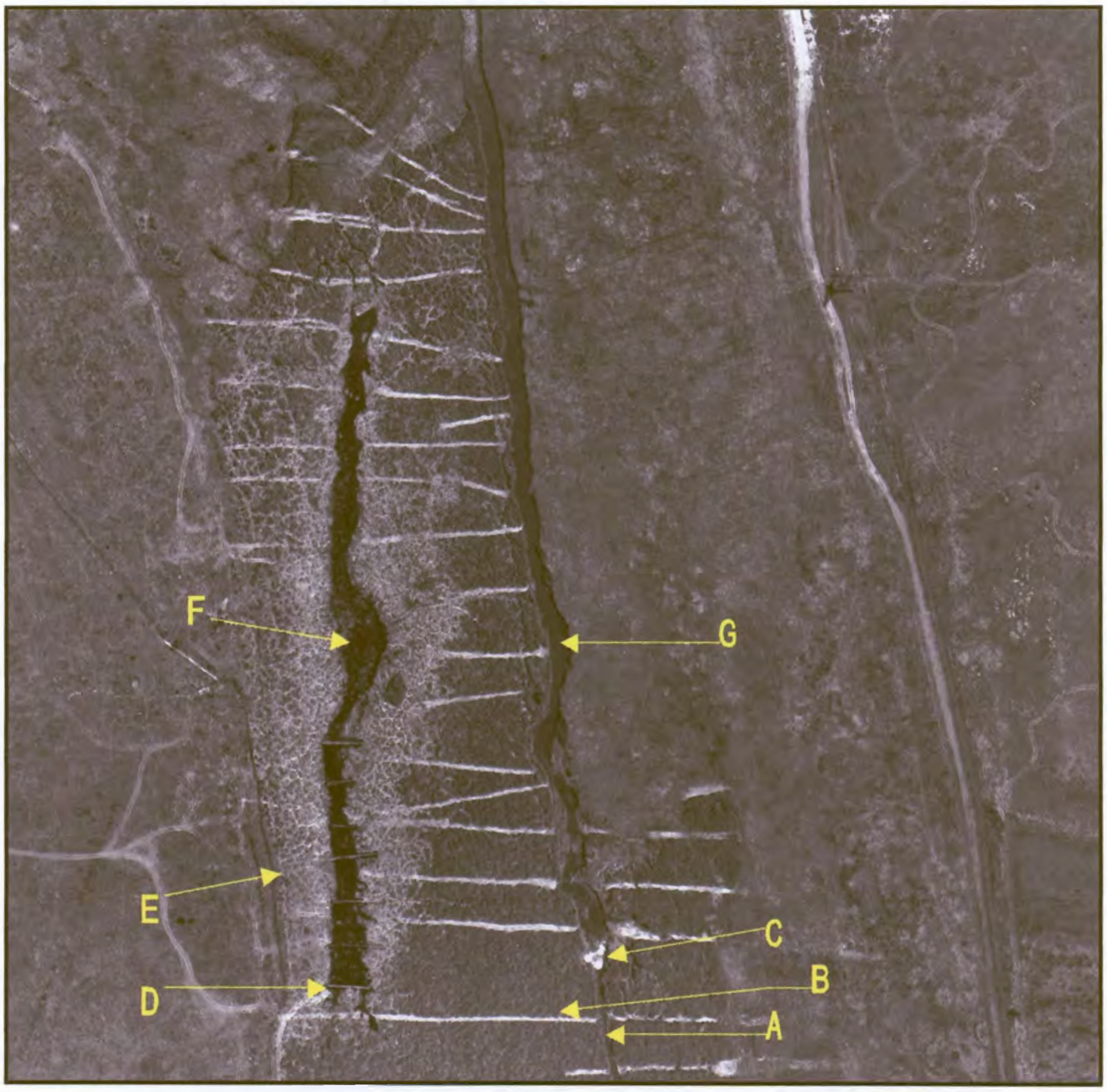

Figure 67: Aerial photograph (2000) indicating remnants of a drain (A) responsible for the desiccation of the wetland. Transects (B) were cut through the Phragmites to be able to delineate the wetland before rehabilitation could commence. Note the headcuts (C) & (D), irrigation furrow (E), shallow erosion feature (F) and donga (G).

The main areas of concern for rehabilitation were summmarised by Grundling and Marneweck (2000) as:

- abandoned peat mining activities;
- water abstraction activities;
- dry peat and peat fires;
- drains and dams associated with the peat excavations;
- drains and irrigation furrows associated with agriculture;
- causeways and erosion associated with the peat excavation and service roads;
- the main stream diversion just upstream of the Rietvlei dam;
- sewage outfall, both quality and quantity; and
- exotic invasive plant species.

iii) Rehabilitation objectives (Grundling and Marneweck, 2000).

1. Restore the original geometry and topography (cross-sectional and longitudinal profile) of the peatlands and the floodplain.
2 Re-vegetation to increase roughness, which has a strong effect on water movement through the system. Using either specified seed mix where appropriate and/or vegetation removed from other stable sites within the wetland.
3. Arrest headcut and donga erosion within the complex and control the preferential flow of water.
4. Re-wetting of desiccated (dry) peatland areas.
5. Sloping of steep slopes and edges of old peat mining work faces and stream channels.
6. Backfilling with wetland soil of drains and trenches in places.
7. Where necessary, regularly spaced culverts (or pillars) should be placed along the roads and causeways in order to limit channeling of water along the roads, backing up of water behind the roads and

desiccation of the peat below the roads.

8. Runoff should rather be controlled and propagation of dormant bulbous species encouraged.
9. The rehabilitation measures should include both ecological and engineering design principles in order to ensure that they are most affected for the purpose they are intended.

iv) Offsite actions required (Grundling and Marneweck, 2000).

1. Impacts also need to be studied on a catchment level.
2. Removal of exotic invasive plant species.

v) Monitoring & Maintenance (Grundling and Marneweck, 2000).

1. The rehabilitation measures which are prescribed should be audited during rehabilitation, and monitored for a period thereafter, until full rehabilitation is assured and stability demonstrated.
2. Monitoring should also include the monitoring of changes in the catchment and the potential impact thereof on the Rietvlei Peatland Complex.

Figure 68: The area between site no. 4 and site no. 5.

vi) Wetland Rehabilitation site details.

Grundling and Marneweck (2000) came to the conclusion that the desiccation in both the southern and northern portion of the peatland complex combined with the concentration of stream flow by causeways, channeling for agricultural purposes and an increased stream volume from the sewage outfall, resulted in erosion and the incising of the stream channels in the wetland. They furthermore mentioned that the erosion problem has been enhanced by the removal of topsoil and vegetation on the slopes of the valley for pot soil mixes. Currently, the higher flow rates as a result of the release of large volumes of sewage water worsen the erosion problem (Grundling and Marneweck, 2000).

Power lines, fences and grazing have had a minor impact on the wetland. However, the large areas of *Populus sp.*, *Eucalyptus sp.* and *Acacia mearnsii* trees contribute to the further degradation of the wetland (Grundling and Marneweck, 2000).

Headcut erosion began as a result of an unattended drainage furrow that was used to drain the peat during the peat mining operation. A causeway was constructed to access the peat mining operation. This compounded the erosion in the furrow by concentrating the water flowing through it.

Figures 69 & 70 describe the wetland rehabilitation site layout details and Table 12 gives a summary of the problems, rehabilitation actions taken and the desired results to attain after the rehabilitation. The photos of each rehabilitation structure (Figure 71 – 85) were taken during the preliminary field visit (26 January 2003).

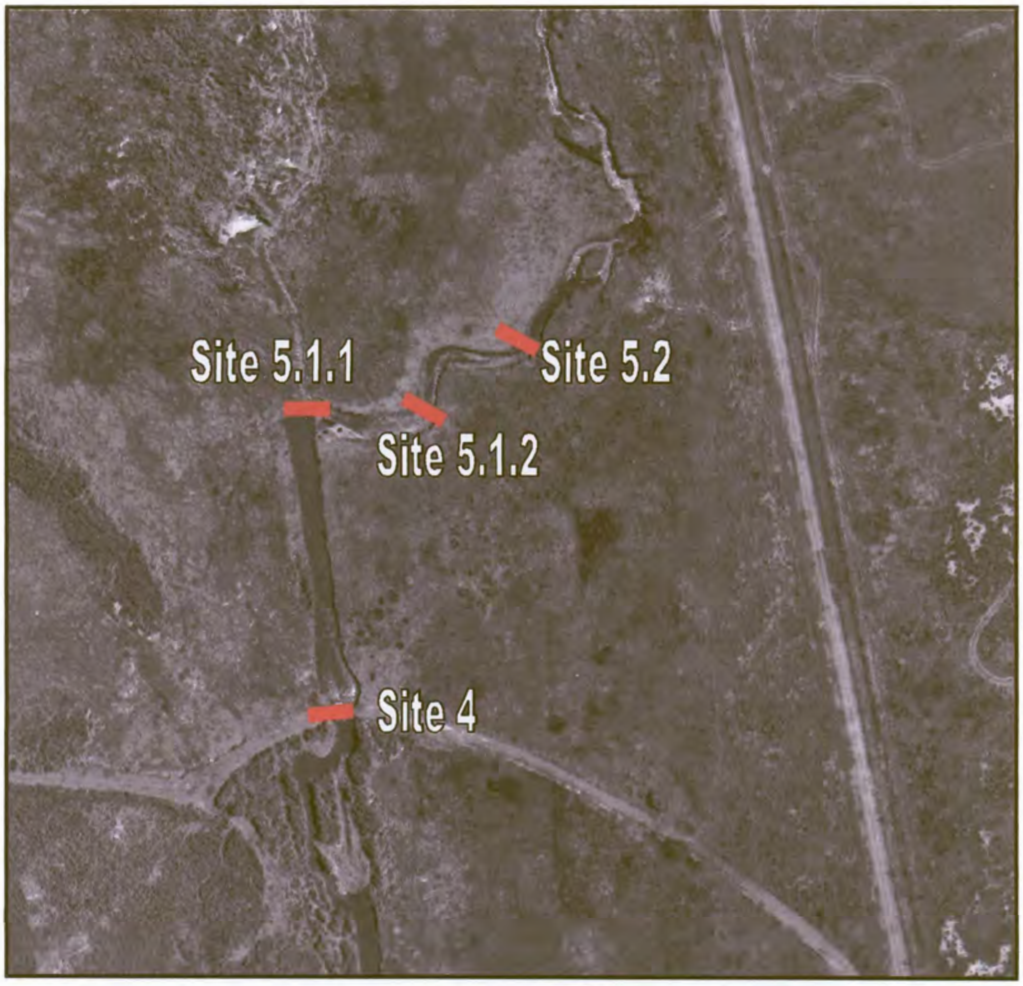

Figure 69: Aerial photograph (2000) indicates the area before rehabilitation was done at sites no. 4 – 5.2.

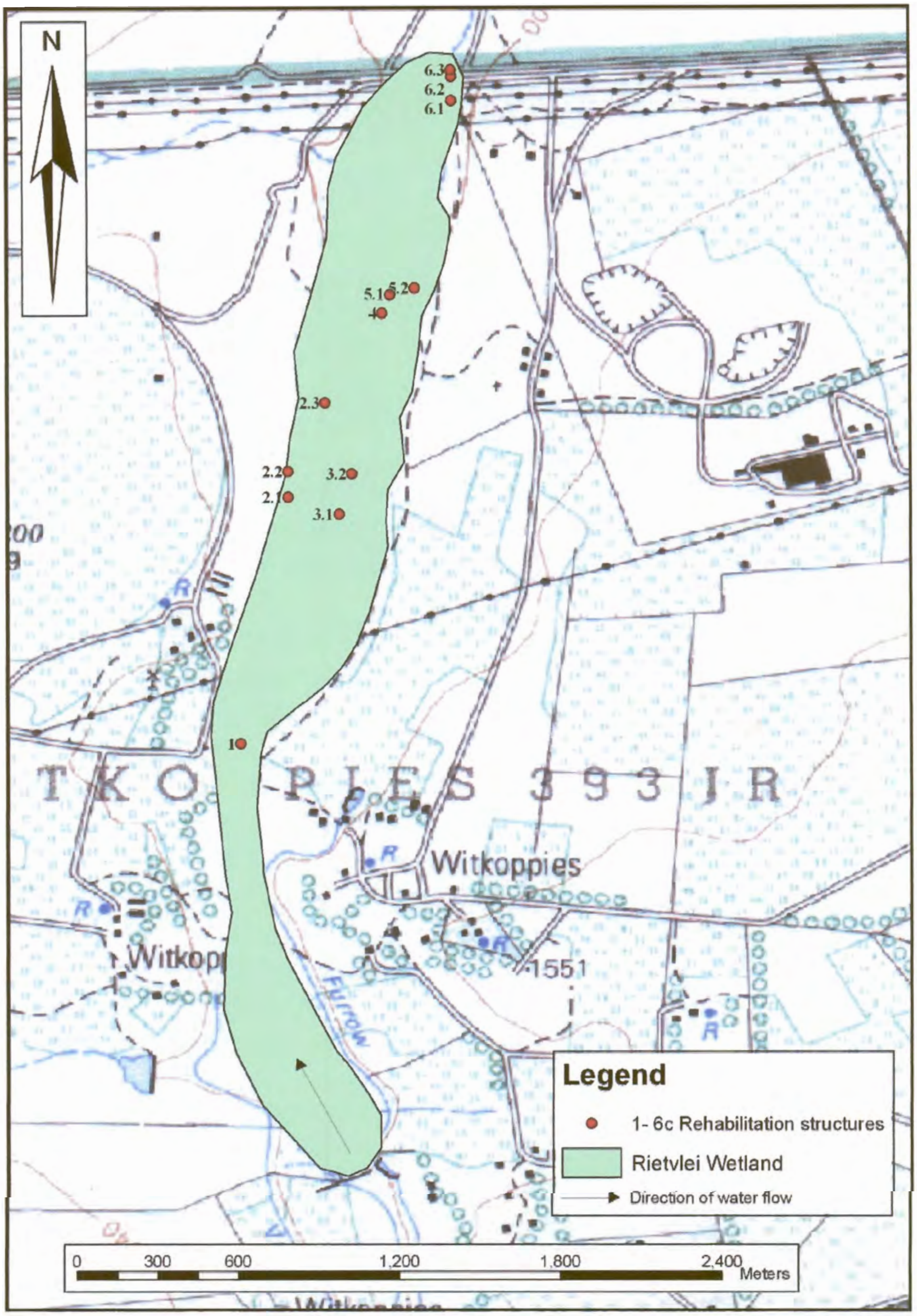

Figure 70: Topographical map (2528CD) showing the locations of the rehabilitation structures.

Figure 71: Site no. 1. A man-made drift was built across the entry point into the Rietvlei Nature Reserve. Due to this the flow of water has been concentrated.

Figure 72: Site no. 1. Energy dissipaters were constructed along the drift to spread the flow and dissipate the energy.

Figure 73: At site no. 2.1 the shallow erosion gully was stabilized with grass bales.

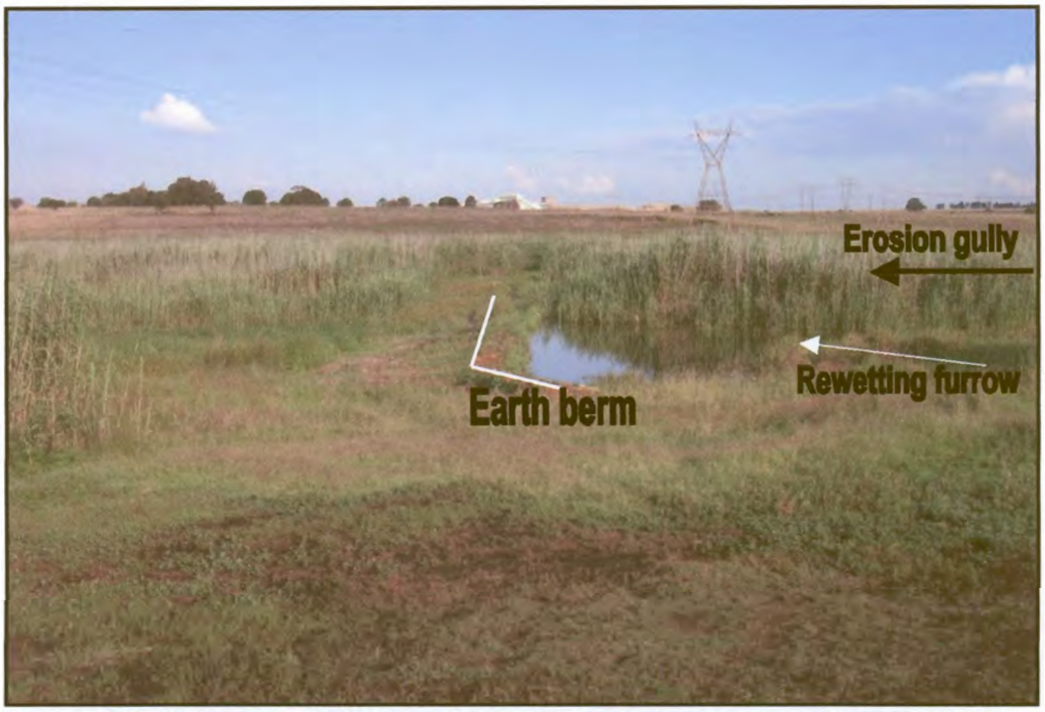

Figure 74: Site no. 2.3. Water damming behind the earth berm at the bottom end of a shallow erosion gully. Re-vegetation of desiccated areas is taking place down-and upstream of the structure.

Figure 75: Headcut and donga (incised drainage channel) at site no. 3.1. The donga sides need to be sloped and re-vegetated.

Figure 76: Site no. 4. Eroded culverts on the road crossing were replaced by a concrete weir.

Figure 77: Site no. 4. A bypass furrow used during the construction of a concrete weir in the causeway was blocked to prevent channel erosion.

Figure 78: Site no. 4. A causeway was applied as a structure to disperse water and to raise the water level in the wetland. Downstream of the structure the erosion was stabilised by using rock packs.

Figure 79: Site no. 5.1. A bypass furrow has been constructed to allow the construction of a gabion weir to facilitate the raising of the water table and to disperse the water.

Figure 80: Construction of a gabion in progress at site. no. 5.1.1. Flooding is taking place.

Figure 81: Site no. 5.1.2. Sedimentation taking place behind the structure.

Figure 82: Gabion structure at site no. 5.2. Note the difference in the water table upstream and downstream of the structure.

Figure 83: Site no. 6.1. Note the higher water table behind the structure. The bent grass on the bank of the channel indicates a previous flooding event.

Figure 84: A drowned gabion structure between sites no. 6.1 and 6.2 due to an increase in back flooding from the structure at site no. 6.3.

Figure 85: Site no. 6.3. The bypass furrow must be closed and the energy must be dissipated to prevent the concentration of water resulting in channel erosion.

3.1.3 Identification of suitable indicators.

3.1.3.1 Kromme River Wetland

1. Decrease of sedimentation downstream of structure.
2. Stabilization of riverbank / donga erosion.
3. Stabilization of headcut erosion.
4. No further infestation of alien vegetation.
5. Recovery of wetland plants on riverbanks / donga.
6. Restore part of the wetland that has eroded away.
7. Higher water table.
8. Monitor the headward movement of the headcut at Kompanjesdrif.

3.1.3.2 Mbongolwane Wetland.

1. Stabilization of erosion.
2. Restoration of wetland vegetation.
3. Wetland vegetation zones.
4. Open water damming and sedimentation behind structures – rewetting of the wetland area.
5. Increasing or decreasing of cultivated areas in the wetland. Determine if cultivation takes place in sensitive areas in the wetland.

3.1.3.3 Wilge River Wetland.

1. Stabilization of the erosion in the wetland.
2. Recovery of wetland vegetation.
3. Wetland vegetation zones.
4. Rewetting of the area behind the structure.

3.1.3.4 Seekoeivlei Wetland (Collins and Thompson, 1996).

1. Monitor the wetland vegetation changes north of the drainage channel as a result of the changes in the hydrological regime of the wetland.
2. Structures must act as silt traps.
3. Stabilization of erosion in the wetland.
4. Open water behind the structure.

3.1.3.5 Zoar Wetland.

1. Re-establishment of wetland plant species. Changes in plant communities as a result of the change in the hydrological zones of the wetland.
2. Stabilisation of the channel erosion in the wetland.
3. No plantation trees in the wetland area and buffer zone.
4. Rewetting of the wetland.
5. Water behind the structures.
6. Sediment behind the structures.

3.1.3.6 Rietvlei Wetland (Grundling and Marneweck, 2000).

1. Re-establishment of wetland plant species. Changes in plant communities as a result of the change in the hydrological zones of the wetland. Figure 67 indicates the area between site no. 4 and site no. 5. Terrestrial plant species have invaded the area. If the structures act successfully as energy dissipaters and re-wet the peat and wetland, then these terrestrial species will disappear and wetland vegetation will dominate.
2. Re-wetting of the wetland.
3. Sedimentation behind the structure.
4. Open water damming behind the structure.
5. Stabilisation of the channel erosion in the wetland.

3.1.4 Remote sensing sensor selection.

In order to evaluate the different remote sensing sensors, a decision was taken that, where possible, at least two different sensor's imagery per wetland will be compared. The issues related to the mapping of the biophysical conditions and utilisation of a wetland are the optimum time of year, the bands required and the spatial resolution to produce accurate maps versus the cost of data and time to process the data. By comparing two different sensor's imagery on the same wetland, the research objective 1.3.3 could be fulfilled.

The Digital Multi-Spectral Video (DMSV) was to be used as one of the two airborne sensors to be evaluated (Appendix 4). However, due to unforeseen circumstances the DuncanTech CIR sensor was used instead.

Landsat images for each wetland were made available for the purpose of this project by the Department of Agriculture. They will be used in the recommendations regarding the most cost-effective procedure for the auditing and monitoring of rehabilitated wetlands. To prevent unnecessary duplication of image collection in an area, Mr. Mark Thompson from Geospace was willing to check their database to see if images were available for the different wetlands. Unfortunately, no images could be used.

3.1.4.1 Kromme River Wetland:

The wetland is a long linear feature in the Eastern Cape. SPOT 5 satellite imagery and Kodak DCS 420 (Near-infrared) are the two sensors to be compared on the same wetland. The Kodak DCS 420 (Near-infrared) sensor is operated by Dr. Tony Palmer, ARC – Range and Forage Institute – Grahamstown (Eastern Cape). The decision to use the Kodak DC 420 (Near-infrared) camera was made to be cost-effective for the project budget as well as to compare single band (Near-infrared) with other conventional multi-colour images.

3.1.4.2 Mbongolwane Wetland:

At Mbongolwane it will be necessary to look at the wetland vegetation, cultivated areas and the two rehabilitation structures. For this wetland it was decided to use Duncan Tech CIR and EROS.

3.1.4.3 Wilge River Wetland:

The main reason for choosing Duncan Tech CIR is because this wetland has only one rehabilitation structure and is otherwise in a generally good condition. The area immediately adjacent to the structure is susceptible to change and therefore it is not necessary to photograph the rest of the wetland.

3.1.4.4 Seekoeivlei Wetland:

The Seekoeivlei wetland in the Seekoeivlei Nature Reserve covers approximately 3 000 ha of the 12 000 ha Klip River flood plain. For this large wetland it was therefore decided to use the EROS imagery to look at the entire wetland system on the Seekoeivlei Nature Reserve.

3.1.4.5 Zoar Wetland:

The Zoar wetland length is 3 600 m and the widest part is 600 m. In order to observe the wetland vegetation it was decided to use the DuncanTech CIR for the entire wetland system.

3.1.4.6 Rietvlei Wetland:

The Rietvlei wetland on the Rietvlei Nature Reserve is regarded as a rare asset in Pretoria (Gauteng). Due to the fact that this wetland was not part of the project in the beginning and because of budget constraints it was decided to make use of an opportunity to piggy-back this project to a flight planned adjacent to this area. The DuncanTech CIR was also used for the Rietvlei wetland.

3.1.5 Identification of optimal time frame for data acquisition.

After some discussions with various wetland and remote sensing experts (Mr. Dirk Pretorius, Mrs. Eliria H. Haigh, Dr. Donovan Kotze, Mr. Mark Thompson, Mr. David Lindley, Mrs. René Glen, Mrs. Lesley Gibson and Mr. Nacelle Collins) concerning the ideal time for image collection it was concluded that there is no fixed date for any wetland. Vegetation peak growth phase in permanent and seasonal swamps is related to the rainy season (Gumbricht *et al.*, 2000). This is typically at the beginning of the wet season as this is just after the onset of rain and the wetlands are the first to become inundated with water and thus experience vigorous vegetation growth compared with the surrounding vegetation (Thompson *et al.*, 2002). Dely *et al.* (1999) and Gibson (2003) re-emphasise this consideration. On the other hand, Whitlow (1984) carried out aerial photography in the dry seasons when tonal differences between dambos (meadow grazing land) and the surrounding areas are enhanced. Van der Linde (1995) acquired Landsat TM satellite imagery during the dry season to establish the locality of peatlands which, if undisturbed, will be wet throughout the year.

Satellite imagery should therefore be acquired at the time of year where there is significant difference between wetlands and the surrounding non-wetland vegetation. The long-term average rainfall data (ARC-ISCW, 2002) (Appendix 2) for each study area suggests the following window of opportunity for each wetland (Table 13):

Table 13: "Window of opportunity" for image acquisition.

Wetland	Sensors	Time frame
Kromme River (Eastern Cape -Kareedouw)	Kodak DCS 420 (Near Infrared) SPOT 5	October – November
Mbongolwane (KwaZulu Natal – Eshowe)	DuncanTech CIR EROS	December – February
Seekoeivlei (Free State – Memel)	EROS LANDSAT	December – February
Wilge River (Free State - Harrismith)	DuncanTech CIR	December – February
Zoar (Mpumalanga – Piet Retief)	DuncanTech CIR	December – February
Rietvlei (Gauteng – Pretoria)	DuncanTech CIR	December – February

3.1.6 Image processing.

3.1.6.1 Classification and identification of indicator classes.

All the remote sensing images were geo-referenced to an ortho-rectified image data set with ground accuracy 15 – 45 m. An unsupervised Isodata classification with 20 classes was done for all imagery. Isodata is an interactive classification method. It repeatedly performs an entire classification, outputting a thematic raster layer and recalculating the statistics. The isodata method uses minimum distance to assign a cluster for each candidate pixel. A second classification was done using the first classification to subset the images. This was done where classes with similar spectral values could not be split from other classes. Subsets of some images were made using a buffer around the wetland to eliminate all the irrelevant data from the images. It was difficult to distinguish between grassland and wetland vegetation in study areas where the image acquisition date was not optimum for mapping the wetland vegetation. Classifications using band reflectance gave better results than band ratio classifications.

A very generalized land cover classification was done for all six study areas. Taking the proposed indicators into account (Table 3), the classification was recorded into seven classes by using image interpretation, namely:

- Erosion / bare soil / harvesting wetland vegetation,
- Sedimentation,
- Open water,
- Wetland vegetation,
- Terrestrial vegetation / burn scars,
- Alien vegetation and
- Cultivation.

Three disturbance indicators were applicable to the six wetland sites namely: *harvesting wetland vegetation*, *cultivation* and *burn scars*. Indicators that have not been used in the classification scheme were: *wet surface area* and *water quality*.

It was evident through the baseline data of each site and the preliminary field visit at each site that neither one of the six wetlands in the study suffered from water contamination, although the occurrences of minor water pollution incidences (such as at Rietvlei) were not ruled out. There has been no record of change in water colour at any one of the six wetlands which made these study sites unsuitable for the testing of water quality. Furthermore the open water areas were too small and shallow and the remote sensing images did not possess a blue band necessary to detect water quality. It was therefore decided not to use this indicator in the classification scheme.

Wetland vegetation reflects the hydrological conditions of the wetland (wet surface area). The reasoning behind this is the fact that the plant species composition changes as a result of the change in the wetland's hydrological regime. Depending on the resolution, wetland plant species and / or groups of plants known as wetland plant communities can be identified. Gumbricht *et al* (2000), documented a pronounced NDVI difference between permanent and seasonally swamps and the vegetation cycle is mainly related to the flow regime of the Okavango River. The wetland vegetation indicator will therefore reflect the wet surface area.

The position of the rehabilitation structures was recorded using a handheld GPS and does not form part of the classification.

3.1.6.2 Description of classes.

i) Erosion / bare soil.

This class included all forms of erosion and bare soil. In some instances unvegetated construction sites and areas of wetland vegetation harvesting were included in this class.

ii) Sedimentation.

This class included sediment deposits in the wetland and behind rehabilitation structures.

iii) Open water.

This class included all rivers, streams and open water areas. It would also include water behind rehabilitation structures.

iv) Wetland vegetation.

This class included the whole range of wetland vegetation, from permanent, seasonal and temporary wetland zones. The image acquisition date was not always spectrally significant in order to distinguish between wetland vegetation and the re-growth of alien vegetation or sugar cane farming.

v) **Terrestrial vegetation / burn scars.**

This class included all forms of natural vegetation including areas that were burned.

vi) **Alien vegetation.**

All forms of alien vegetation are included into this class (including planted plantations, wind breaks and re-growth of removed alien plants in rivers).

vii) **Cultivation**

This class included all commercial and subsistence farming activities. It also included old farmlands and orchards.

3.1.7 Calculation of the efficiency.

3.1.7.1 Field data collection.

The main aim of the preliminary fieldwork (1-10 July 2003) was to establish where the rehabilitation structures were, what problems were encountered and what the desired results of the structure should be. Classification of the different vegetation types at each wetland was made difficult because the preliminary field data were only collected at the rehabilitation structures and not for detailed vegetation mapping. For this reason only one broad vegetation zone could be mapped, namely: wetland vegetation. Rietvlei was the only wetland where detailed vegetation surveys have been done in the wetland zones (Venter *et al.*, 2003).

Field data collection was done before images were acquired and thus not synchronized with the acquisition of the images due to the time constraints brought about by the acquisition date of the DuncanTec CIR imagery.

3.1.7.2 Cost estimation of all evaluated sensors.

Different remote sensor images with different resolutions were used for each wetland. The cost estimation included the total area (ha) of image cover (Appendix 6), the total study or wetland area (ha) covered by the image and the total area (ha) around the rehabilitated structures covered by imagery (Table 14). A cost estimation for all evaluated sensors is presented in Table 15.

Table 14: Remote sensor imagery covering the rehabilitated area around the structures.

Wetland	Rehabilitation structure sites	Remote sensor imagery covering rehabilitated area (ha) around the structures
Kromme River	Site 1	3.8 ha
	Site 2	3.3 ha
	Site 3	1.9 ha
	Site 4	17.0 ha
	Site 5	11.8 ha
		37.8 ha
Mbongolwane	Uvova	11.5 ha
	Amatigulu	29.0 ha
		40.5 ha
Wilge River	Headcut	**7.7 ha**
Seekoeivlei	Site 1	3.7 ha
	Site 2	2.5 ha
	Site 3 & 4	8.0 ha
	Site 5	7.3 ha
	Site 6	4.9 ha
	Site 7	9.6 ha
		36 ha
Zoar	There were no exceptional sites. The whole wetland area was measured (**135 ha**).	
Rietvlei	Site 1	8.1 ha
	Site 2-5	57.3 ha
	Site 6	9.4 ha
		74.8 ha
The total area (ha) around the rehabilitated structures covered by imagery: Each area (ha) covering the rehabilitation structures as well as the rehabilitated area down-and upstream of the rehabilitation structure was measured and a total area for each wetland determined.		

Table 15: Cost estimation for evaluated sensors.

Wetland	Sensor	Resolution	Total Cost				Price covering: (R/ha)		
				Total area covered by the imagery	Total wetland area covered by imagery (ha)	Total area around the rehabilitated structures covered by imagery (ha)	Total area covered by the imagery	Total wetland area covered by imagery	Total area around the rehabilitated structures covered by imagery (ha)
Kromme River	SPOT 5 Kodak DCS 420	10m 1.0m	R30 400.00 R22 000.00	379 200 ha 2 010 ha	3 70.7 ha	37.8 ha	R0.080/ha R10.94/ha	R82.00/ha R59.34/ha	R804.23/ha R582.00/ha
Mbongolwane	EROS DuncanTech CIR	1.8m 0.25m	R12 600.00 R10 400.00	19 128 ha 1 578.0 ha	349 ha	40.5 ha	R0.65/ha R6.60/ha	R36.10/ha R256.79/ha	R311.00/ha R256.79/ha
Wilge River	DuncanTech CIR	0.5m	R5 875.00	1 602 ha	7.7 ha	7.7 ha	R3.66/ha	R762.98/ha	R762.98/ha
Seekoeivlei	Landsat EROS	30m 1.8m	R6 000.00 R12 600.00	3.4 milj ha 17 325 ha	976.3 ha	36 ha	R0.001/ha R0.73/ha	R6.15/ha R12.90/ha	R166.00/ha R350.00/ha
Zoar	DuncanTech CIR	0.25m	R7 400.00	708 ha	135.1 ha	135.1 ha	R10.45/ha	R54.77/ha	R54.77/ha
Rietvlei	DuncanTech CIR	0.5m	R9 975.00	1 706 ha	130.7 ha	74.8 ha	R5.84/ha	R76.31/ha	R133.35/ha

Total Cost excludes positioning fee & data processing.

Total wetland area covered by imagery (ha): Wetland delineation was done on 1:50 000 topographical maps to determine the total wetland area. The wetland area covered by the remote sensor imagery was digitally measured in ha.

The total area (ha) around the rehabilitated structures covered by imagery: Each area (ha) covering the rehabilitation structures as well as the rehabilitated area down - and upstream of the rehabilitation structure was measured (Table 14) and a total area for each wetland determined.

In determining the total wetland area (in ha) that had to be covered by imagery the following steps were taken:

- Wetland delineation was done on 1:50 000 topographical maps to determine the total wetland study area.
- The wetland study area covered by the remote sensor imagery was measured in ha.

The total area (in ha) around the rehabilitated structures covered by imagery, was determined in the following way:

- Each area (in ha) covering the rehabilitation structures as well as the portions down - and upstream of the rehabilitation structure was measured (Table 14) and a total area for each wetland determined.

DuncanTech CIR was used on four out of the six wetlands. The fact that all four wetlands could be covered in one flight made the total cost of the DuncanTech CIR sensor for each of the four wetlands much lower than the cost of flying one wetland at a time. This, however, made it difficult to select a suitable flight time that would insure cloudless conditions over all four of the wetlands. This approach influences the correct time for data acquisition for specific wetlands that differ from the rest.

3.1.7.3 Remote Sensor Data.

Table 16 lists the suggested window of opportunity for each wetland as well as the actual date that image acquisition was done for each wetland.

Table 16: Image acquisition dates.

WETLAND	SENSOR	WINDOW OF OPPORTUNITY	DATE
Kromme River	SPOT 5 Kodak DCS 420 (near infrared)	October – mid November.	10 February 2003 22 January 2003
Mbongolwane	EROS DuncanTech CIR Landsat	December	24 December 2002 09 June 2003

WETLAND	SENSOR	WINDOW OF OPPORTUNITY	DATE
Wilge River	DuncanTech CIR	January - February	08 April 2003 09 June 2003
Seekoeivlei	EROS Landsat	January - February	20 December 2002
Zoar	DuncanTech CIR	December, January and February	09 June 2003
Rietvlei	DuncanTech CIR	December, January and February	09 June 2003

3.1.8 Validation of data.

3.1.8.1 Field assessment.

The fieldwork assessment information acquired from the various wetland rehabilitation implementing agents was used, together with the results from the remote sensor images, to identify the function of the rehabilitation structures. The effect of the rehabilitation measures on the ability of the wetland to perform the various hydrological functions was identified as well. Photos taken during the fieldwork visits together with subsets of the various remote sensors images are discussed in Phase 5, section 11.2.

Fieldwork at the Kromme River wetland took place on 21 March 2003 to verify the processed SPOT 5 and Kodak DCS 420 (Near infrared) images. The Image acquisition date for SPOT 5 was 10 February 2003 and for Kodak DCS 420 (Near infrared), 22 January 2003.

Due to unforeseen and unavoidable delays experienced with the acquisition of the DuncanTech CIR imagery because of technical problems and unsuitable weather conditions, no continuation of the fieldwork for the remaining five wetlands could commence. The acquisition of the first set of DuncanTech CIR imagery was on 8 April 2003 and the second on 9 June 2003. The acquisition dates of both sets of imagery were not 100% optimal in terms of identifying seasonal wetland characteristics (refer to Table 3, Time frame for image acquisition). Data processing for the remaining five wetlands took a further 3 months. It was necessary to collaborate with the different wetland's contact persons to gather useful information such as photos that were taken at the rehabilitation structure sites. Feedback reports of the wetland conditions were gathered from field visits of the remaining five wetlands from different wetland contact persons.

The following field visits took place:

- Rietvlei - 26 January 2003.
- Mbongolwane – 18 January 2003 and 30 April 2003.
- Wilge River – 9-10 March 2003.
- Seekoeivlei – 9-10 March 2003, July 2003.
- Zoar - 26 May 2003.

A combined field visit to the two wetlands in the Free State was hampered by the fact that the image acquisition date for Wilge River wetland was on 8 April 2003 and again on 9 June 2003 (DuncanTech CIR) and 24 December 2002 (EROS) for the Seekoeivlei wetland.