

Client:

City of Cape Town

**BASELINE ASSESSMENT OF ECOSYSTEMS POTENTIALLY
IMPACTED BY THE WELL-FIELD DEVELOPMENT AT
STEENBRAS**

FRESHWATER AND BOTANICAL SPECIALIST REPORT

Submitted to

Aurecon South Africa (Pty) Ltd



Prepared by

Justine Ewart-Smith and Charlie Boucher

The Freshwater Consulting Group

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Freshwater Consulting Group
Unit F6, Prime Park
Mocke Road
Diep River, 7800
Cell: 082 3738380
Email: Justine@freshwaterconsulting.co.za

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1 INTRODUCTION

1.1 Background

Extreme drought conditions and the urgent need to augment bulk water supply for the City of Cape Town (CoCT) meant that the CoCT initiated emergency drilling operations for the production of groundwater within the Steenbras catchment surrounding the Steenbras Dam. Drilling operations commenced in late 2017. In late December 2017, drilling operations at H8H7 resulted in the spillage of a slurry of sediments and drilling surfactants into a small pristine stream approximately 120 m downstream of the drilling site. Drilling was temporarily halted in early January 2018 following concerns around the ecological sensitivity of the area and the potentially high and irreversible impacts associated with the development of a wellfield in Steenbras.

In early 2018, an Environmental Working Group (EWG) was formed and tasked with assessing the sensitivity of proposed borehole sites in Steenbras. Thereafter, the group undertook a screening process of the borehole sites and concluded that the bulk of the proposed locations were situated within highly sensitive areas (Cape Nature 2018). The unanimous recommendation from the EWG was that these sites should be avoided, and that siting of boreholes should be done to proactively avoid high impact areas. Despite these recommendations, the CoCT informed the EWG on 29th May 2018 that they intended to complete drilling and pump-testing at 16 of the locations.

In terms of the NEMA Section 30A directive issued by DEAD&P for undertaking emergency drilling within Steenbras, it is required that potentially affected habitats, mitigation methods and remediation activities be identified. Also, The DWS issued a Water Use License (WUL) for abstraction of groundwater under Section 21 (a) of the National Water Act (NWA). The License agreement stipulates however that Section 21 (c) and (i) water uses associated with the drilling operations and infrastructure associated with wellfield development need to be identified together with proposed mitigation to minimize impacts, including rehabilitation measures, as well as monitoring activities to be implemented.

This report thus provides an assessment of habitats identified within the footprint of all 16 production boreholes and along the infrastructure route, including stockpile areas and the proposed siting of the borehole pump houses and water treatment facility near the dam.

1.2 Terms of Reference

More specifically this study was commissioned to:

- Identify and map the freshwater ecosystems (rivers and wetlands) within the footprint of the borehole drilling sites and associated infrastructure, including the pipeline and powerline routes, stockpiles, pump houses and the water treatment facility;
- Assess the ecological condition, importance and sensitivity of these habitats;

- Identify potential impacts to these habitats as they pertain to development activities during both the construction and operational phases of wellfield development;
- Provide recommendations to minimise impacts and mitigate the loss of ecologically important habitat;
- Specify rehabilitation measures required following the construction phase;
- Compilation of a report detailing the above.

During this assessment, the need to upgrade various bridge crossings within Steenbras was identified. A description of the potentially affected freshwater ecosystems, together with an evaluation of impacts and mitigation measures to alleviate impacts are provided in a separate report (Ewart-Smith 2018). While recommendations and general guidelines for rehabilitation are provided in this report, details of rehabilitation activities associated with rehabilitation will be provided in a separate rehabilitation plan for the area. Furthermore, details for ongoing monitoring of potential impacts to guide adaptive management requirements will be provided elsewhere.

1.3 Use of this Report

This report reflects the professional judgements of its authors. It is FCG's policy that the full and unedited contents thereof should be presented to the client and included in any application to relevant authorities. Any summary of the findings should only be produced with the approval of the authors.

1.4 Approach to this assessment

This study focused on the following key areas:

- The footprint of each of the 16 boreholes which includes the footprint of the pump houses to be constructed once borehole drilling operations are complete;
- The alignment of the proposed below ground pipeline and powerline routes along existing roads. A 10 m corridor adjacent to the road along the route was assessed;
- The alignment of the proposed overhead transmission line within a corridor of approximately 20 m;
- The footprint of the stockpile areas;
- The footprint of the water treatment facility.

Wetlands and water courses referred to in this document are based on the following as stipulated in the National Water Act (NWA) (Act 36 of 1998):

“watercourse” means -

- (a) a river or spring;
- (b) a natural channel in which water flows regularly or intermittently;
- (c) a wetland, lake or dam into which, or from which, water flows; and
- (d) any collection of water which the Minister may, by notice in the Gazette, declare to be watercourse, and a reference to a watercourse includes, where relevant, its bed and banks;

“wetland” means - land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which

land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

All other habitats are referred to as “**dryland**” and were assessed from a botanical perspective.

The following tasks were undertaken to meet the scope of work and terms of reference for this study:

- Examination of relevant existing maps and GIS covers to ascertain where watercourses and wetlands have already been mapped. In particular, this involved examination of the latest version of the City of Cape Town’s Wetlands Map to identify possible wetlands and watercourses within or close to the 16 borehole drilling sites or the proposed infrastructure route.
- Examination and interpretation of recent colour aerial imagery of the Steenbras Area along the infrastructure route and within the footprint of the 16 borehole drilling sites.
- Completion of three days of field work to verify and ground-truth the ecological condition, ecological importance and ecological sensitivity of ecosystems (defined as habitat “units”) potentially impacted by development and operation of the proposed wellfield at Steenbras.
- Each habitat “unit” identified in the field was tracked using a GPS device and categorised in terms of condition, importance and sensitivity, together with notes on recommended working widths, identification of proposed bypass areas, mitigation measures and general management recommendations. Evaluation of the ecological condition of each habitat “unit” was based on the definitions for the assessment of Habitat Integrity provided by Kleynhans (1996) (Table 1.1). Categorisation of ecological importance was based on a list of criteria developed by FCG as outlined in Table 1.2. Ecological sensitivity was based on a consideration of both the condition and importance of each habitat “unit” relative to the proposed activity that potentially impacts the system.
- Consolidation of habitat units into 17 Management Units based largely on surrounding land-use, habitat condition and sensitivity to specific development considerations.
- Compilation of habitat and sensitivity maps of potentially affected areas within each Management Unit to assist with quantification of specific rehabilitation requirements and management requirements.
- Two site visits and subsequent liaison with the project engineers (Stephan Kleynhans and Martie Wahl from Aurecon) to discuss mitigation measures, including recommendations for limiting the working width in specific areas and the possibility of potential alternative routes.
- Identification of the possible “water uses” that would require authorisation from the Department of Water and Sanitation (DWS) in terms of Sections 21 of the National Water Act (Act No. 36 of 1998).
- Identification of potential construction and operational phase impacts associated with the wellfield development.
- Preparation of an Assessment Report which includes recommended mitigation measures to minimise potential impacts during the design (pre-construction), construction and operational phases of the proposed infrastructure route.

Due to the sensitive nature of the natural environment affected by well-field development in Steenbras, input to the layout and design of various infrastructural requirements involved an iterative process between the ecologists and engineering team in an attempt to minimise impacts to the natural environment as far as possible.

Table 1.1 Descriptions of Habitat Integrity categories (after Kleynhans 1996)

CATEGORY	DESCRIPTION
A	Unmodified, natural
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

1.5 Assumptions and Limitations

- Due to time limitations and the extensive area requiring assessment, the extent of wetland habitat and thus the exact boundary of wetlands habitat units were not delineated using the standard procedure detailed in DWAF (2005) for the delineation of these habitats. Assessment was however undertaken towards the end of the wet season when many of the key hydrological indicators were clear and obligate and facultative wetland plants were readily identifiable in natural areas.
- Due to the large number of natural (both dryland and wetland) ecosystems that had to be assessed in this study, the categorisation of the present ecological condition was limited to a rapid, visually based assessment of the hydrology, geomorphology, water quality and vegetation associated with each wetland and the vegetation and habitat integrity of dryland ecosystems.
- Delineation of habitat units within the plantation area was complicated by the lack of indicator vegetation species in degraded areas and thus the confidence in the separation of habitats within these areas is generally low.
- Also, the categorisation of ecological importance was limited by the lack of detailed information in the species of fauna and/or flora within each system as well as the lack of detailed functional assessments. While the collection of species specific data would have increased the confidence in the categorisation of ecological importance and sensitivity of these ecosystems, it is our option that the lack of such data in an area with low existing levels of impact did not compromise the outcome significantly.

1.6 Site location

The extent of the Steenbras well-field is shown in Figure 1.1. It is situated on the north facing slopes of the Hottentot Holland Mountains south of the Steenbras Dam within a formally Protected Area declared as a Section 23 Nature Reserve. This also falls within a declared World Heritage Site. It

straddles the buffer and core zones of the Kogelberg Biosphere Reserve with the buffer areas identified as the Utility Zone, which is within the existing plantation areas surrounding the dam. Thus, the area is largely natural and of high sensitivity to anthropogenic disturbance, although some areas close to the dam support secondary habitat previously under pine plantations as well as some sections still under pine and gum plantations.

Table 1.2 Criteria used to assign low, moderate or high ecological importance to ecosystems identified in the study area (note that the highest category applicable to any ecosystem, based on any one criteria, is the one accorded the wetland as a whole) (modified from Ewart-Smith & Ractliffe 2002):

LOW CONSERVATION IMPORTANCE: • does not provide ecologically or functionally significant habitat, because of extremely small size or degree of degradation, and/or • of extremely limited importance as a corridor between systems that are themselves of low conservation importance.
MODERATE CONSERVATION IMPORTANCE: • provides ecologically significant habitat (e.g. locally important wetland habitat types), and/or • fulfils some wetland functional roles within the catchment, and/or • acts as a corridor for fauna and/or flora between other wetlands or ecologically important habitat types, and/or • supports (or is likely to support) fauna or flora that are characteristic of the region and/or provides habitat to indigenous flora and fauna, and/or • is a degraded but threatened habitat type (e.g. seasonal wetlands), and/or • is degraded but has a high potential for rehabilitation, and/or • functions as a buffer area between terrestrial systems and more ecologically important wetland systems, and/or • is an aquatic habitat upstream of systems that are of high conservation importance.
HIGH CONSERVATION IMPORTANCE: • supports a high diversity of indigenous wetland species, and/or • supports, or is likely to support, red data species; supports relatively undisturbed communities, and/or • forms an integral part of the habitat mosaic within a landscape, and/or • is representative of a regionally threatened / restricted habitat type, and/or • is a wetland with a high functional value (e.g. nutrient filtration; flood attenuation) in the catchment, and/or • is a wetland habitat of a significant size (and therefore provides significant habitat, albeit degraded or of low diversity).



Figure 1.1 Location of the Borehole sites and infrastructure network within the proposed Steenbras wellfield.

2 PROJECT DESCRIPTION

The following main infrastructure components have been considered in this study, as potentially of relevance to both dryland and freshwater aquatic ecosystems:

- Borehole sites for the construction and testing of production boreholes;
- Above ground pump station chambers and footprints required for construction;
- Below ground pipelines and powerlines, including watercourse and wetland crossings;
- Above ground powerline route;
- A water treatment facility;
- Stockpile areas.

These components are indicated in Figure 1.1.

2.1 Borehole sites

The Steenbras Wellfield includes 16 production boreholes and 7 monitoring boreholes. Production boreholes are drilled using percussion drilling where water and surfactants are added to the borehole during the drilling process for lubrication. Large volumes of effluent containing water, pulverised rock and lubricant are produced and discharged during the process. Also, drilling effluent sprays periodically from the hole in a radius of about 30 m (if not mitigated) as a result of blowing the hole to remove rock fragments from the hole. Aside from the associated infrastructure (i.e. the drill rig and vehicles) required during percussion drilling, the drilling site usually includes:

- Two settlement sumps to promote settling of fines
- An array of polytex sediment curtains.
- Sandbags to contain discharge
- Stockpiles for spoil
- A parking area.

Upon completion of the drilling, each borehole is test-pumped to determine its long-term sustainable yield. The test-pumping is typically performed over a period of one to two weeks, which includes a step test and a 7-day constant discharge test.

The monitoring boreholes have a much smaller footprint than the production boreholes and do not require the same level of site preparation or the construction of sumps. The monitoring boreholes involve diamond bit core drilling. During this process, externally sourced water is pumped down the core hole for lubrication and to reduce heat friction at the contact between the diamond drill bit and the rock face. Water is stored in storage tanks on site and then pumped down each hole. Overflow from the core hole is pumped into a series of re-circulation tanks where it is stored and then pumped back into the hole. Unlike percussion drilling therefore, core drilling involves a closed system where water is contained and re-used. The monitoring boreholes, once drilled, are completed with a precast manhole ring and base slab to protect the borehole and for future access to undertake monitoring.

2.2 Infrastructure

2.2.1 Above Ground Pump Station Chambers

The construction of 16 above ground pump station chambers and footprints had to be considered in this study. The pump station chambers will house the borehole pump, motors and electrical equipment. The flow meter chamber will be located adjacent to the pump station chamber, but will be below ground. The completed pump station chamber will have a footprint of approximately 11 m long x 4 m wide x 3.2 m high, which excludes any provision for improving the visual appearance of the chambers (e.g. by means of stone cladding or dry packing).

During construction, provision will need to be allowed for working space around the pump station chamber. Post construction, access to the chamber would need to be provided from the existing access roads in order to maintain the equipment.

2.2.2 Below ground pipeline/powerline route

Wellfield infrastructure includes a network of below ground pipelines and powerlines. Approximately 12.5km of pipeline and electrical cables will be placed in the same trench. Approximately 2.8km of electrical cables will be placed in a single trench, which does not coincide with pipeline routes. The pipelines will have diameters varying between 160mm and 560mm.

Depending on the width of the existing roads, the sensitivity of the natural habitat and the required pipeline diameter along different sections of the route, the extent of encroachment into natural habitat varied between zero (in the case where the road is 12 m wide and all activities can be located within the existing road footprint and 3.5 m where the road is 5 m wide. In the case where habitat is sensitive, regardless of the road width, excavation into natural habitat will be limited to 2.m although a bypass every 200 m will be required.

Air valve chambers and scour valve chambers (if required) would be constructed along the pipeline route. These chambers will be precast manhole rings and would not extend beyond the disturbed footprint.

The geotechnical investigation indicated that rock would be encountered in certain parts of the pipeline excavations, which would require removal of the rock with pneumatic equipment. It is envisaged that blasting would not be required.

2.2.3 Above ground transmission route

An above ground power transmission line is required from the existing Eskom transformer, located immediately downstream of the Rockview Dam, to the metering point located at the City of Cape

Town's boundary. The length of the overhead section is approximately 420 m. The positions of the poles were determined based on the topography and lengths that can feasibly be spanned.

2.2.4 Watercourse crossings

Above ground stream crossings will be implemented at wide and deep crossings where there is a presence of rock and medium or high flows. These crossings would typically comprise two concrete piers, located on either side of the stream, with steel pipelines spanning between the two piers. Where the width of the stream crossing is such that an intermediate pier would be required, it would need to be constructed at a location identified *in situ* such that hydraulic changes in river flow are minimised.

Below ground stream crossings will be implemented at typically narrow or shallow crossings, where there is no presence of rock and flows are generally seasonal or ephemeral. The pipeline will be buried with a minimum soil cover of 500 mm.

2.2.5 Water treatment facility

A pre-treatment works, with a likely initial capacity of 15 to 20 Mℓ/d, which could be expanded up to 40 Mℓ/d to treat water from the Nuweberg wellfield, was considered as part of this study. The pre-treatment works was sited near existing buildings and close to the National Road (N2) for easy access and maintenance. The final footprint size of the treatment works will be influenced by the height of the structure (based on visual appearance) and the yield of the wellfield.

2.2.6 Stockpiles

Areas are needed to stockpile materials arising from excavations and pipes during construction, especially due to the restricted working widths. Potential stockpile areas were considered as part of this study.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 A broad ecoregional and catchment context

The Steenbras wellfield falls within the South Western Fynbos Bioregion, known for its high levels of diversity and exceptionally high levels of endemics (Raimondo *et al.* 2009) across both the terrestrial and aquatic ecosystems. As a formally Protected Area, this area was set aside for the protection and maintenance of biodiversity and ecological integrity. The habitats supported within the study area are listed as threatened ecosystem types with both the Kogelberg Sandstone Fynbos as well as the Elgin Shale Fynbos close to the dam rated as Critically Endangered Ecosystems. The Upper and Lower Steenbras Dams have disrupted the Fynbos Riparian Vegetation lining the Steenbras River. The Kogelberg Sandstone Fynbos supports threatened plant species while the Elgin Shale fynbos is rated as critically endangered because of the irreversible loss of natural habitat of this type. Surface material of this region is characteristically low in nutrients to which the fynbos are naturally adapted and highly sensitive to enrichment.

From an aquatic perspective, the area is within the Southern Folded Mountain Ecoregion described by Kleynhans *et al* (2005). This ecoregion is characterised by closed hills and mountains of moderate and high relief with a high diversity of vegetation types. Rainfall arrives mainly in the autumn and winter months with a varied annual precipitation and a moderate to high Coefficient of Variation of annual precipitation. Streams within the Steenbras Catchment are characteristically acidic with pH between 3.5 and 5 and low in nutrient concentrations due to the naturally oligotrophic (nutrient poor) substrata typical of the region.

The study area is located with DWS Quaternary Catchment G40A which has a Mean Annual Precipitation (MAP) >1050 mm per annum and a Mean Annual Runoff (MAR) of 537.5 million cubic meters.

3.2 Description of habitats with the Study Area

The habitat along the north-facing slopes of the Hottentots Holland Mountains is characterized as a mosaic of wet and dry habitat underlain by sandy (white acidic sands) or rocky weathered surface material with vegetation communities typical of Sandstone Fynbos along the slopes and Shale Fynbos close to the dam itself. There are numerous ephemeral or seasonal streams with a few perennial bedrock rivers that drain northwards off these slopes. Most ephemeral watercourses are associated with seep wetland habitat while the perennial systems are flanked by riparian fringes that often merge with hillslope seep wetlands. Many of the seeps and perennial watercourses are likely fed by topographically-driven interflow through sandy weathered surface material, or via fracture flow within the Skurweberg Formation (Freshwater Consulting Group 2014). Seasonal systems are likely fed by surface runoff during the wet season although the relative contribution of groundwater versus surface water or interflow is largely unknown.

For the purpose of this assessment, dryland (Figure 3.1) and wetland habitat was identified at the broadest scale with wetlands further separated into four categories based on hydroperiod as indicated by terrain and vegetation indicators and to some extent, soil form and wetness characteristics¹. These include:

- Temporary wetlands which are waterlogged for a very limited period (less than 3 months of the year) and are never inundated (Figure 3.2).
- Seasonally saturated wetlands which are waterlogged during the wet season but dry for up to 9 months of the year (Figure 3.3).
- Permanently saturated, seasonally inundated wetlands are those which are waterlogged throughout the year and have standing water on the surface during the wet season (Figure 3.4).
- Permanently saturated wetlands are permanently waterlogged but are rarely or never inundated during the wet season (Figure 3.5)

Further distinction was made between ephemeral and perennial watercourses within the area.

Ephemeral (or in some cases, seasonal) channels are generally narrow (approximately 50 cm wide channels) with sand, gravel and some small cobbles and pebbles on the channel bed (Figure 3.6). The riparian fringe is largely absent or ill-defined, although most are flanked by seep habitat.

A number of perennial streams are situated within the Steenbras Wellfield. These can be described as either mountain streams or transitional rivers with bedrock/ boulder active channels supporting a diversity of instream habitat types (Figure 3.7) and Fynbos Riparian Vegetation. These streams are characterised by a distinct riparian fringe which is often associated with hillslope seep habitat.

Key features of these habitats are summarised in Table 3.1.

Besides the high floral diversity and endemism of the area, the habitats support a fauna that is unique to the area. From an aquatic perspective, these range from fish such as the endemic Cape Galaxid, of which the taxonomy is yet to be described, to aquatic macroinvertebrate faunal endemics and amphibian species. While the list of endemic macroinvertebrate taxa for the region are given in Ewart-Smith (2018) and Grainger (2018), tadpoles of the critically endangered ghost frog (*Heliophryne purchelli*) have been recorded in some streams (see Mossop *et al* 2018 as an example). Other species identified by sound within the seep habitats of the area include moss frogs (i.e. *Arthroleptella kogelbergensis* and *A. villiersii*), *Breviceps montanus*, *Poyntonia paludicola*, *Strongylopus bonispei* and *S. greyii*.

¹ The distinction between wetland types described here is of low confidence due to the limited timeframe of this study and lack of detailed biophysical understanding of the functionality of these systems.

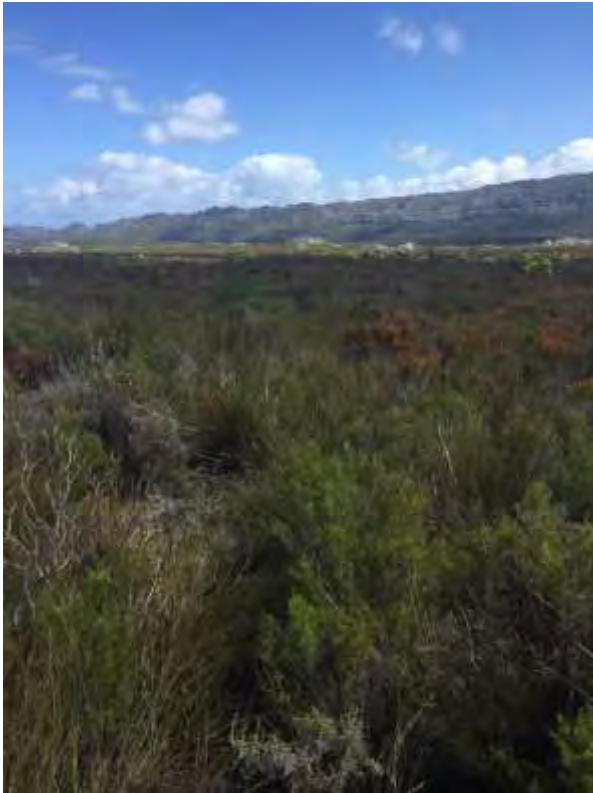


Figure 3.1 Typical dryland habitat at Steenbras.



Figure 3.2 Temporary wetland habitat in pine plantations at Steenbras.



Figure 3.3 Seasonally saturated wetland habitat at Steenbras.



Figure 3.4 Permanently saturated wetland habitat at Steenbras.



Figure 3.5 Permanently saturated but seasonally inundated wetland habitat.



Figure 3.6 Seasonal or ephemeral channels in Steenbras.



Figure 3.7 Perennial Rivers with riparian habitat in Steenbras.

Table 3.1 Key features of the Habitat Types in the Steenbras Catchment identified within the Steenbras Wellfield area.

Habitat type	Key characteristics
Dryland	Either rocky or sandy sandstone derived soils which are characteristically low in nutrients (oligotrophic). A mixed vegetation with proteoid, ericoid, asteraceous and restioid elements.
Temporary wetland habitat	Sandy sandstone with poor nutrients in which ericoid and restioid vegetation is prominent.
Seasonally saturated wetland habitat	Local patches of vegetation in which single species dominance is conspicuous.
Permanently saturated, seasonally inundated wetland habitat	Ericoid-restioid vegetation in which <i>Berzelia lanuginosa</i> , <i>Restio occultus</i> , and <i>Restio purpurascens</i> are common.
Permanently saturated wetland habitat	<i>Elegia mucronata</i> is a common emergent restioid in this vegetation.
Ephemeral or seasonal channels	Vegetation as below but with a larger component of species found in seasonally saturated wetlands.
Perennial streams with fringing riparian habitat.	Substratum is dominated by large bed material such as boulders and bedrock that support riffles and cascades separated by cobble and gravel runs and occasion pools. Instream Fynbos Riparian Vegetation includes the sedge, <i>Isolepis digitata</i> with stands of palmiet (<i>Prionium serratum</i>), <i>Disa tripetaloides</i> <i>Juncus lomatophyllus</i> , <i>Metrosideros angustifolius</i> and <i>Osmitopsis asteriscoides</i> along the channel and slower flowing margins.

Besides these habitats, some areas that are currently transformed either to accommodate the road network through the area or permanently cleared of vegetation for the maintenance of firebreaks were described as “disturbed” areas.

3.3 Existing impacts to habitats within the study area

While the Steenbras Wellfield falls within a natural area, there are a number of existing impacts to both aquatic ecosystems and drylands within this area. Portions of the area were previously used for forestry, particularly in the lower lying areas surrounding the dam. Portions of the wellfield fall within areas that support secondary vegetation indicative of both wetlands and drylands that has recovered following the clear felling of pine plantations. Although extensive loss of natural habitat is evident within the extant pine plantations, natural habitats, mostly permanently saturated seeps, still support natural vegetation under the sparser pine tree canopy (Figure 3.8). Most of the areas under pine still retain the natural soil structure and is probably still rich in indigenous seed and thus, it is likely that removal of pines will result in the recovery of both wetlands and drylands as observed in the areas where pines have already been cleared (pers. obs. in Steenbras Catchment). Unlike the areas under pines there are areas under gum plantation where the organic layer and topsoil horizon have been lost due to erosion following the loss of base vegetation under large gum trees. Removal of gums have resulted in some recovery of the natural vegetation although it is likely that more intensive remediation measures would be required to return these areas back to functional habitat.

The existing road network through the Steenbras Dam catchment has resulted in a number of impacts of varying significance for habitats within the area. In particular:

- Loss of both dryland and wetland habitat associated with the footprint of the road. This affects connectivity and the movement of biota through a largely pristine environment.
- Road maintenance has resulted in the loss of habitat along the road margin where graded material has been placed on top of natural vegetation in both wetlands and drylands. While vegetation is still present within this area, the habitat is degraded thus contributing to the cumulative loss of habitat of high conservation importance in this area.
- Foreign top material (red shales) has been imported into the area to maintain the condition of the major roads through the area. These materials generally have higher nutrient concentrations and thus road runoff affects the natural chemistry of the soils and water of wetlands and drylands through the contribution of nutrients to a naturally nutrient poor environment.
- Many roads traversing wetland seep habitats have resulted in compaction of the habitat and hydrological alteration of natural surface and subsurface flow patterns such that “drying out” of wetland habitat downslope of the road is evident through the area (Figure 3.9).
- Culverts below the road tend to concentrate flows which would be naturally diffuse. Thus, many of the existing seasonal and ephemeral channels have been artificially created by the concentration of flows. Within areas where plantations still dominate, this has led to erosion and down-cutting to bed material with associated “drying out” of adjacent wetland habitat.
- The road crossings over perennial streams have impacted somewhat on the local hydraulics of these streams which in turn affects the quality of instream habitat. Also, river crossings affect the ecological connectivity of these systems as longitudinal movement of aquatic biota is affected by obstructed flows, particularly towards the end of the dry season when these systems are naturally at their driest.



Figure 3.8 Wetland habitats within pine plantations in Steenbras.



Figure 3.9 Example of diverted runoff caused by the roads that bisect wetlands and result in drying out of wetlands downslope of the road.

4 ECOLOGICAL CONDITION, IMPORTANCE AND SENSITIVITY OF HABITATS WITHIN THE STUDY AREA.

Prior to the assessment of the infrastructure routes within Steenbras, the 16 production boreholes were subject to a screening process undertaken by the Environmental Working Group in early 2018 (Pence *et al.* 2018) to establish the level of sensitivity of boreholes to anthropogenic impacts. That evaluation was used to inform the ecological condition, ecological importance and ecological sensitivity of these sites prior to drilling operations because drilling has already commenced on some of these sites.

The results of ecological condition, importance and sensitivity of each habitat unit identified in the field was collated into 17 Management Units based largely on surrounding land use and thus, to some extent, differences in sensitivity to disturbance associated with the wellfield development. This section provides a summary description of the habitats, their condition and their sensitivity within each Management Unit.

4.1.1 Management Unit 1 (Track 125 to 132):

The pipeline route within this MU is situated north of the dirt track within a mature pine plantation (Figure 4.1). The area to the south of the dirt track was cleared of pines in the last decade and is characterised by secondary vegetation on sandy soils.

This MU includes the footprint of borehole **H1A1**. H1A1 falls within wetland habitat adjacent to a small vegetated seasonal channel (Track 125 in Figure 4.1 and Figure 4.2). All vegetation has already been cleared within the borehole footprint, although this site is considered of moderate to high sensitivity with a high potential for recovery following pine removal (Table 4.1; Figure 4.3).

Although the pipeline/powerline route is situated within a mature pine plantation, some habitats within this route support natural vegetation (Table 4.1). The majority of this MU includes sandy dryland with *Lanaria lanata* and *Tribolium uniola* with some restios and a few juveniles of the invasive alien *Acacia melanoxylon* among the pines. There is also a relatively extensive area of sandy temporary wetland with *Pennisetum macrourum* separating it from the drylands. There are a few sections of permanently saturated but seasonally inundated wetlands that drain northwards across the track via culverts. These are dominated by *Senecio rigidus* with sedges such as *Ficinia indica*. These habitats are in moderate condition with High Ecological Importance and, with the exception of the permanent wetland with channel flow (Wypt 157 in Figure 4.2) which is of High to Moderate sensitivity, most of these habitats are of Moderate or Moderately Low sensitivity (Table 4.1 and Figure 4.2). These habitats have a high potential for rehabilitation following removal of the pines considering that the top soil is still intact. The wetland habitat at the far western extent of MU1 is significantly impacted by the existing road because flows are artificially directed across the road and enter an existing drainage ditch that runs along the north eastern site of the road (see MU2: section 4.1.2.). It is likely that flows would naturally have drained to the north west but loss of flow to the area downstream of the road has led to extensive drying of wetland in this area.

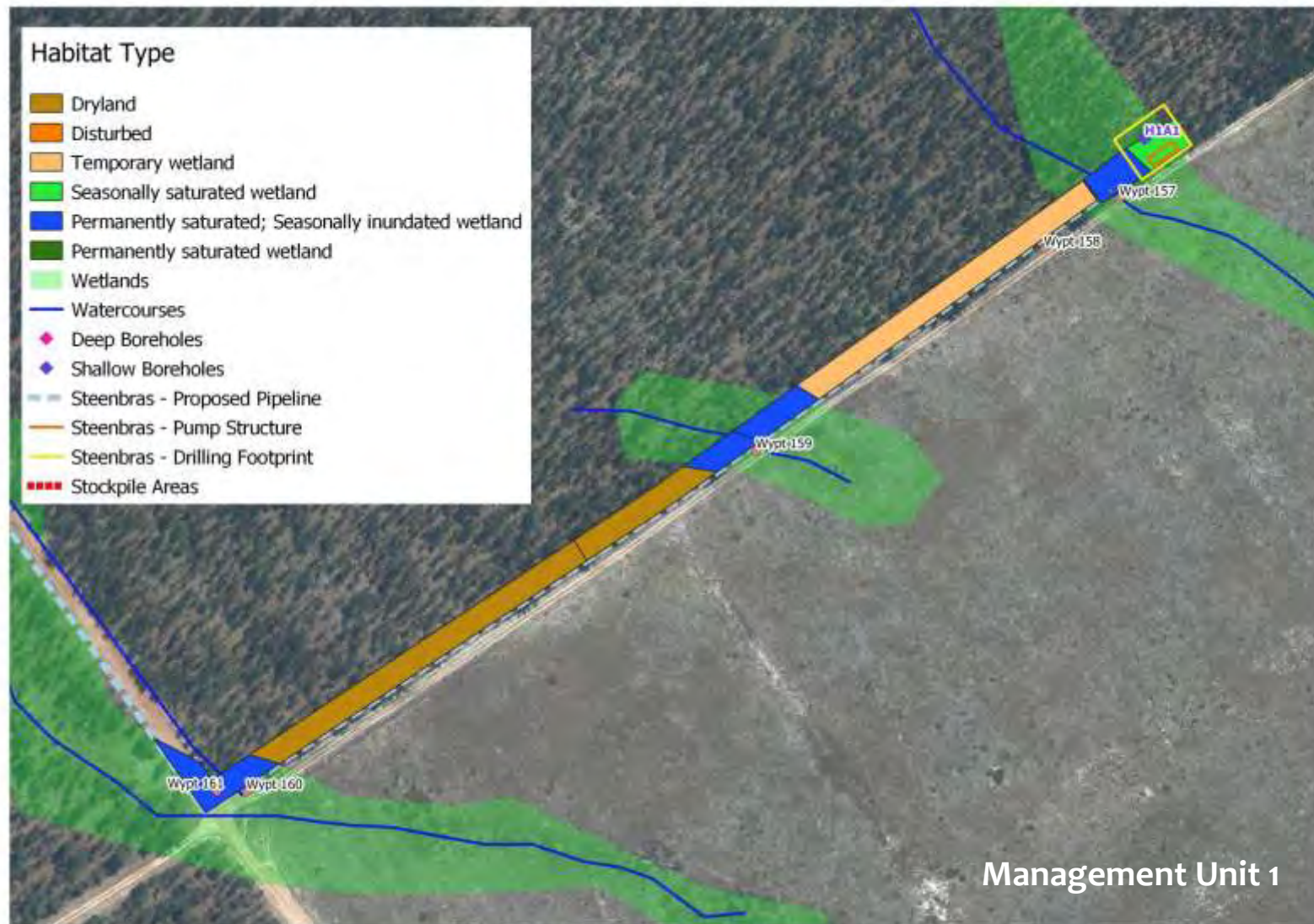


Figure 4.1 Management Unit 1: Spatial extent of Habitat Types.

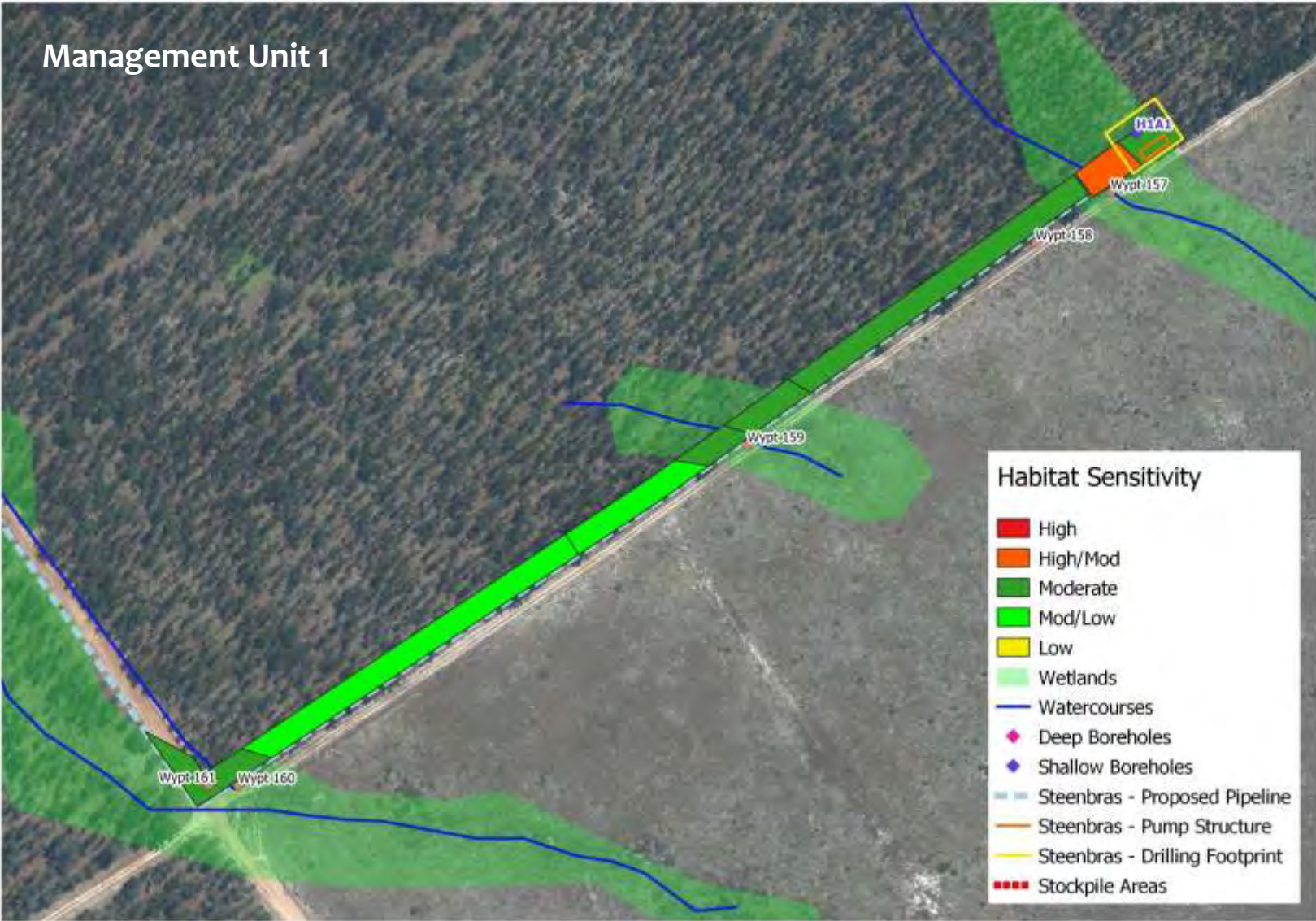


Figure 4.2 Management Unit 1: Habitat sensitivity.



Figure 4.3 a) Site of borehole H1A1 prior to clearing, b) immediately adjacent to a permanent wetland with seasonal flow in winter.

Table 4.1 MU 1: Characteristics of Habitat Types together with Ecological Condition (PES), Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 125	Wetland (seep)	Plantation (north only)	Seasonally saturated	Seasonally saturated wetland within pine plantation - all vegetation has already been removed for siting of borehole (H1A1)	Prior to borehole construction activities: Class C but now Class E : sumps and pumps etc are sited within the wetland	High	Moderate	Rated sensitivity based on conditions prior to borehole drilling activities. Although within pines, the topsoil is intact and wetland would have easily recovered with removal of pines
Track 126	Wetland (seep)	Plantation (north only)	Permanently saturated; seasonally inundated	<i>Senecio rigidus</i> , <i>Pentameris thuarii</i> , <i>Ficinia indica</i> , <i>Lanaria lanata</i> , <i>Lagurus ovata</i>	Class C : road disturbance	High	High/Moderate	
WP 157	Stream	Plantation (north only)	Seasonal	<i>Senecio rigidus</i> , <i>Pentameris thuarii</i> , <i>Ficinia indica</i> , <i>Lanaria lanata</i> , <i>Lagurus ovata</i>	Class B : in pines but channel itself relatively intact with good habitat and water quality	High	High	
Track 127	Wetland (seep)	Plantation (north only)	Temporary	<i>Tribolium uniolae</i> , <i>Lagurus ovata</i> , <i>Ehrharta longiglumae</i> , <i>Tetraria cuspidata</i> , <i>Sonchus oleraceus</i> , <i>Hypochaeris radicata</i> , <i>Syncarpha vestita</i> , <i>Athanasia trifurcata</i> , <i>Lanaria lanata</i> . <i>Lobelia coronopifolia</i> , <i>Corymbium glabrum</i> , <i>Pennisetum macrourum</i> , <i>Tetraria capillacea</i> . Aliens: <i>Acacia melanoxylon</i> , <i>Pinus pinaster</i>	Class C : road disturbance	High	Moderate	Topsoil intact so high potential for recovery following pine removal
Track 128	Wetland (seep)	Plantation (north only)	Permanently saturated; seasonally inundated	<i>Pentameris curvifolia</i> , <i>Ehrharta ramosa</i> , <i>Senecio rigidus</i> . Aliens: <i>Acacia melanoxylon</i> , <i>Pinus pinaster</i>	Class C : road disturbance	High	Moderate	
WP 159	Stream	Plantation (north only)	Seasonal	<i>Ficinia filiformis</i>	Class B : relatively intact	High	High/Moderate	
Track 129	Wetland (seep)	Plantation (north only)	Permanently saturated; seasonally inundated	<i>Dilatis corymbosa</i> , <i>Elegia mucronata</i> , <i>Ceratocaryum argenteum</i> . Aliens: <i>Acacia melanoxylon</i>	Class C/D : road disturbance and high density of blackwoods. <i>Dilatis corymbosa</i> , <i>Elegia mucronata</i> , <i>Ceratocaryum argenteum</i> , <i>Agapanthus walchei</i>	High	Moderate	<i>Tribolium</i> is and indicator of disturbance along the road margin.
Track 130/131	Dryland	Plantation (north only)	N/A	<i>Lanaria lanata</i> , <i>Tribolium uniolae</i> , <i>Restio capensis</i> , <i>Ursinia dentata</i> , <i>Ficinia indica</i> . Aliens: <i>Acacia melanoxylon</i>	Class D : disturbed dryland within pines	Moderate	Mod/Low	Could site a bypass here if necessary
Track 132	Wetland (seep)	Plantation (north only)	Permanently saturated; seasonally inundated	<i>Senecio rigidus</i> , <i>Tetraria cuspidata</i> , <i>Restio gaudichaudianus</i> , <i>Restio perplexus</i> , <i>Tetraria flexuosa</i> , <i>Erica labialis</i>	Class C : road disturbance and hydrological impacts	High	Moderate	Impacted by road through wetland and thus change in hydrological functioning as well as pine plantation
WP 160	Artificially created drainage channel	Plantation (north only)	Seasonal	Small channel with sparse vegetation along the margins. Some rocky substrate but mostly fine sediments.	Class C : relatively intact but hydrological impacts due to culvert diversion of flows	High	High/Moderate	This stream is a diversion of flow from upstream of the road. Flows have been artificially channelled via culvert along this ditch

4.1.2 Management Unit 2 (Track 133 to 137)

The proposed pipeline/powerline route is to the south west of the existing road. Through discussions with the engineering team, it has been agreed that the pipeline can be placed to the north east of the road as a preferred alternative from an ecological perspective because an existing drainage ditch flows parallel to the road along this alignment and could be used as the pipeline trench thus minimising encroachment into habitat. Thus the habitat type and sensitivity maps represent the route to the north east of the road in MU 2 (Figure 4.4 and Figure 4.5).

Mature pine plantations are situated either side of the road within this MU and the habitats are moderately to largely impacted by the loss of natural vegetation and changes in the hydrological functioning of wetlands. Most of the adjacent habitat is dryland with a low sensitivity, although some wetland habitat is present with a moderate sensitivity to disturbance (Table 4.2; Figures 4.4 and 4.5). Runoff from the upstream seep channel has been artificially diverted such that a culvert directs runoff via an artificial channel adjacent to the existing road. Habitat condition is thus significantly impacted by down cutting due to channelized runoff and erosion of the banks.

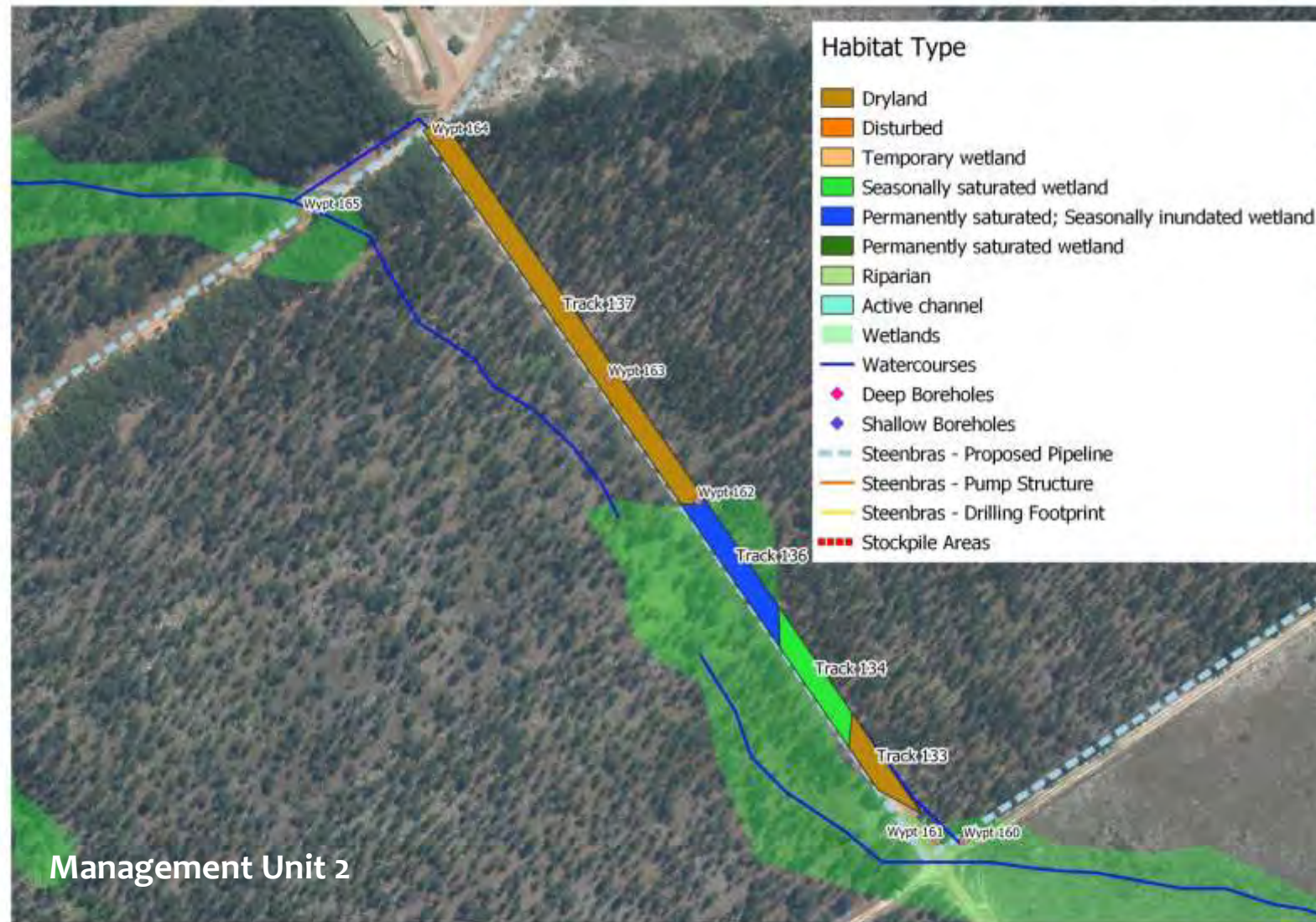


Figure 4.4 Management Unit 2: Spatial extent of Habitat Types.

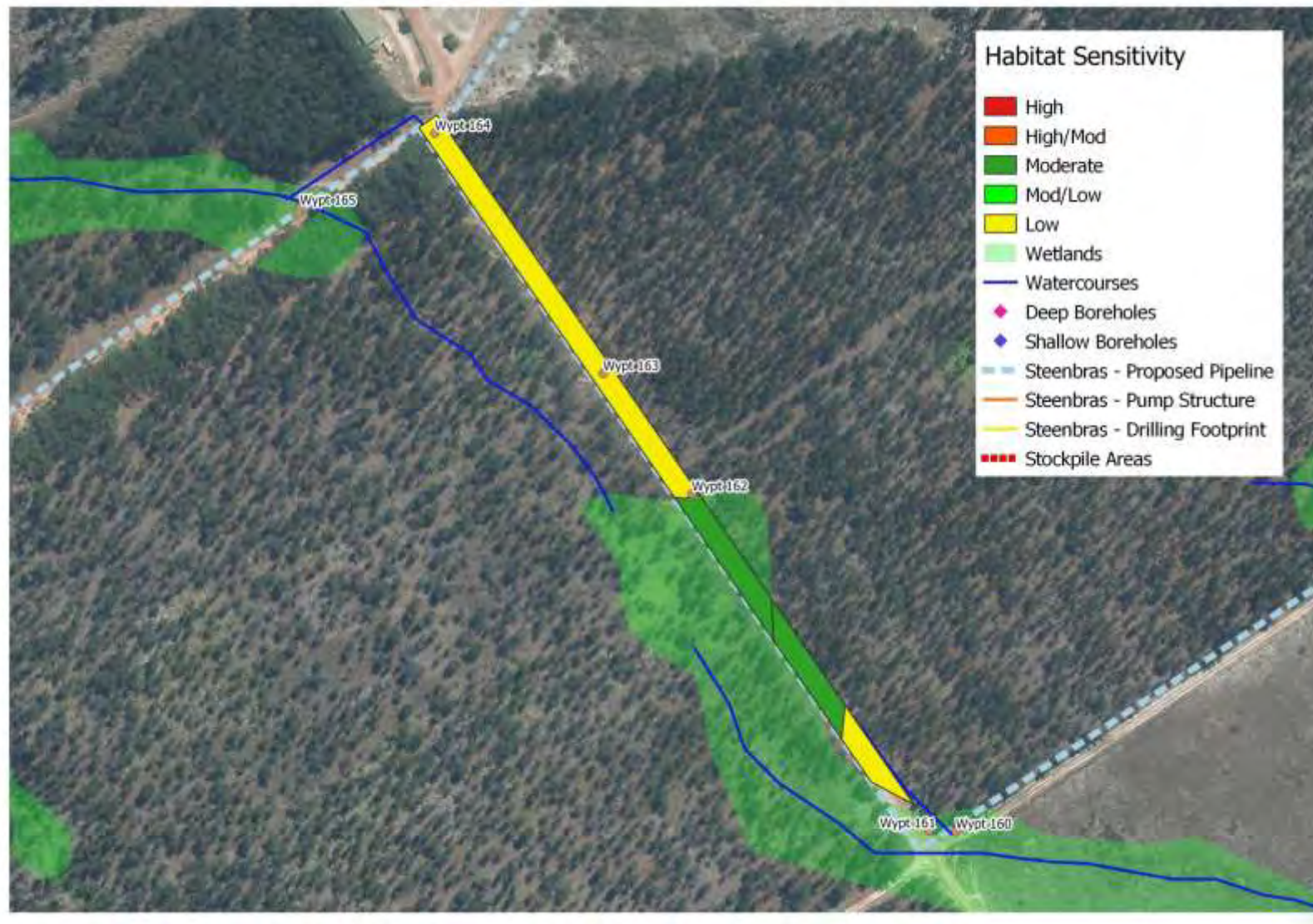


Figure 4.5 Management Unit 2: Habitat sensitivity.

Table 4.2 MU 2: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 133	Dryland	N/A	Very little vegetation on the road margin due to drainage ditch which is actively eroding	Class E: disturbed dryland with ditch	Low	Low	
Track 134-135	Wetland (seep)	Seasonally saturated	Remnant wetland area but disturbed. Veg includes: <i>Podalyria calyptrata</i> , <i>Lanaria lanata</i> , <i>Restio sieberi</i> , <i>Oxalis luteola</i> , <i>Ursinia dentata</i> , <i>Pentameris patula</i> , <i>Tribolium uniolae</i> , <i>Hypochaeris radicata</i> , <i>Senecio rigidus</i> . Aliens: <i>Pinus pinaster</i> and <i>Callistemon viminalis</i>	Class D few natural features; within pines	High	Moderate	
Track 136	Wetland (seep)	Permanently saturated; seasonally inundated	<i>Callistemon viminalis</i> or <i>Callistemon rigidus</i> , <i>Nevillea obtusissima</i> , <i>Gleichenia polypodioides</i> , <i>Fuirena hirsuta</i> , <i>Drosera aliciae</i>	Class C: road disturbance and hydrological impacts	High	Moderate	Impacted by road through wetland and thus change in hydrological functioning as well as pine plantation
Track 137	Dryland	N/A	<i>Cliffortia ruscifolia</i> , <i>Mastersiella digitata</i> , <i>Restio sieberi</i> , <i>Tribolium uniolae</i> , <i>Leucadendron xanthoconus</i> , <i>Syncarpha vestita</i>	Class D: disturbed dryland with ditch	Low	Low	

4.1.3 Management Unit 3 (Track 138 to 143)

This management unit includes a severely impacted section of the Steenbras Nature Reserve. The road along this stretch is flanked either side by mature *Eucalyptus* (gum) trees mostly through dryland and marginal wetland where top soil loss is extensive and natural vegetation cover is sparse. There are three watercourses that traverse this area, one of which is a perennial system with a developed active channel and riparian habitat. The other two are channelled flow from seep wetlands. While these seeps may have had naturally channelled flow, concentration of runoff via culverts and the likely increase in peak runoff associated with the *Eucalyptus* plantations has resulted in severe down-cutting of the channel (particularly the one to the east) and thus drying of the surrounding wetland habitat. Considering the poor condition of the habitats within this reach, these habitats are of low ecological importance and sensitivity. The riparian fringe and active channel of the perennial stream is however rated as of High to Moderate sensitivity as this system still retains natural functioning with intact habitats.

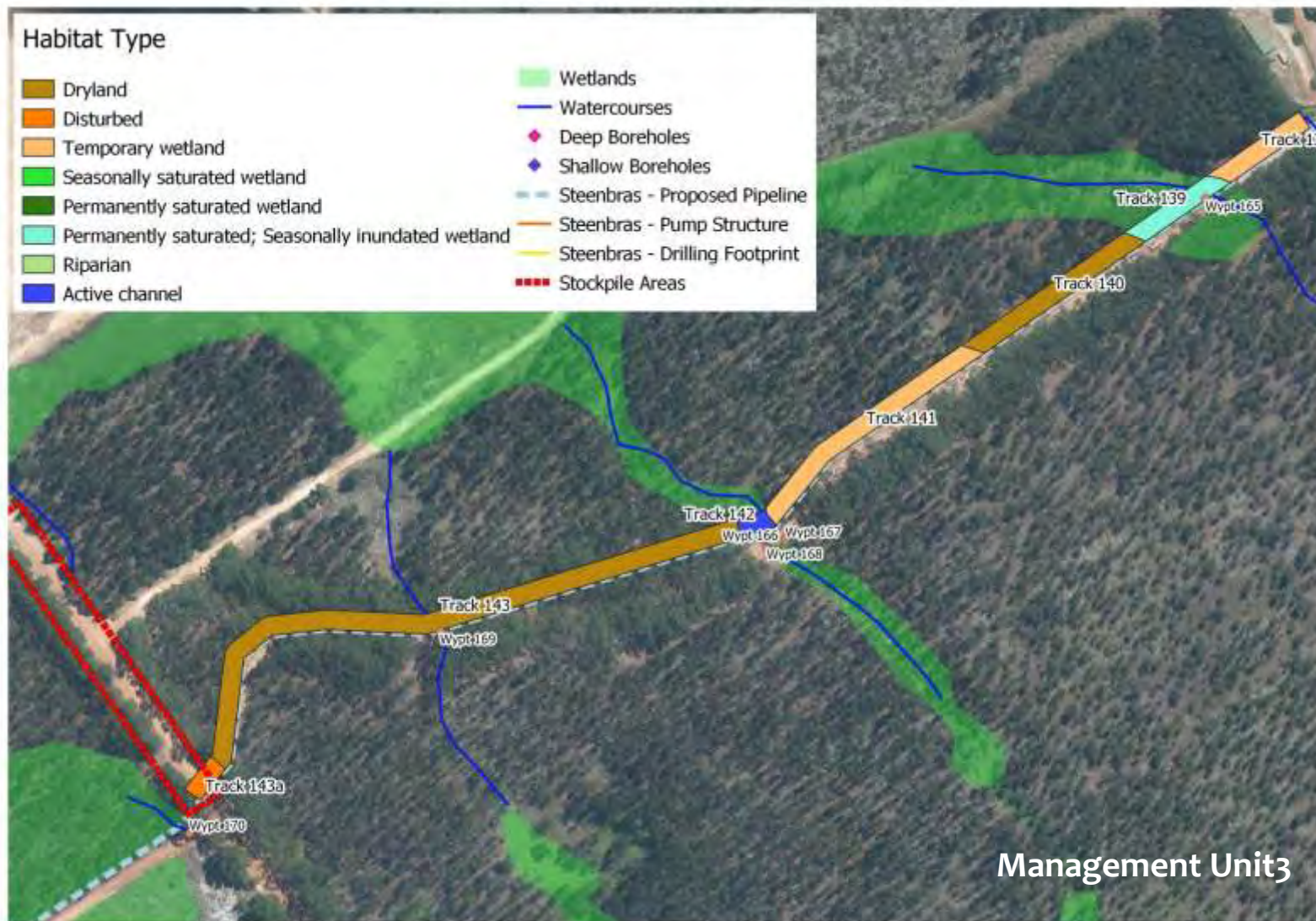


Figure 4.6 Management Unit 3: Spatial extent of Habitat Types.

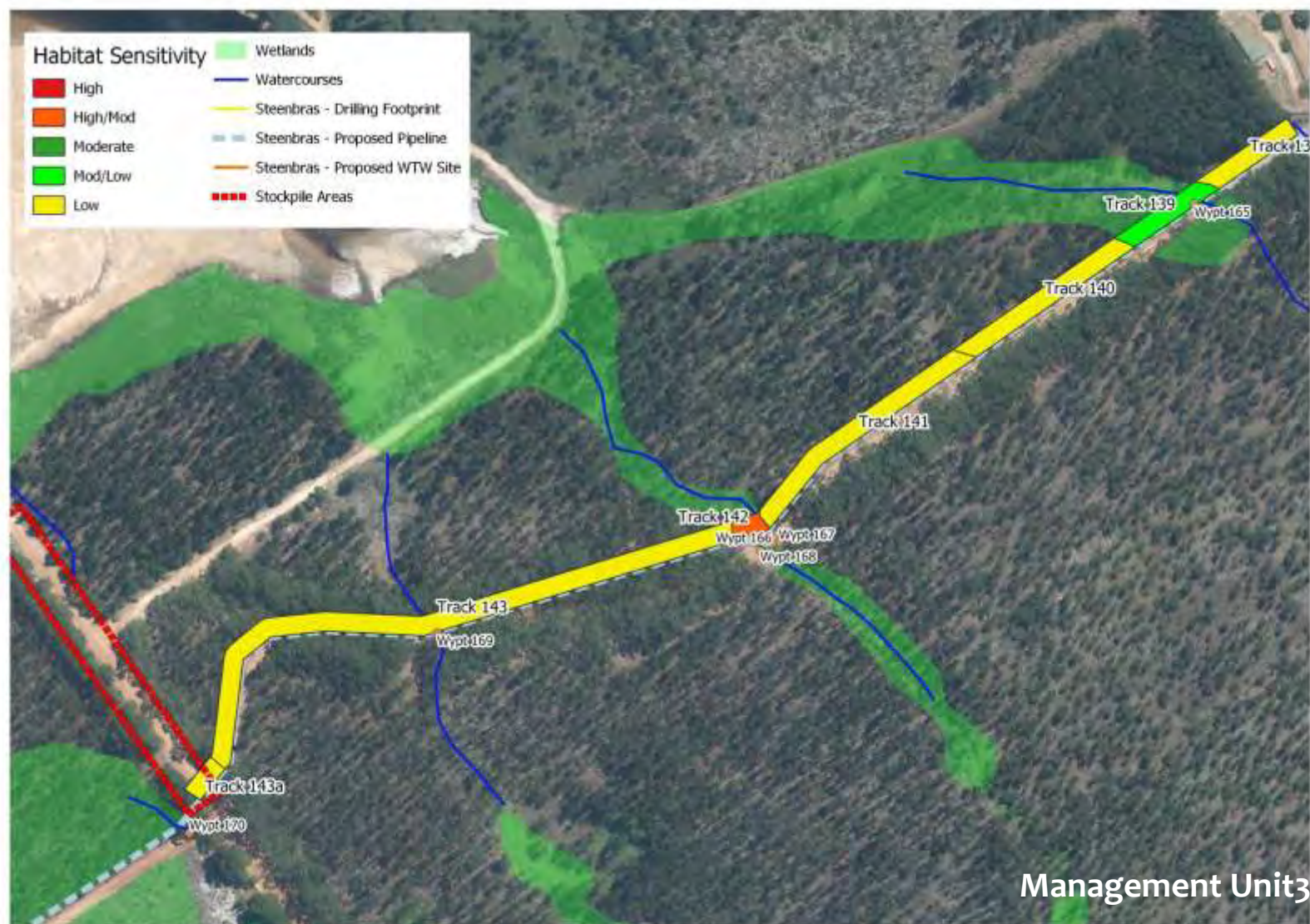


Figure 4.7 Management Unit 3: Habitat sensitivity.

Table 4.3 MU 3: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 138	Wetland (seep)	Plantation	Temporary	Within gums - very disturbed. No natural features. Has drainage ditch carrying runoff from across the road.	Class E: no natural features. Not functional	Low	Low	
WP 165	Artificially created drainage channel	Plantation	Ephemeral	Channel downcut due to concentration of flows from upstream and thus downcutting and drying out of adjacent wetland.	N/A	Low	Low	Channelled flow would naturally have been diffuse flows through wetland seep habitat. Flows have been concentrated, which has led to the formation of an unvegetated, narrow ditch with hydrologically altered wetland habitat on their bank
Track 139	Wetland (seep)	Plantation	Permanently saturated	In blue gums <i>Restio subverticillatus</i> , <i>Pteridium aquilinum</i> , <i>Rumohra adiantiformis</i> ; <i>Acacia longifolia</i>	Class D: invaded with blue gums with sparse natural veg	Moderate	Mod/Low	
Track 140	Dryland	Plantation	N/A	<i>Hackia hedge</i> , <i>Diospyros glabra</i> , <i>Ursinia dentata</i> , <i>Leucadendron salicifolium</i> , <i>Tribolium uniolae</i> . Lots of debris and juvenile <i>Eucalyptus diversicolor</i>	Class E: very impacted	Low	Low	
Track 141	Wetland (seep)	Plantation	Temporary	In Bluegums; <i>Leucadendron xanthoconus</i> , <i>Restio subverticillatus</i> , <i>Diospyros glabra</i> , <i>Stoebe spiralis</i> , <i>Lanaria lanata</i> , <i>Passerina corymbosa</i>	Class D/ E: dried out wetland remnant	Low	Low	was probably seasonal wetland but has dried out due to Eucalyptus and road
WP 166/track 142	Stream	Plantation	Perennial	<i>Gleichenia polypodioides</i> , <i>Osmitopsis asteriscoides</i> , <i>Carphe glomerata</i> , <i>Neesenbeckia punctoria</i> , <i>Pennisetum macrourum</i> , <i>Restio gaudichaudianus</i> , <i>Diospyros glabra</i> , <i>Gnidia oppositifolia</i> , <i>Isolepis digitata</i> . Aliens: <i>Acacia longifolia</i>	Class C/D: riparian habitat is disturbed	High	High/Moderate	
Track 143	Dryland	Plantation	N/A	No topsoil remaining within Eucalyptus forest	Class F: no natural veg	Low	Low	
Track 143a	Disturbed	Plantation	N/A	road		Low	Low	
WP 169	Artificially created drainage channel	Plantation	Ephemeral	Channel downcut due to concentration of flows from upstream and thus downcutting and drying out of adjacent wetland.	N/A	Low	Low	Channelled flow would naturally have been diffuse but there are no natural wetland features

4.1.4 Management Unit 4 (Track 164 to 166)

The overhead powerline route in this MU is through pristine fynbos immediately downstream of the Rockview Dam. The habitat is a combination of *Tetraria thermalis* dominated dry rocky outcrops with permanently saturated *Berzelia lanuginosa* wetlands. This habitat is of high ecological importance and sensitivity.

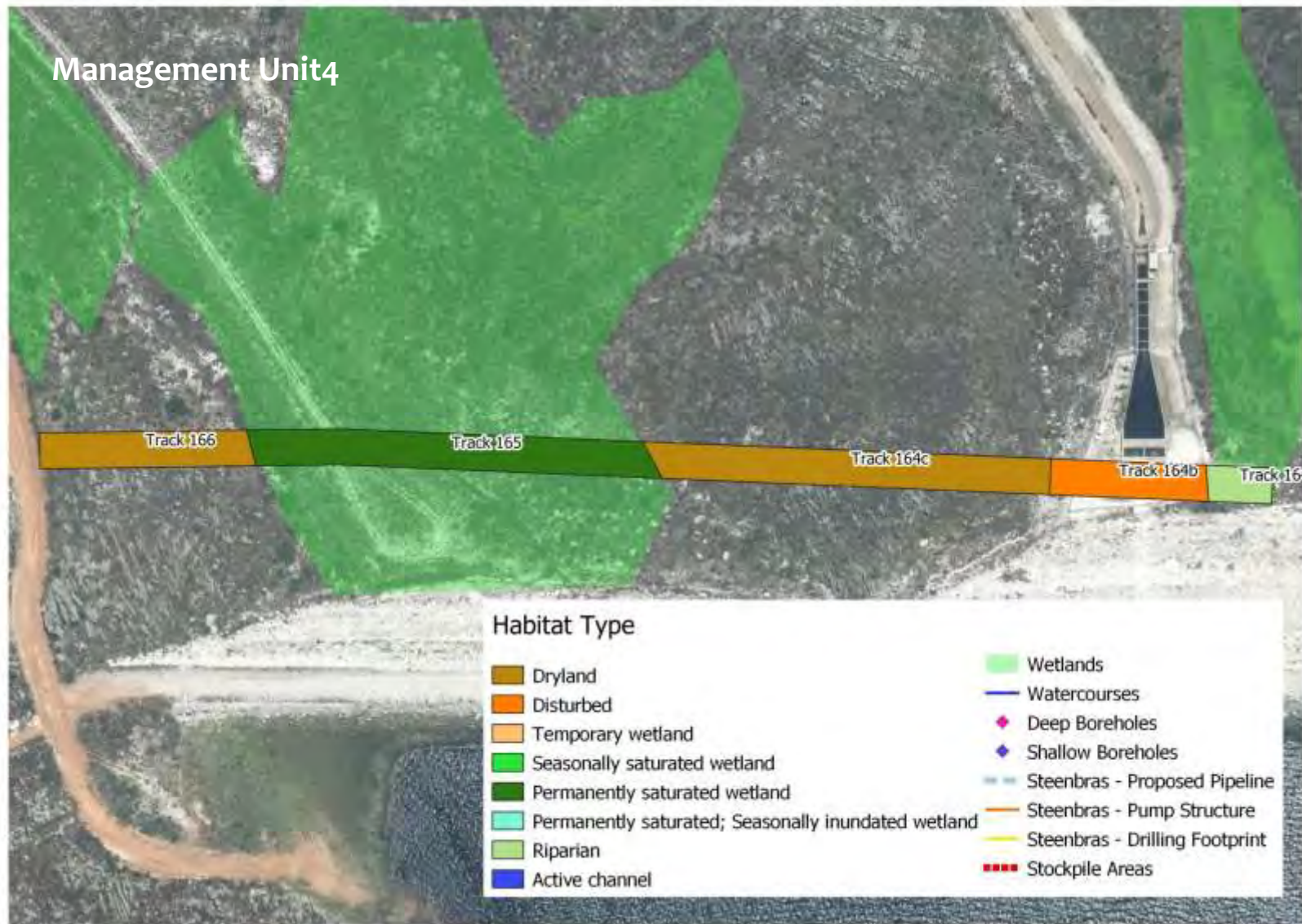


Figure 4.9 Management Unit 4: Spatial extent of Habitat Types.



Figure 4.10 Management Unit 3: Habitat sensitivity.

Table 4.4 MU 4: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological condition	EI	ES
WP 193 & Track 164a	stream	natural	perennial	This marshy stream was probably a rocky system with an active prior to the construction of the dam. It is now a vegetated system fed from the dam with <i>Typha capensis</i> , <i>Berzelia lanuginosa</i> , <i>Gleichenia polypodioides</i> , <i>Stoebe plumosa</i> , <i>Tetraria thermalis</i> , <i>Senecio rigidus</i>	Class C: impacted by dam but still provides functional habitat for aquatic biota	High	High/Moderate
Track 164b	Disturbed	Disturbed	N/A	Footprint of aquaduct	N/A	Low	Low
Track 164c	Dry land	natural	N/A	Rocky outcrop dominated by <i>Erica ericoides</i> , <i>Hypodiscus argenteus</i> . Some aliens along the disturbed dam wall margin include <i>Callistemon viminalis</i>	Class A: pristine habitat	High	High
Track 165	Wetland (seep)	natural	Permanently saturated	Berzelia seep habitat over sand	Class B: natural habitat but disturbed by track through the area	High	High
Track 166	Dry land	natural	N/A	<i>Tetraria thermalis</i> rocky outcrop. Other species include <i>Diospyros glabra</i> , <i>Erica hispidula</i> , <i>Erica coccinea</i>	Class A: pristine habitat	High	High

4.1.5 Management Unit 5 (Track 167 to 180)

The below ground powerline route traverses an area of natural pristine fynbos, characterised by a mix of either permanently or seasonally saturated wetland habitat interspersed by dry rocky outcrops or dryland with deep sands. Habitats along the road margin are however impacted by edge effects from the road and hydrological alterations due to poor drainage of wetlands across the existing road. Most of these habitats are of high to moderately high Ecological Importance and Sensitivity. Towards the northern extent of this route, the habitat is affected to some extent by alien invasion (mostly juvenile *Eucalyptus*) and although the condition of habitats in this area is somewhat affected, the Ecological Sensitivity of these areas remain High to Moderate.

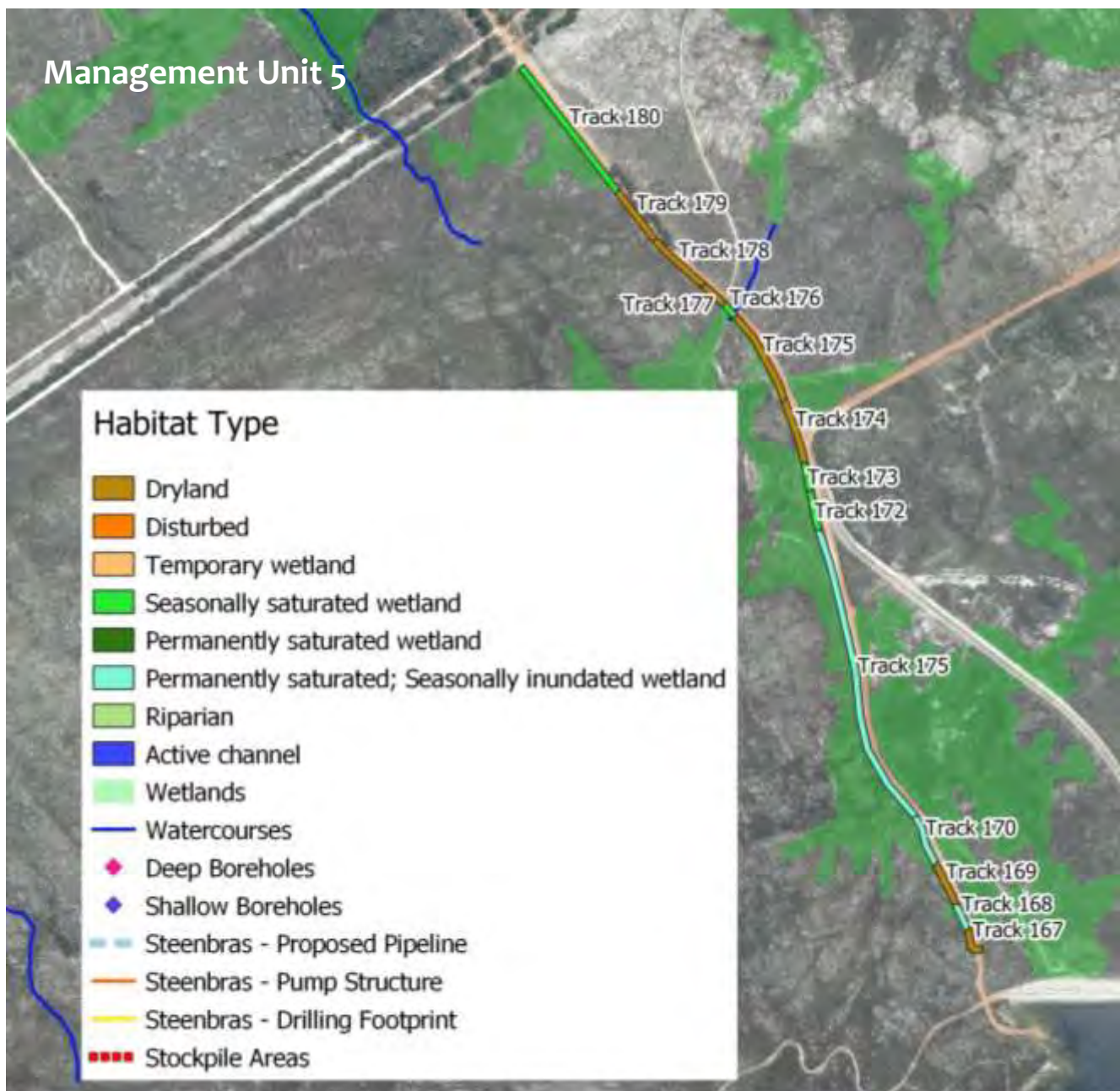


Figure 4.11 Management Unit 5: Spatial extent of Habitat Types.

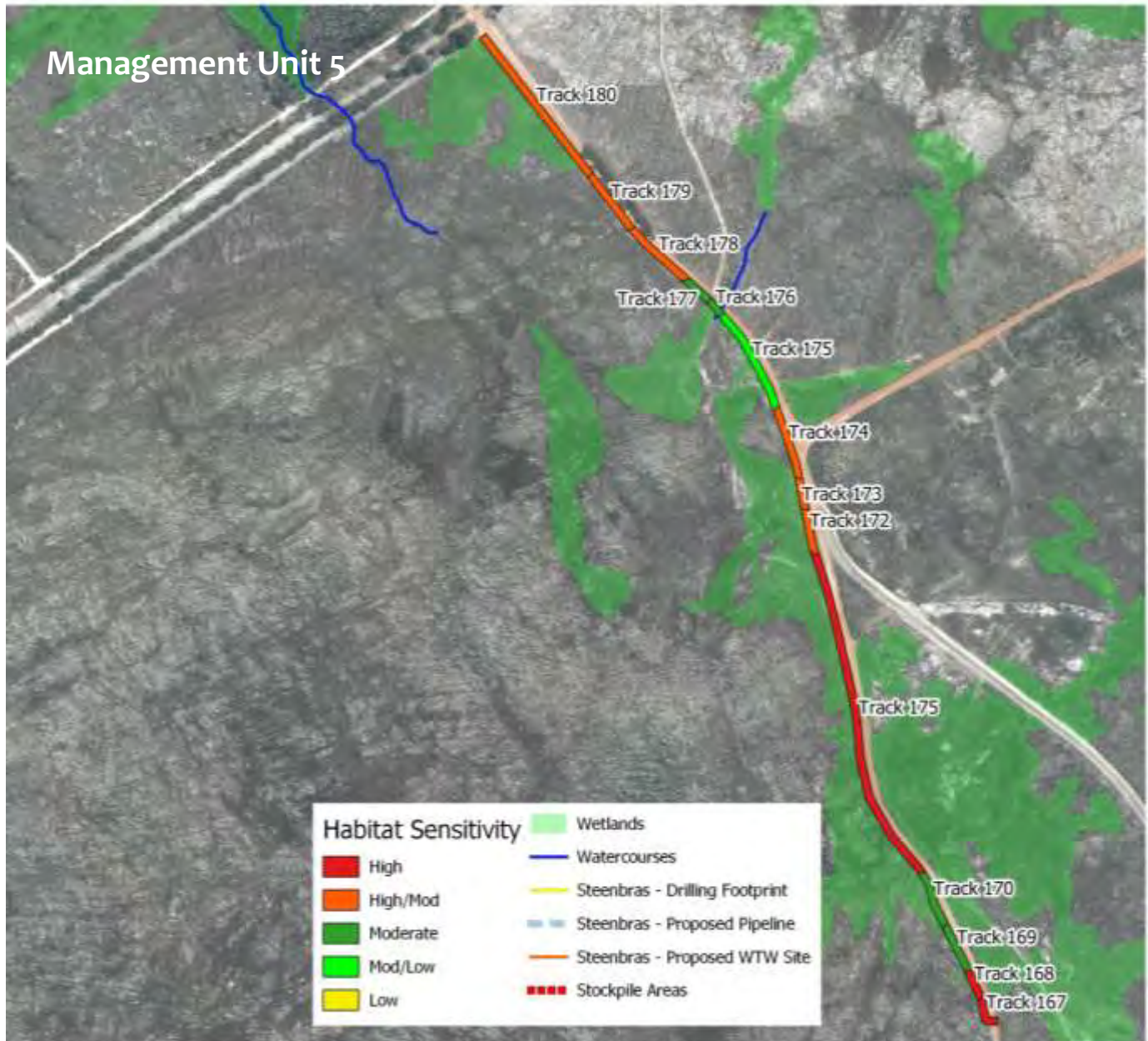


Figure 4.12 Management Unit 5: Habitat sensitivity.

Table 4.5 MU 5: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 167	Dry land	natural	N/A	<i>Berzelia lanuginosa</i> , <i>Cliffortia ruscifolia</i> , <i>Erica ericoides</i> , <i>Restio occultus</i> , <i>Erica hispidula</i> , <i>Anthospermum aethiopicum</i> , <i>Diospyros glabra</i>	Class A: pristine habitat	High	High	
Track 168	Wetland (seep)	natural	permanently saturated; seasonally inundated	<i>Erica viscaria</i> , <i>Diospyros glabra</i> , <i>Berzelia lanuginosa</i> , <i>Erica hispidula</i> , <i>Elegia hookerianum</i> , <i>Erica coccinea</i> , <i>Erica sessiliflora</i> , <i>Restio purpurascens</i> , <i>Psoralea pinnata</i> , <i>Pelargonium cucullatum</i>	Class A: pristine habitat	High	High	
Track 169	Dry land	natural	N/A	Rocky outcrop. Wetness along road margin but runoff from road and impeded wetland upslope. Dominant veg is: <i>Cliffortia ruscifolia</i> . <i>Aristea africana</i>	Class C: Disturbed habitat due to drainage manipulation along road edge.	Moderate	Moderate	
Track 170	Wetland (seep)	natural	permanently saturated; seasonally inundated	<i>Cliffortia ruscifolia</i> along road margin.	Class C: Disturbed habitat due to drainage manipulation along road edge.	Moderate	Moderate	
Track 171	Wetland (seep)	natural	permanently saturated; seasonally inundated	<i>Elegia mucronata</i> , <i>Aristida junciformis</i> , <i>Phaenocoma prolifera</i> , <i>Brunia fragarioides</i> , <i>Erica serrata</i> , <i>Erica sessiliflora</i> , <i>Elegia filacea</i> , <i>Elegia hookerianum</i>	Class A: pristine habitat	High	High	Drainage along this route is somewhat impeded by the road and its diverted along a channel to a culvert below the road
WP 200	Artificially created drainage channel	natural	ephemeral	Channel has been created to divert runoff via a culvert to the downslope side of the road.	N/A	High	High	Don't want turbid runoff during construction entering the <i>Berzelia</i> wetlands downslope of the road via the culvert.
Track 172	Wetland (seep)	natural	seasonally saturated	<i>Erica fastigiata</i> , <i>Leucadendron gandogerii</i> , <i>Restio bifariis</i> , <i>Utricularia capensis</i> , <i>Anthocortus crinalis</i> , <i>Leucadendron salicifolium</i> , <i>Aristida junciformis</i> . <i>Acacia saligna</i> in road material adjacent to the road	Class B/C: Functional wetland habitat but disturbed by road runoff and drainage impediment	High	High/Moderate	road disturbance
Track 173	Wetland (seep)	natural	seasonally saturated	Disturbed wetland.	Class D: margin is very disturbed and erod	High	High/Moderate	Significant erosion of the sandy substratum adjacent to the road (possible overflow from the aquaduct??). Thick mats of red algae suggest nutrient rich inputs of water in the drainage channel adjacent to the road

Table 4.5 continued MU 5: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 174	Dry land	natural	N/A	<i>Tetraria thermalis</i> rocky outcrop.	Class A: pristine habitat	Moderate	High/Moderate	Road margin is disturbed by drainage channel
Track 175	Dry land	natural	N/A	<i>Syncarpha vestita</i> , <i>Elytropappus rhinocerotis</i>	Class B/C: road disturbance	Moderate	Mod/Low	Intact drainage line in close proximity to the road but the road margin is dry
Track 176	Wetland (seep)	natural	seasonally saturated	Disturbed wetland with <i>Thamnochortus gracilis</i> , <i>Ursinia dentata</i> , <i>Stoebe plumosa</i> , <i>Eragrostis curvula</i> , <i>Staberoha cernua</i> , <i>Passerina corymbosa</i> , <i>Athanasia trifurcata</i>	Class B/C: road disturbance and fill	Moderate	Moderate	Vegetation is dominated by roadside pioneers from introduced road material - <i>Anthospermum aethiopicum</i> , <i>Diospyros glabra</i> , <i>Cliffortia ruscifolia</i>
WP 204	Artificially created drainage channel	natural	ephemeral		N/A	High	High/Moderate	
Track 177	Dry land	natural	N/A	<i>Cliffortia ruscifolia</i> , <i>Hypodiscus aristatus</i> , <i>Diastella thymelaeoides</i> , <i>Adenandra marginata</i> , <i>Protea cynaroides</i> , <i>Phaenocoma prolifera</i> , <i>Grubbia tormentosa</i>	Class B: road disturbance and some aliens	Moderate	Moderate	
Track 178	Dry land	natural	N/A	<i>Cliffortia ruscifolia</i> , <i>Syncarpha vestita</i> , <i>Stoebe plumosa</i> , <i>Hypodiscus aristatus</i> , <i>Restio occultus</i> , <i>Erica hispidula</i> , <i>Ursinia dentata</i> , <i>Gnidia pinifolia</i>	Class A: pristine habitat	High	High/Moderate	Opposite side of the road has many juvenile blue gums
Track 179	Dry land	natural	N/A	<i>Restio occultus</i> , <i>Protea cynaroides</i> , <i>Ursinia dentata</i> , <i>Thamnochortus gracilis</i> , <i>Stoebe cinerea</i> , <i>Phaenocoma prolifera</i> , <i>Diospyros glabra</i> , <i>Cliffortia atrata</i>	Class A: pristine habitat	High	High/Moderate	
Track 180	Wetland (seep)	natural	seasonally saturated	<i>Erica ericoides</i> , <i>Diospyros glabra</i> , <i>Hypodiscus argenteus</i> , <i>Elytropappus rhinocerotis</i> , <i>Anthospermum aethiopicum</i> , <i>Athanasia trifurcata</i> , <i>Ursinia dentata</i> , <i>Erica denticulata</i> , <i>Eragrostis curvula</i> , <i>Erica hispidula</i> , <i>Tribolium uniola</i> . Aliens: <i>Eucalyptus diversicolor</i>	Class B/C: disturbed by road and aliens	High	High/Moderate	

4.1.6 Management Unit 6 (Track 181 to 166)

The below ground powerline route in this MU is along a road that passes through dense mature *Eucalyptus* plantations to the east with a line *Eucalyptus* immediately west with either Pine plantations or recently felled pine trees further west. With the exception of an area of permanently saturated and seasonally inundated wetlands to the west, the habitat within this MU is highly disturbed dryland with low Ecological Importance and Sensitivity.



Figure 4.13 Management Unit 6: Spatial extent of Habitat Types.

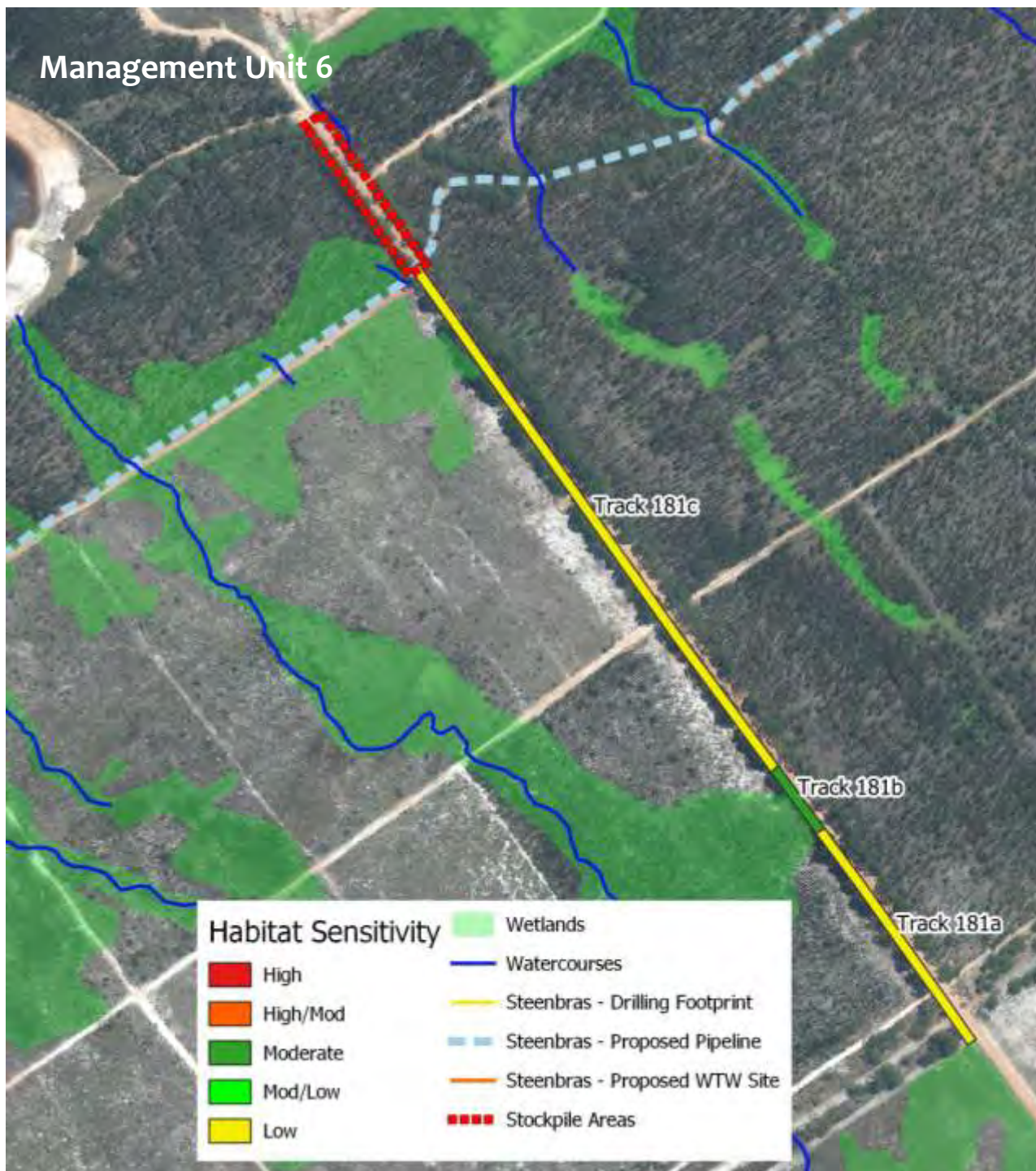


Figure 4.14 Management Unit 5: Habitat Sensitivity.

Table 4.6 MU 6: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ground-truthed PES (site visit)	EI	ES	Comment
Track 181a	Dry land	Plantation	N/A	<i>Eucalyptus diversicolor</i>	Class F - no topsoil	Low	Low	
Track 181b	Wetland (seep)	Plantation	permanently saturated; seasonally inundated	<i>Nevillea obtusissima</i> , <i>Elegia mucronata</i> , <i>Elegia hookerianum</i> , <i>Hymenolepis crithmifolia</i>	Class B/C: disturbed by aliens	Moderate	Moderate	High Iron content in water, area could be groundwater fed
Track 181c	Dry land	Plantation	N/A	<i>Eucalyptus diversicolor</i>	Class F - no topsoil	Low	Low	
WP 213	Wetland (seep)	Plantation	seasonally saturated	<i>Elegia mucronata</i> , <i>Gleichenia polypodioides</i>	Class B: disturbed by aliens	Moderate	Moderate	Drier than wetland upslope

4.1.7 Management Unit 7 (Track 144 to 150)

The pipeline route is situated north of the dirt track within a mature pine plantation with an area recently cleared of pines to the south of the dirt track. Most of the habitat along this route is wetland, disturbed by alien trees (pines) and hydrological changes due to the road that traverses these wetlands. There are several artificial drainage channels across the road that channel naturally diffuse runoff across the road. This has led to drying out of the wetlands downslope as most of the runoff is concentrated. Despite these impacts, the habitat is relatively intact and supports functional wetlands that are of moderate Ecological Sensitivity. The top soil is still intact and thus removal of the pines would result in significant recovery of these habitats. There are two natural ephemeral watercourses across this route with runoff passing via culverts below the road. These habitats, together with the wetlands either side are considered of High to Moderate Ecological Importance and Sensitivity.

The footprint of borehole **H83b** falls within wetland habitat at the western extent of the MU.

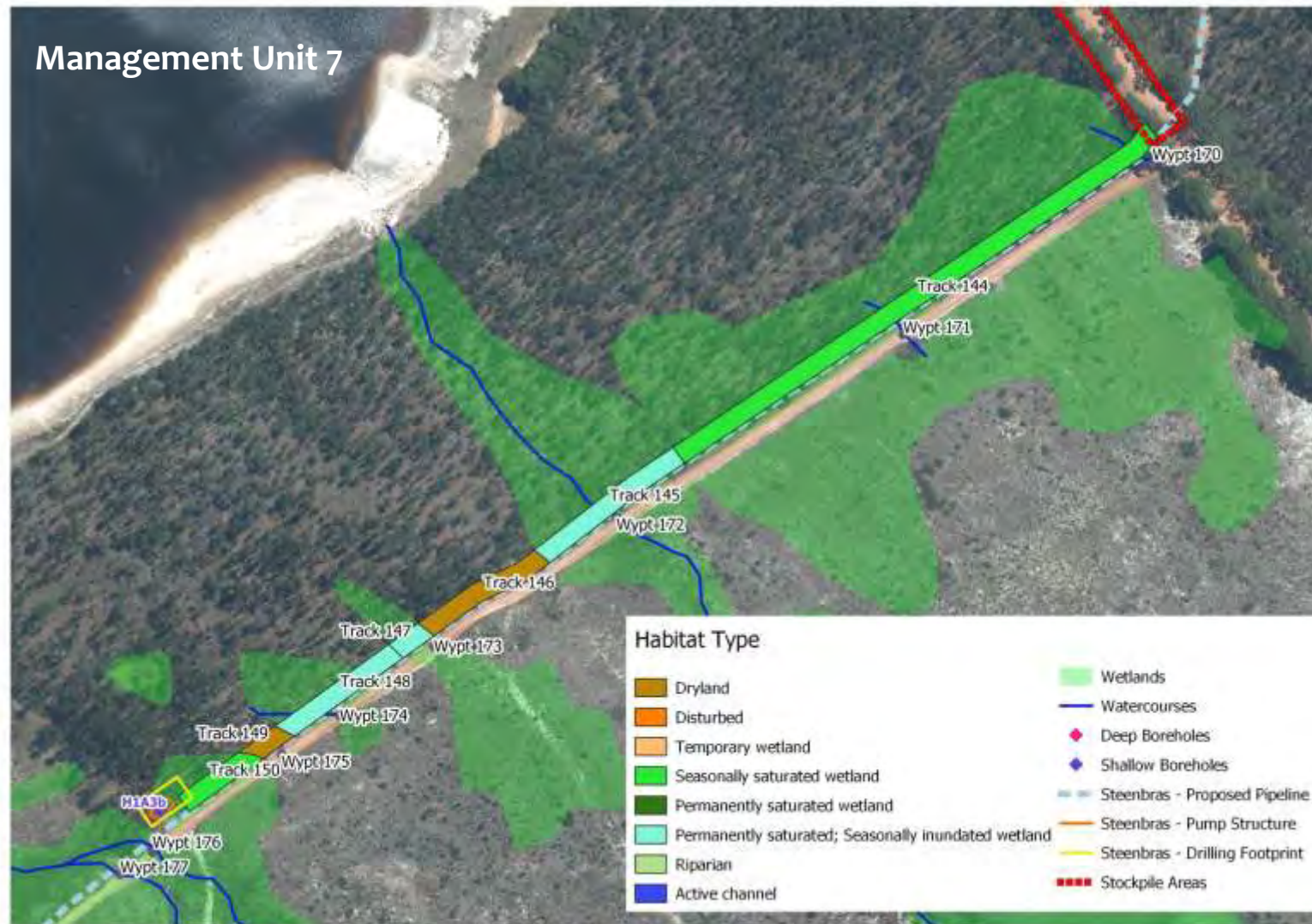


Figure 4.15 Management Unit 7: Spatial extent of Habitat Types.

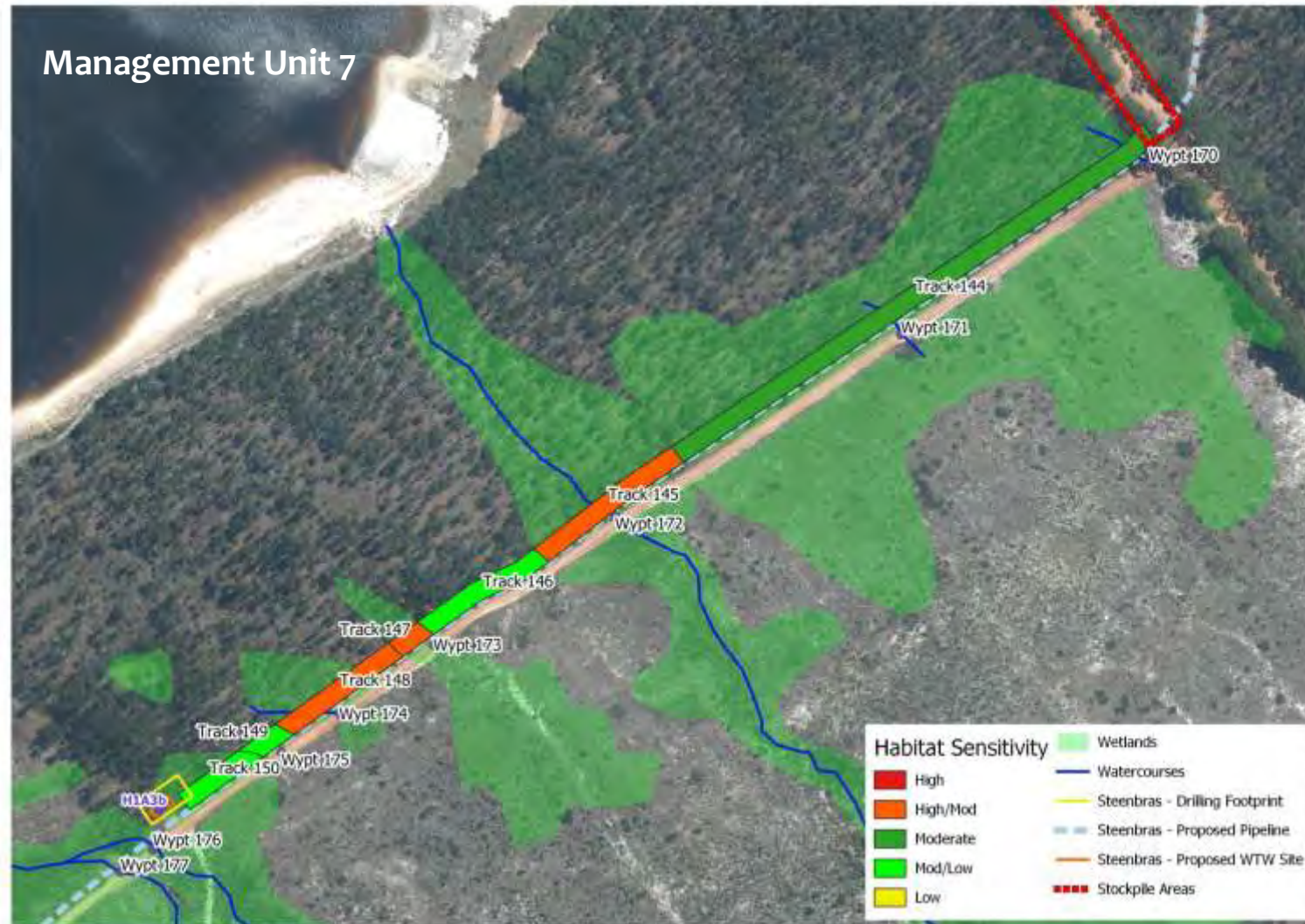


Figure 4.16 Management Unit 7 Habitat Sensitivity.

Table 4.7 MU 7: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 144	Wetland (seep)	Plantation - north side only	Seasonal wetland	<i>Thamnochortus gracilis</i> , <i>Aristida junceiformis</i> , <i>Diospyros glabra</i> , <i>Lanaria lanata</i> , <i>Ursinia dentata</i> , <i>Restio perplexus</i> , <i>Stoebe cinerea</i> , <i>Tribolium uniola</i> , <i>Leucadendron xanthoconus</i> , <i>Elytropappus rhinocerotis</i> . Aliens: <i>Acacia longifolia</i>	Class D/ E: dried out wetland remnant	Moderate	Moderate	Still has rehabilitation potential so if pines were removed, wetland would recover somewhat although drainage impeded by road
WP 170	Artificially created drainage channel	Plantation - north side only	ephemeral	No remaining wetland veg species adjacent to channel	N/A	Low	Low	Diffuse flows from upslope of the road are channelised and directed to the downslope area via culverts below the road
WP 171	Artificially created drainage channel	Plantation - north side only	ephemeral	Some wetland grasses surrounding the channel. Dry at the time of site visit. Veg species include: <i>Mimetes cucullatus</i> , <i>Tetraria flexuosa</i> , <i>Gnidia oppositifolia</i>	N/A	Low	Low	Diffuse flows from upslope of the road are channelised and directed to the downslope area via culverts below the road
Track 145	Wetland (seep)	Plantation - north side only	permanently saturated; seasonally inundated	<i>Lanaria lanata</i> , <i>Willdenowia teres</i> , <i>Berzelia lanuginosa</i> . Aliens include: <i>Acacia longifolia</i> , <i>Acacia melanoxylon</i>	Class C: road disturbance and hydrological impacts but functional habitat	Moderate	High/Moderate	
WP 172	stream	Plantation - north side only	ephemeral	<i>Neesenbeckia punctaria</i> , <i>Senecio rigidus</i> , <i>Diospyros glabra</i> , <i>Erica perspicua</i> , <i>Restio egregius</i> , <i>Pseudopentameris macrantha</i> , <i>Elegia hookerianum</i> , <i>Gleichenia polypodioides</i> all within pine plantation	Class C: road disturbance and hydrological impacts but functional habitat	Moderate	High/Moderate	Diffuse flows from upslope of the road are channelised and directed to the downslope area via culverts below the road
Track 146	Dryland	Plantation - north side only	N/A	<i>Staberoha cernua</i> , <i>Elytropappus rhinocerotis</i> , <i>Stoebe cinerea</i> , <i>Lanaria lanata</i> . Aliens: <i>Pinus pinaster</i>	Class D: impacted by pine plantation	Moderate	Mod/Low	Would recover if pines removed because top soil and seed bank still present
WP 173	stream	Plantation - north side only	ephemeral	Well vegetated ephemeral stream	Class C: in pines and impacted by road but still functional	High	High/Moderate	
Track 147	Wetland (seep)	Plantation - north side only	permanently saturated; seasonally inundated	<i>Restio obtusissimus</i> , <i>Erica serrata</i> with some alien <i>Acacia longifolia</i>	Class C: Pines and road disturbance and hydrological impacts but functional habitat	Moderate	High/Moderate	
Track 148	Wetland (seep)	Plantation - north side only	seasonally saturated	<i>Tetraria flexuosa</i> , <i>Diospyros glabra</i> , <i>Erica ericoides</i> , <i>Elegia filacea</i> , <i>Erica labialis</i> , <i>Gleichenia polypodioides</i> , <i>Hypolaena digitata</i> , <i>Athanasia trifurcata</i> with some alien <i>Acacia longifolia</i>	Class C: Pines and road disturbance and hydrological impacts but functional habitat	Moderate	High/Moderate	Some road disturbance within the habitat along road
WP 174	stream	Plantation - north side only	ephemeral		Class C/D: some downcutting due to concentration of flows from upstream seep habitat.	Moderate	Moderate	Flows would naturally be more diffuse
Track 149	Dryland	Plantation - north side only	N/A		Class D: impacted by pine plantation	Moderate	Mod/Low	
Track 150	Wetland (seep)	Plantation - north side only	seasonally saturated	Already under construction site	Class D: impacted by pine plantation	Moderate	Mod/Low	Footprint of H1A3b

4.1.8 Management Unit 8 (Track 151 to 162 and Track 205 to 211)

This management unit includes an area that is naturally vegetated but secondary habitat following the removal of a mature pine plantation. Wetlands are extensive, both seasonally and permanently saturated systems, separated by small areas of sandy dryland. Several natural channels cross the road via culverts within this area, with one perennial stream at the western end of the route. Most of the wetlands are considered of High to Moderate Ecological Importance and Sensitivity, while the drylands are of Moderate ES, largely due to disturbance from the road. Areas of low ecological sensitivity are those through the firebreak and *Eucalyptus* trees west of the fire break.



Figure 4.17 Management Unit 8: Spatial extent of Habitat Types.



Figure 4.18 Management Unit 8 Habitat Sensitivity.

Table 4.8 MU 8: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 205	Riparian	Natural	permanently saturated	<i>Berzelia lanuginosa</i> , <i>Passerina corymbosa</i> , <i>Hypodiscus argenteus</i> , <i>Diospyros glabra</i> , <i>Elegia mucronata</i> , <i>Neesenbeckia punctoria</i> , <i>Brachylaena neriifolia</i> , <i>Stoebe cinerea</i>	Class B: natural habitat but with some juvenile alien <i>Acacia longifolia</i> and <i>Eucalyptus diversicolor</i>	High	High	Riparian fringe of stream 2
WP 227	stream	Natural	perennial	Boulder/bedrock stream with <i>Prionium serratum</i> , <i>Isolepis digitata</i> , <i>Penaea mucronata</i> , <i>Brunia africana</i> , <i>Restio purpurascens</i>	Class A/B: natural stream with some minor impacts from road and historic plantations	High	High	Active channel of stream 2
Track 206	Wetland (seep)	Natural	permanently saturated	<i>Elegia hookerianum</i> , <i>Erica viscaria</i> , <i>Erica fastigiata</i> , <i>Erica ericoides</i> , <i>Berzelia alopecuroides</i>	Class B: natural habitat but with some disturbance (no aliens)	High	High	
Track 207	Dryland	Recovered post plantation	N/A	Rocky outcrop with <i>Saltera sarcocolla</i> , <i>Lanaria lanata</i> , <i>Erica fastigiata</i> . Some aliens (<i>Eucalyptus diversicolor</i>)	Class C: natural habitat with some aliens but good natural cover among rocky outcrops	Moderate	High/Moderate	
Track 208	Wetland (seep)	Recovered post plantation	seasonally saturated	<i>Elegia hookerianum</i> marsh	Class C: natural seep habitat in relatively good condition	Moderate	High/Moderate	
WP 228	Artificially created drainage channel	Plantation	ephemeral	Drainage line within impacted seep habitat. Narrow channel with concentrated flows from culvert beneath the road. Fine substratum susceptible to erosion due to sparse base cover within <i>Eucalyptus</i> stand.	N/A	Moderate	High/Moderate	Susceptible to erosion
Track 209	Wetland (seep)	Plantation	seasonally saturated	<i>Elegia hookerianum</i> marsh	Class D: seep habitat invaded by <i>Eucalyptus</i>	Moderate	Moderate	
WP 229	Artificially created drainage channel	Plantation	ephemeral	Drainage line within impacted seep habitat. Downcutting evident due to concentrated flows. Fine substratum susceptible to erosion due to sparse base cover within <i>Eucalyptus</i> stand. Feeds intact <i>Berzelia</i> wetland further downstream.	N/A	Moderate	High/Moderate	
Track 210	Dryland	Rocky outcrop - pl	N/A	Rocky outcrop with <i>Erica serrata</i> , <i>Lanaria lanata</i> , <i>Erica ericoides</i> , <i>Elegia persistens</i> , <i>Willdenowia teres</i> , <i>Saltera sarcocolla</i>	Class C/D: Relatively good vegetation cover within rocky area with some alien invasion	Moderate	High/Moderate	
Track 211	Dryland	Rocky outcrop - pl	N/A	Rocky outcrop infested with <i>Eucalyptus diversicolor</i>	Class E: infested with aliens - indigenous vegetation almost all gone	Low	Low	
Track 211a	Disturbed	Firebreak		Bare sand in firebreak - no veg	Class F	Low	Low	
Track 163a	Wetland (seep)	Recovered post plantation	seasonally saturated		Class D: invaded with juvenile blue gums	Moderate	Mod/Low	
Track 163	Dryland	Plantation	N/A	Invaded with mature Gums - very little natural vegetation	Class E: no natural veg remaining and topsoil lost	Low	Low	
WP 182	stream	Recovered post plantation	seasonal			Moderate	Moderate	
Track 162	Wetland (seep)	Recovered post plantation	permanently saturated; seasonally inundated	<i>Nevillea obtusissima</i> , <i>Elegia mucronata</i> , <i>Senecio rigidus</i> , <i>Berzelia ecklonii</i>	Class B: wetland habitat in relatively good condition but previously a pine plantation	High	High/Moderate	Some road disturbance within the habitat along road
Track 161	Dryland	Recovered post plantation	N/A	<i>Serruria elongata</i>	Class C: impacted by road disturbance and previous plantations but relatively intact	Moderate	Moderate	Some road disturbance within the habitat along road

Table 4.8 continued MU 8: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 160	Wetland (seep)	Recovered post plantation	seasonally saturated	<i>Cliffortia ruscifolia</i> , <i>Anthospermum aethiopicum</i> , <i>Tetraria fasciata</i> , <i>Berzelia lanuginosa</i> , <i>Restio perplexus</i> , <i>Psoralea pinnata</i> , <i>Passerina corymbosa</i> , <i>Hypolaena digitata</i> , <i>Athanasia trifurcata</i> . Some juvenile Eucalyptus species	Class B/C: wetland habitat in relatively good condition but aliens encroaching	High	High/Moderate	
Track 159	Dryland	Recovered post plantation	N/A	<i>Erica serrata</i> , <i>Cliffortia ruscifolia</i>	Class C: impacted by road disturbance and previous plantations but relatively intact	Moderate	Moderate	Some road disturbance within the habitat along road
Track 158	Wetland (seep)	Recovered post plantation	seasonally saturated	<i>Erica labialis</i> , <i>Pentameris curvifolia</i> , <i>Stoebe cinerea</i> , <i>Diospyros glabra</i> , <i>Crassula fascicularis</i> , <i>Stoebe plumosa</i> , <i>Cliffortia ruscifolia</i> , <i>Hypolaena digitata</i>	Class B: wetland habitat in relatively good condition but previously a pine plantation	High	High/Moderate	Some road disturbance within the habitat along road
Track 157	Dryland	Recovered post plantation	N/A	<i>Diospyros glabra</i> , <i>Anthospermum aethiopicum</i> , <i>Carpobrotus edulis</i> , <i>Lanaria lanata</i> , <i>Eragrostis curvula</i> , <i>Ursinia dentata</i>	Class C: impacted by road disturbance and previous plantations but relatively intact	Moderate	Moderate	Some road disturbance within the habitat along road
Track 156	Wetland (seep)	Recovered post plantation	seasonally saturated		Class B/C: wetland habitat in relatively good condition but impacted hydrologically by road	High	High/Moderate	Runoff impeded by road
WP 181	Artificially created drainage channel	Recovered post plantation	ephemeral		Class C/D: some downcutting due to concentration of flows from upstream seep habitat.	Moderate	Moderate	Flows would naturally be more diffuse
Track 155	Dryland	Recovered post plantation	N/A	<i>Erica serrata</i> , <i>Erica ericoides</i> , <i>Hypodiscus aristatus</i> , <i>Hypodiscus argenteus</i> , <i>Stoebe cinerea</i> , <i>Diospyros glabra</i> with some young pines	Class C/D: impacted by road disturbance and previous plantations	Moderate	Mod/Low	
WP 180	Wetland (seep)	Recovered post plantation	seasonally saturated	Disturbed area	Class E: very little natural veg remaining	Low	Low	Area impacted by gravels washing off the road; potential bypass area
Track 154	Wetland (seep)	Recovered post plantation	seasonally saturated	<i>Erica curvula</i> , <i>Athanasia trifurcata</i> , <i>Stoebe cinerea</i>	Class B/C: wetland habitat in relatively good condition	High	High/Moderate	
WP 179	Artificially created drainage channel	Recovered post plantation	ephemeral	Donga through habitat due to concentration of flows from upstream	Class D: Erosion	Moderate	High/Moderate	Sensitive to further erosion
Track 153	Dryland	Recovered post plantation	N/A	<i>Erica serrata</i> , <i>Erica ericoides</i> , <i>Hypodiscus aristatus</i> , <i>Hypodiscus argenteus</i> , <i>Stoebe cinerea</i> , <i>Diospyros glabra</i> with some young pines	Class C/D: impacted by road disturbance and previous plantations	Moderate	Mod/Low	
WP 178	Artificially created drainage channel	Recovered post plantation	ephemeral	Narrow ephemeral channel with little evidence of erosion (rocky substratum). Indigenous veg along margins include <i>Diospyros glabra</i> , <i>Stoebe plumosa</i>	Class B/C: wetland habitat in relatively good condition	High	High/Moderate	Flowing at the time of site visit. No donga formation but flows are concentrated and likely to erode downwards with time
WP 177	Artificially created drainage channel	Recovered post plantation	ephemeral	Concentrated flows from upstream wetland due to culvert. <i>Erica coccinea</i> , <i>Berzelia lanuginosa</i> , <i>Erica labialis</i> , <i>Elegia mucronata</i> , <i>Cliffortia juniperifolia</i> , <i>Aristida junciformis</i> , <i>Ficinia indica</i>	Class B/C: wetland habitat in relatively good condition	Moderate	Moderate	Channel is not eroding as flows tend to spread downstream.
WP 176	stream	Recovered post plantation	seasonal	Rocky substratum with seasonal flows and surrounded by <i>Berzelia</i> / <i>Elegia</i> wetlands	Class B/C: wetland habitat in relatively good condition	High	High/Moderate	
Track 152	Wetland (seep)	Recovered post plantation	permanently saturated; seasonally inundated	<i>Berzelia</i> and <i>Elegia mucronata</i> wetland. Veg species: <i>Berzelia lanuginosa</i> , <i>Neesenbeckia punctoria</i> , <i>Elegia mucronata</i> , <i>Cliffortia ruscifolia</i> , <i>Erica labialis</i>	Class B: wetland habitat in relatively good condition	High	High	
Track 151	Wetland (seep)	Plantation	seasonally saturated	No veg - site of borehole: H1A3b	Class D: wetland habitat functional but impacted by pines	Moderate	Moderate	H1A3b

4.1.9 Management Unit 9 (Track 191 and Track 197)

This entire MU is characterised as sandy dryland through *Eucalyptus* with areas dominated by restios. There are some rocky outcrops at the southern extent of the route that are more sensitive than the disturbed sandy habitats and thus the sensitivity of the habitats within this route range from Low to Moderate. Both H8A4a and H8A4b fall within this MU.

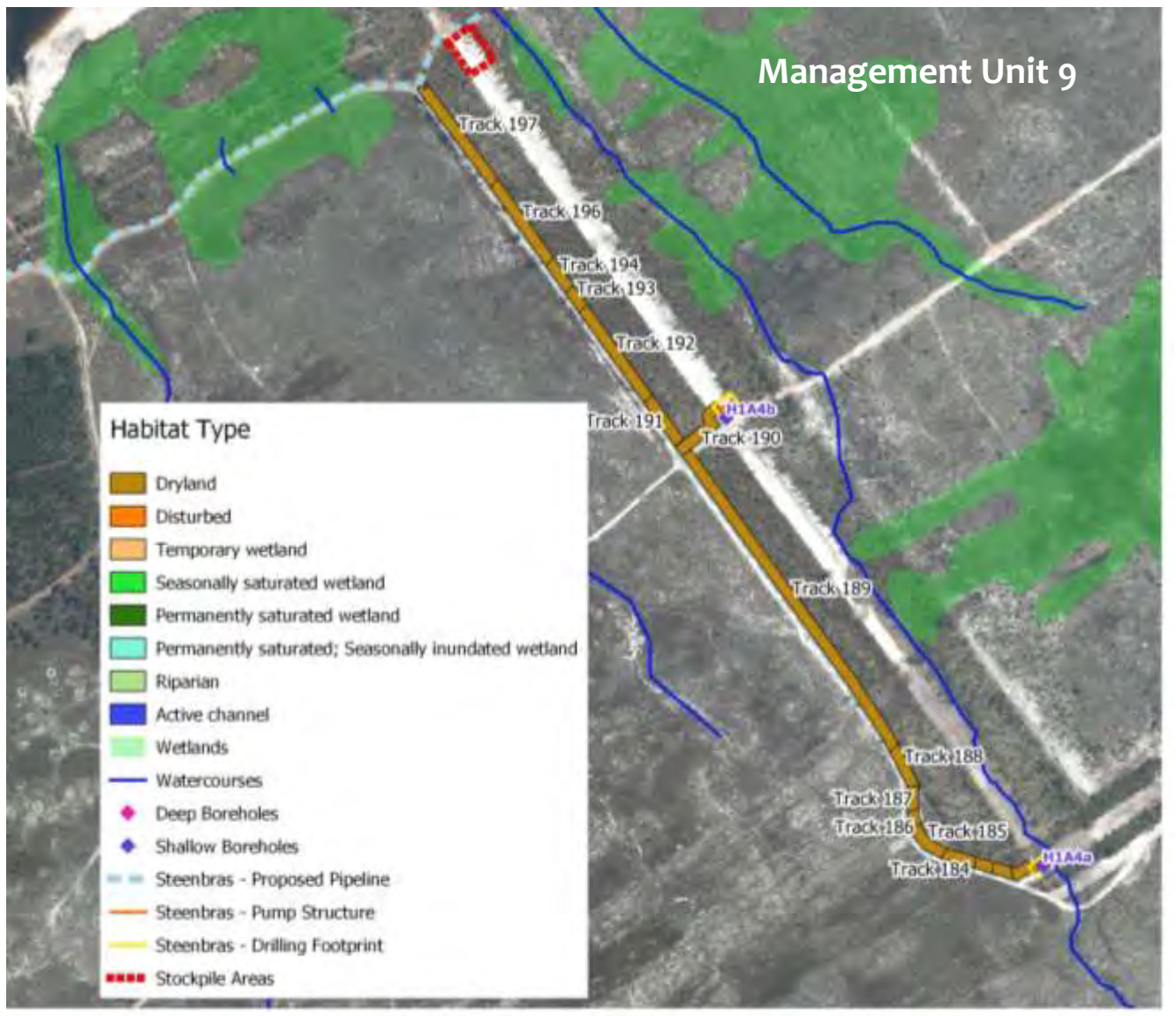


Figure 4.19 Management Unit 9: Spatial extent of Habitat Types.



Figure 4.20 Management Unit 9 Habitat Sensitivity.

Table 4.9 MU 9: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 182 and WP 214	Dry land	Plantation - east side only	N/A	Sandy dryland in <i>Eucalyptus</i> with <i>Elegia filacea</i> , <i>Thamnochortus gracilis</i> , <i>Anthochortus crinalis</i> , <i>Erica pulchella</i> , <i>Stoebe cinerea</i> , <i>Hypodiscus aristatus</i> , <i>Erica serrata</i> , <i>Erica imbricata</i> , <i>Willdenowia teres</i>	Class C/D: impacted by invaded alien Blue gums but still some natural vegetation	Moderate	Moderate	
Track 182a	Disturbed	Plantation - east side only	N/A	Firebreak	N/A	Low	Low	
Track 183	Dry land	Plantation - east side only	N/A	Parking lot - sandy with no veg	Class E - no veg	Low	Low	Can be used to store material during construction of infrastructure
Track 184	Dry land	Natural	N/A	Rocky area with <i>Leucadendron gandogerii</i> , <i>Erica ericoides</i> , <i>Hypodiscus aristatus</i> , <i>Willdenowia teres</i> , <i>Phaenocoma prolifera</i> , <i>Lanaria lanata</i> , <i>Corymbium glabrum</i> , <i>Erica pulchella</i> , <i>Anthochortus crinalis</i> , <i>Restio capensis</i> , <i>Elegia persistens</i> , <i>Thamnochortus gracilis</i> , <i>Stoebe cinerea</i> . Also <i>Erica hispidula</i> , <i>Restio bifarius</i> , <i>Cliffortia tridentata</i> , <i>Diospyros glabra</i>	Class C - although previously in plantation, has natural vegetation	Moderate	Moderate	Rocky habitat
Track 185	Dry land	Natural	N/A	Similar to Track 184 but worse condition	Class C/D - natural vegetation sparse	Moderate	Mod/Low	
Track 186	Dry land	Plantation - east side only	N/A	Disturbed area where pines have been burnt so has left a scar in the landscape	Class E - very little natural vegetation	Low	Low	Can be used to store material during construction of infrastructure or as a bypass
Track 187	Dry land	Plantation - east side only	N/A	Rocky dryland with <i>Lanaria lanata</i> , <i>Ursinia dentata</i> , <i>Elegia persistens</i> , <i>Anthochortus crinalis</i> , <i>Erica hispidula</i> , <i>Erica calycina</i> , <i>Mastersiella digitata</i>	Class D - natural vegetation sparse	Moderate	Mod/Low	
Track 188	Dry land	Plantation - east side only	N/A	<i>Lanaria lanata</i> , <i>Thamnochortus gracilis</i> , <i>Hypodiscus aristatus</i> , <i>Mastersiella digitata</i> , <i>Tetraria cuspidata</i> , <i>Elegia deustum</i> , <i>Erica ericoides</i> .	Class D - natural vegetation sparse	Moderate	Mod/Low	
Track 189	Dry land	Plantation - east side only	N/A	<i>Eucalyptus</i> disturbed restio veld but some natural vegetation includes <i>Anthochortus crinalis</i> , <i>Restio pedicellatus</i> , <i>Diastella thymelaeoides</i> , <i>Elegia filacea</i> , <i>Syncarpha vestita</i> , <i>Mastersiella digitata</i> . Aliens include <i>Pinus pinaster</i>	Class E - very little natural vegetation	Moderate	Mod/Low	
WP 219	Dryland	Plantation - east side only	N/A	Sandy dryland with no vegetation because it is within the firebreak	Class E/F - no veg	Low	Low	Footprint of H1A4b
Track 190	Dryland	Plantation - east side only	N/A	Restio veld under <i>Eucalyptus</i> stand with <i>Hypodiscus aristatus</i> , <i>Lanaria lanata</i> , <i>Willdenowia teres</i> , <i>Anthochortus crinalis</i> , <i>Tetraria fasciata</i> , <i>Elegia persistens</i>	Class D - natural vegetation sparse	Moderate	Mod/Low	
Track 191	Dryland	Plantation - east side only	N/A	Disturbed restio veld with <i>Thamnochortus gracilis</i> , <i>Anthochortus crinalis</i> , <i>Mastersiella digitata</i> , <i>Tetraria fasciata</i>	Class D/E - natural vegetation sparse with high level of disturbance in the area adjacent to the road	Moderate	Low	This whole strip has rehabilitation potential but could be used as a bypass
Track 192	Dryland	Plantation - east side only	N/A	Disturbed restio veld. <i>Thamnochortus gracilis</i> , <i>Anthochortus crinalis</i> , <i>Mastersiella digitata</i> , <i>Tetraria fasciata</i>	Class D/E - natural vegetation sparse with high level of disturbance in the area adjacent to the road	Moderate	Mod/Low	Less disturbed along road margin so more sensitive.
Track 193	Dryland	Plantation - east side only	N/A	Disturbed restio veld under <i>Eucalyptus</i> stand	Class E: Natural vegetation very sparse under gum canopy	Low	Low	Can be used as a bypass
Track 194/195/196	Dryland	Plantation - east side only	N/A	Disturbed restio veld but with some natural vegetation	Class D - natural vegetation sparse	Moderate	Mod/Low	
Track 197	Dryland	Plantation - east side only	N/A	Disturbed restio veld under <i>Eucalyptus</i> stand	Class E: Natural vegetation very sparse under gum canopy	Low	Low	Can be used as a bypass

4.1.10 Management Unit 10 (Track 1150, 124b; Track 199 to 204)

Management Unit 10 traverses a disturbed section of the reserve, largely flanked by pine (*Pinus pinaster*) and Blue Gum (*Eucalyptus* sp.) plantations (Figure 4.23). The majority of the habitat is sandy dryland although several ephemeral drainage lines pass below the road along this route via pipes. Stream 3, a bedrock/boulder dominated perennial stream in good condition with intact instream and riparian habitat traverses the area (Figure 4.23, Table 4.10). Most of the habitat along this route is highly disturbed and of low Ecological Importance and Sensitivity (Figure 4.24 and Table 4.10).

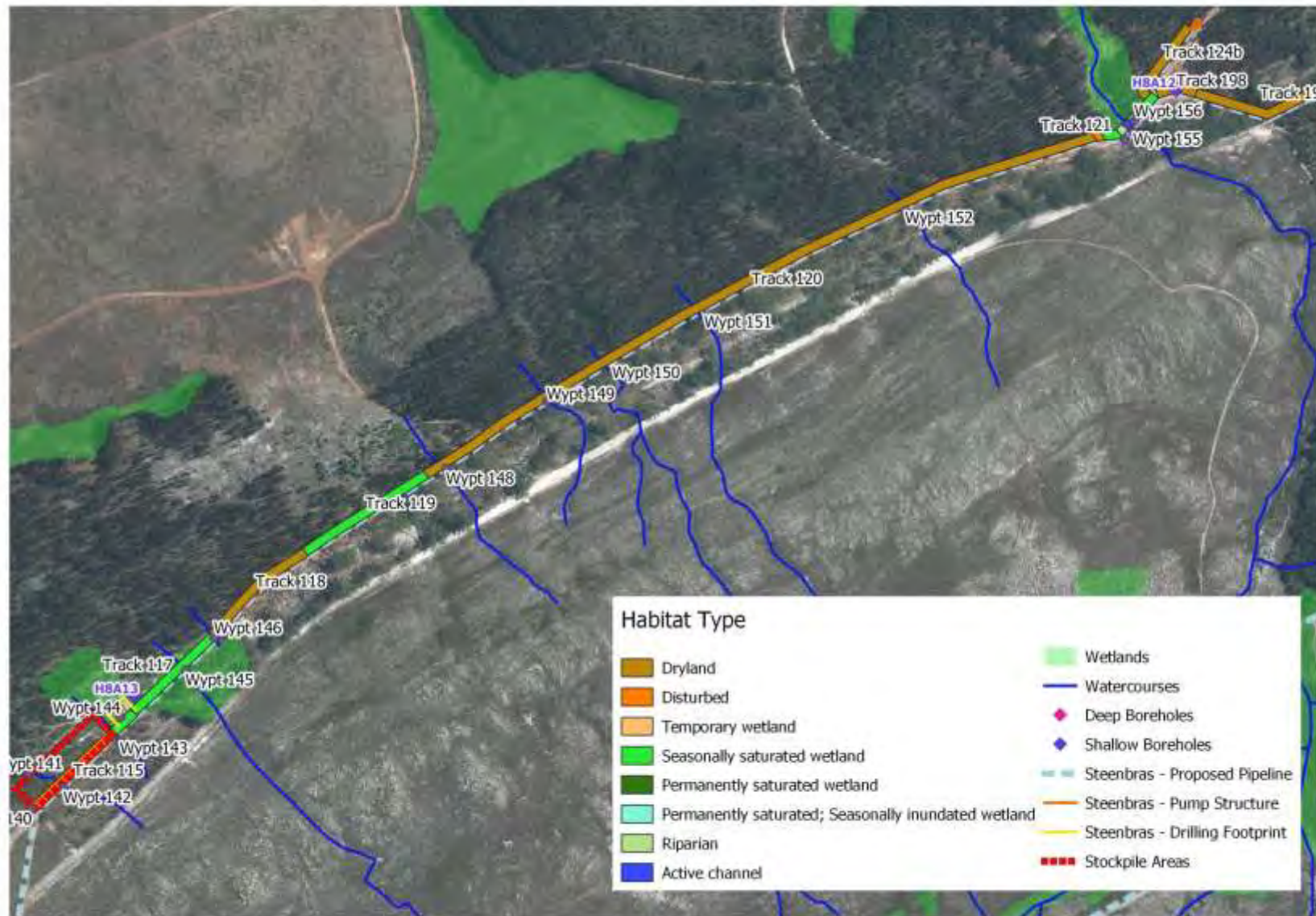


Figure 4.21 Management Unit 10a: Spatial extent of Habitat Types.

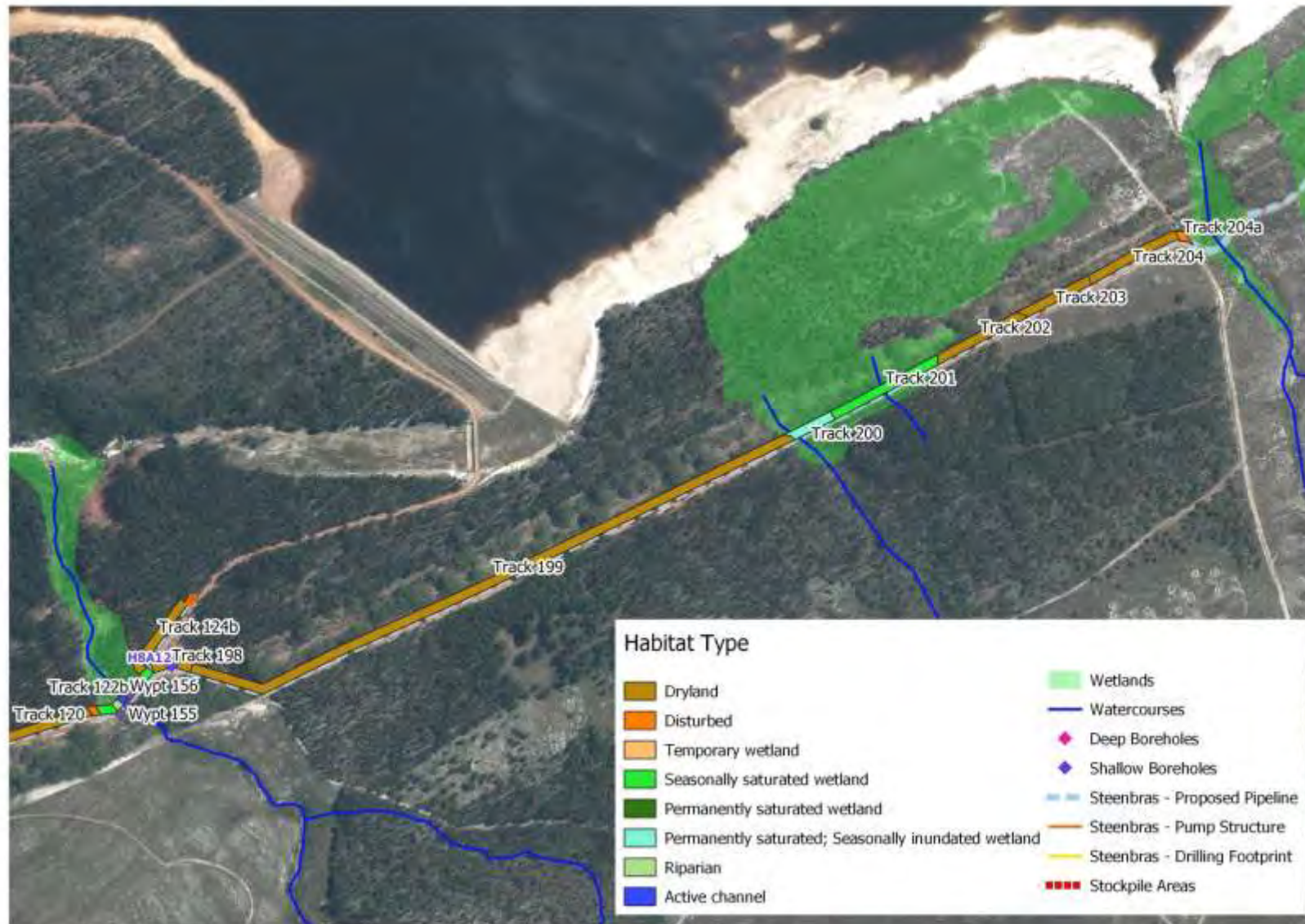


Figure 4.22 Management Unit 10b: Spatial extent of Habitat Types.

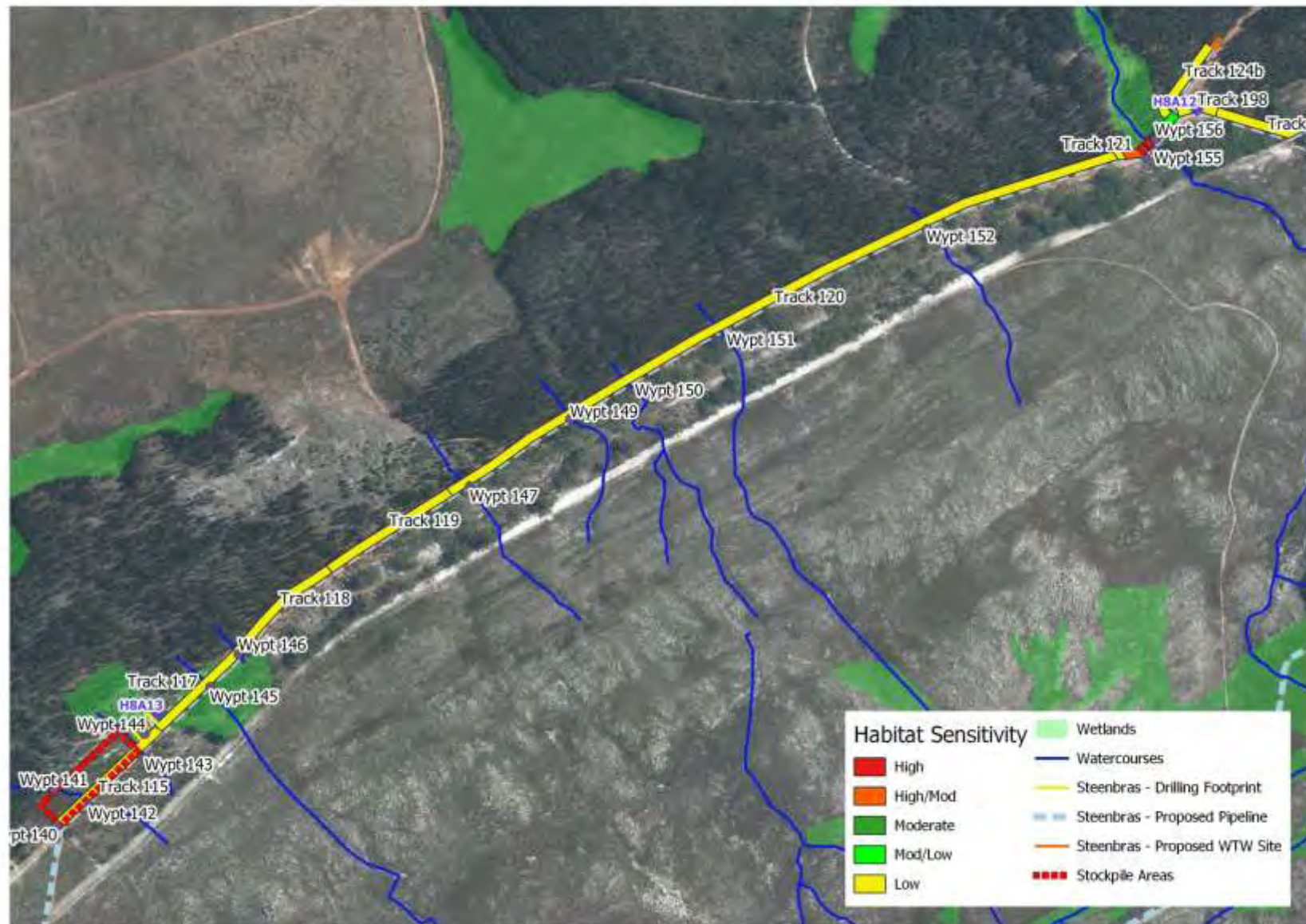


Figure 4.23 Management Unit 10a: Habitat Sensitivity.

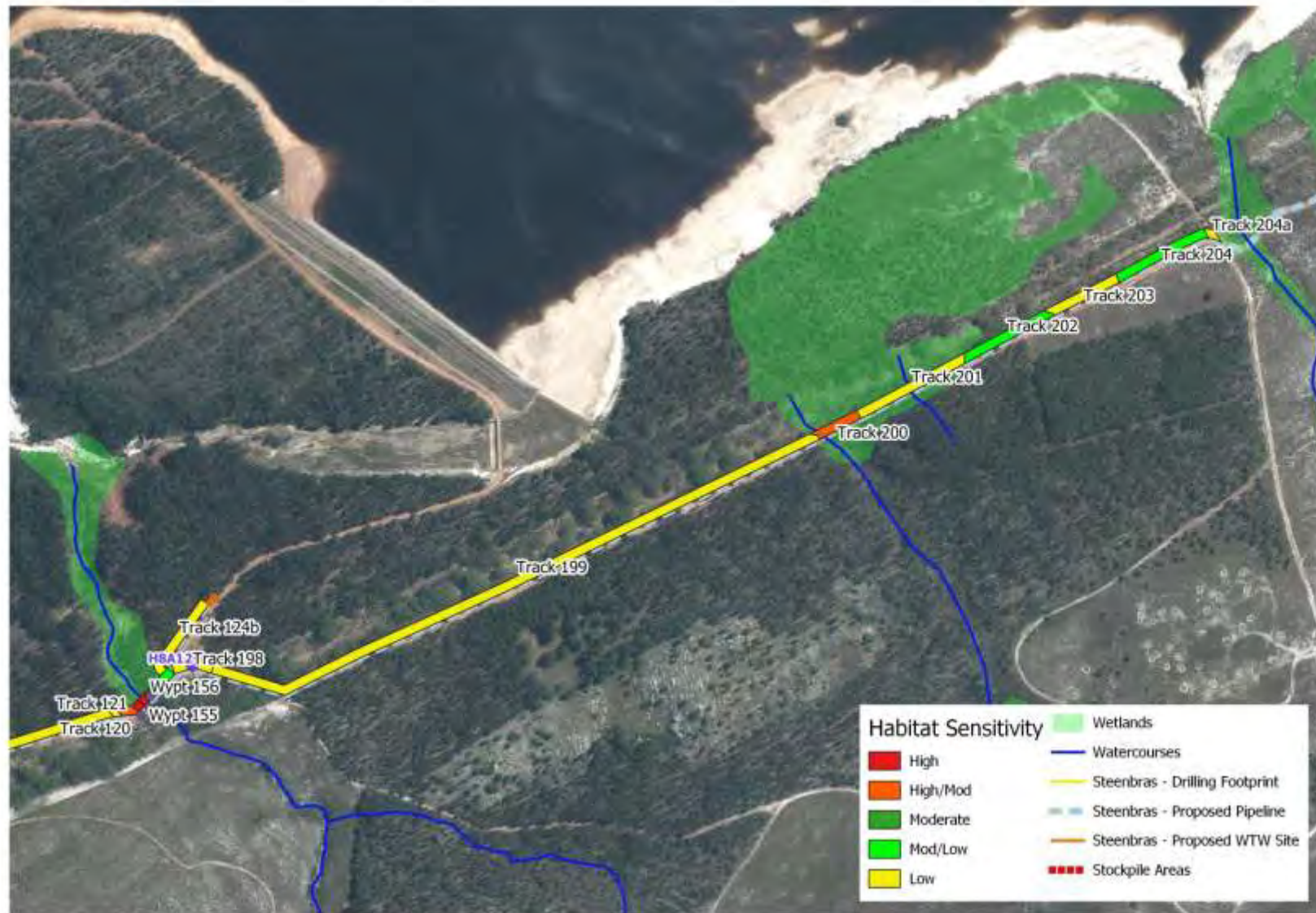


Figure 4.24 Management Unit 10b: Habitat Sensitivity.

Table 4.10 MU 10: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 115	Dry land - sandy	Plantation	N/A	<i>Eucalyptus diversicolor</i> , <i>Pinus pinaster</i> , alien debris	Class E: invaded with juvenile blue gums - top soil lost	Low	Low	Difficult to rehab due to loss of top soil and seedbank
WP 142	Artificially created drainage channel	Plantation	ephemeral	Bare drainage ditch with concentrated flows following rainfall events - no ecological value	N/A	Low	Low	diffuse flows from upslope of the road are channelised and directed to the downslope area via culverts below the road
WP 143	watercourse	Plantation	ephemeral	Impacted but with some natural features. Likely less defined prior to channelisation below the road. Main vegetation species include: <i>Stoebe plumosa</i> , <i>Thamnochortus gracilis</i> , <i>Erica serrata</i> , <i>Tribolium uniola</i> , <i>Hypodiscus aristatus</i> , <i>Diospyros glabra</i> . Alien trees (juvenile) : <i>Eucalyptus</i>	Class E: invaded with juvenile blue gums - top soil lost	Low	Low	Impact by road which cuts off water. Already the start of a donga formation from road runoff
Track 116	Wetland (seep)	Plantation	Seasonally saturated	<i>Stoebe plumosa</i> , <i>Thamnochortus gracilis</i> , <i>Erica serrata</i> , <i>Tribolium uniola</i> , <i>Hypodiscus aristatus</i> , <i>Diospyros glabra</i> but dominated by <i>Eucalyptus diversicolor</i> , <i>Pinus pinaster</i> , alien debris	Class E: invaded with juvenile blue gums - top soil lost	Low	Low	End of stock pile, beginning of Wetland
WP 144	Wetland (seep)	Plantation	Seasonally saturated	<i>Athanasia trifurcata</i> , <i>Stoebe plumosa</i> , <i>Hymenolepis crithmifolia</i> , <i>Restio capensis</i> , <i>Ursinia dentata</i> , <i>Pseudoselago serrata</i> , <i>Anthospermum aethiopicum</i> , <i>Syncarpha vestita</i> . Alien species: <i>Eucalyptus diversicolor</i> , <i>Pinus pinaster</i> , <i>Acacia longifolia</i>	Class D/E: invaded with juvenile blue gums but some remaining veg species (very few)	Low	Low	The site is situated immediately adjacent to a drainage line among alien trees (Blue Gums). The drainage line is impacted due to channelisation and invasion by blue gums and thus the risk to freshwater ecosystems associated with the footprint is low. The channel will erode and result in a donga if used for pump testing. There is intact wetland habitat downstream may be impacted by drawdown
WP 145	watercourse	Plantation	ephemeral			Low	Low	
Track 117	Wetland (seep)	Plantation	Seasonally saturated	<i>Mimetes cucullatus</i> , <i>Leucadendron ganderi</i> , <i>Berzelia lanuginosa</i> , <i>Anthochortus crinalis</i> , <i>Diospyros glabra</i> , <i>Staberoha cernua</i> , <i>Tetraria cuspidata</i> , <i>Erica viscaria</i> , <i>Tetraria flexuosa</i>	Class D: Impacted by alien blue gum invasion and hydrological alteration created by the road but has natural features	Low	Low	Impacted but some value
WP 146	Artificially created drainage channel	Plantation	ephemeral	Bare drainage ditch with concentrated flows following rainfall events - no ecological value. Some vegetation remnants upslope of the road include: <i>Tetraria cuspidata</i> , <i>Lanaria lanata</i>	N/A	Low	Low	diffuse flows from upslope of the road are channelised and directed to the downslope area via culverts below the road
Track 118	Dry land	Plantation	N/A	Sandy dryland with <i>Tetraria cuspidata</i> , <i>Diospyros glabra</i> , <i>Searsia angustifolia</i>	Class D: recovery compromised because top soil lost	Low	Low	Dry land in pine plantation
Track 119	Wetland (seep)	Plantation	Seasonally saturated	<i>Restio purpurascens</i> , <i>Lanaria lanata</i> , <i>Diospyros glabra</i> , <i>Willdenowia teres</i>	Class D: Impacted by pine plantation - top soil lost so recovery compromised	Low	Low	Very impacted seasonal wetland in pine plantation
Track 120	Dry land	Plantation	N/A	Pine plantation	Class D: recovery compromised because top soil lost	Low	Low	Dry land in pine plantation
WP 147	Artificially created drainage channel	Plantation	ephemeral	Trickle flow at time of site visit; substrate is gravels (wash from road) over sands.	N/A	Low	Low	
WP 149	Artificially created drainage channel	Plantation	ephemeral	Trickle flow at time of site visit; substrate is gravels (wash from road) over sands.	N/A	Low	Low	
WP 150	Stream	Plantation	ephemeral	Flowing at time of site visit. Stream would naturally have been more diffuse flow through seep. Some natural restio and erica species along the channel margins but mostly pines	Class D: loss of natural riparian vegetation	Moderate	Mod/Low	
WP 151	Artificially created drainage channel	Plantation	ephemeral		N/A	Low	Low	
WP 152	Artificially created drainage channel	Plantation	ephemeral	Flowing at time of site visit with no natural vegetation, only pines	N/A	Low	Low	

Table 4.11 continued MU 10: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 120a	Disturbed	Plantation	N/A	Road		Low	Low	
Track 121	Wetland (seep)	Plantation	Seasonally saturated	<i>Diospyros glabra</i> , <i>Tribolium uniola</i> , <i>Aristida junciformis</i> , <i>Stoebe plumosa</i> , <i>Cliffortia atrata</i> , <i>Restio occultus</i>	Class C: disturbed but functional seep habitat	Moderate	High/Moderate	
Track 122	Riparian	Plantation	permanently saturated	<i>Diospyros glabra</i> , <i>Penaea mucronata</i> , <i>Berzelia lanuginosa</i> , <i>Passerina corymbosa</i> , <i>Brachylaena neriifolia</i> , Fern similar to <i>Blechnum</i> , <i>Searsia angustifolia</i> , <i>Gleichenia polypodioides</i> , <i>Brunia africana</i> , <i>Osmitopsis asteriscoides</i>	Class A/B: impacted by bridge crossing but largely intact	High	High	
Track 122b	Riparian	Plantation	permanently saturated	<i>Diospyros glabra</i> , <i>Penaea mucronata</i> , <i>Berzelia lanuginosa</i> , <i>Passerina corymbosa</i> , <i>Brachylaena neriifolia</i> , Fern similar to <i>Blechnum</i> , <i>Searsia angustifolia</i> , <i>Gleichenia polypodioides</i> , <i>Brunia africana</i> , <i>Osmitopsis asteriscoides</i>	Class A/B: impacted by bridge crossing but largely intact	High	High	
Track 123	Active channel	Plantation	Perennial	Bedrock/boulder stream with <i>Prionium serratum</i> , <i>Neesenbeckia punctoria</i> , <i>Erica coccinea</i>	Class A/B: impacted by bridge crossing but largely intact	High	High	Stream 3
Track 124	Wetland (seep)	Plantation	seasonally saturated	<i>Diospyros glabra</i> , <i>Thamnochortus gracilis</i> , <i>Tetraria cuspidata</i> , <i>Ehrharta longiglumae</i> , <i>Aristida junciformis</i> , <i>Stoebe cinerea</i> , <i>Passerina corymbosa</i> , <i>Athanasia trifurcata</i> , <i>Lobelia pinifolia</i> , <i>Ursinia dentata</i> , <i>Hymenolepis crithmifolia</i>	Class C: disturbed but functional seep habitat within pine plantation	Moderate	Mod/Low	Although loss of natural vegetation is extensive, top soil is intact and thus the area is readily resorable with the removal of pines
Track 124b	Dryland	Plantation	N/A	Pine plantation	Class E: no natural veg remaining although topsoil still intact	Moderate	Low	
Track 198	Dryland	Plantation	N/A	Disturbed isolated pocket of dryland vegetation - secondary growth following <i>Eucalytus</i> removal but lots of dead gum debris. Natural vegetation includes <i>Stoebe cinerea</i> , <i>Ursinia dentata</i> , <i>Pentameris</i> sp	Class D - natural vegetation sparse. Lots of alien debris	Moderate	Low	Can be used as a bypass
Track 199	Dryland	Plantation	N/A	<i>Eucalyptus</i> stand with no understorey cover and loss of topsoil and very little potential for recovery following blue gum removal	Class F: no natural vegetation, only blue gums with no topsoil.	Low	Low	Deep donga along the road carrying road runoff.
Track 200	Wetland (seep)	Plantation	permanently saturated; seasonally inundated	Within pine plantation (<i>Pinus pinaster</i>) with aliens such as <i>Acacia longifolia</i> but natural seep vegetation includes <i>Elegia neesii</i> , <i>Elegia mucronata</i> , <i>Elegia hookerianum</i> , <i>Erica labialis</i> , <i>Ficinia filiformis</i> , <i>Tetraria cuspidata</i>	Class D: impacted by hydrological changes due to concentrated flows via road culvert (drying out) and aliens.	Moderate	High/Moderate	
Track 201	Wetland (seep)	Plantation	seasonally saturated	Disturbed seasonal wetland within <i>Eucalyptus</i> stand	Class D/E: alien veg	Low	Low	Rehab potential is difficult
WP 224	Artificially created drainage channel	Plantation	ephemeral	no natural vegetation surrounding this small ephemeral drainage ditch with gravel substratum.	N/A	High	High/Moderate	
Track 202	Dryland	Rocky outcrop	N/A	Rocky outcrop within <i>Eucalyptus</i> stand	Class E: Natural vegetation very sparse	Moderate	Mod/Low	
Track 203	Dryland	Deep Sand	N/A	Deeper sandy area within <i>Eucalyptus</i> stand with some rocky areas. Ingenious speices: <i>Elegia hookerianum</i> . Aliens: <i>Acacia longifolia</i>	Class E: Natural vegetation very sparse	Moderate	Low	
Track 204	Dryland	Rocky outcrop	N/A	Rocky outcrop with <i>Elegia persistens</i> , <i>Lanaria lanata</i> , <i>Elegia hookerianum</i> , <i>Thamnochortus gracilis</i> , <i>Elegia filacea</i>	Class D - natural vegetation but sparse	Moderate	Mod/Low	
Track 204a	Disturbed	track		No vegetation		Low	Low	

4.1.11 Management Unit 11 (Track 098 to 114)

This MU traverses an area that is predominantly dryland characterised by sandy disturbed areas along the road margin (Figure 2.25) considered of moderate sensitivity to anthropogenic disturbance (Figure 2.26, Table 4.12). Towards the north, the vegetation is secondary following removal of pines with some juvenile alien veg still present. Some rock outcrops and seasonally saturated wetlands (Figure 2.25) characterise this area and are considered of high or high to moderate sensitivity because they are natural systems with a high ecological importance (Table 4.12). There are two ephemeral streams that traverse the area, flanked by permanently saturated and seasonally inundated wetland habitat of High to moderate sensitivity (Figure 2.26; Table 4.12).

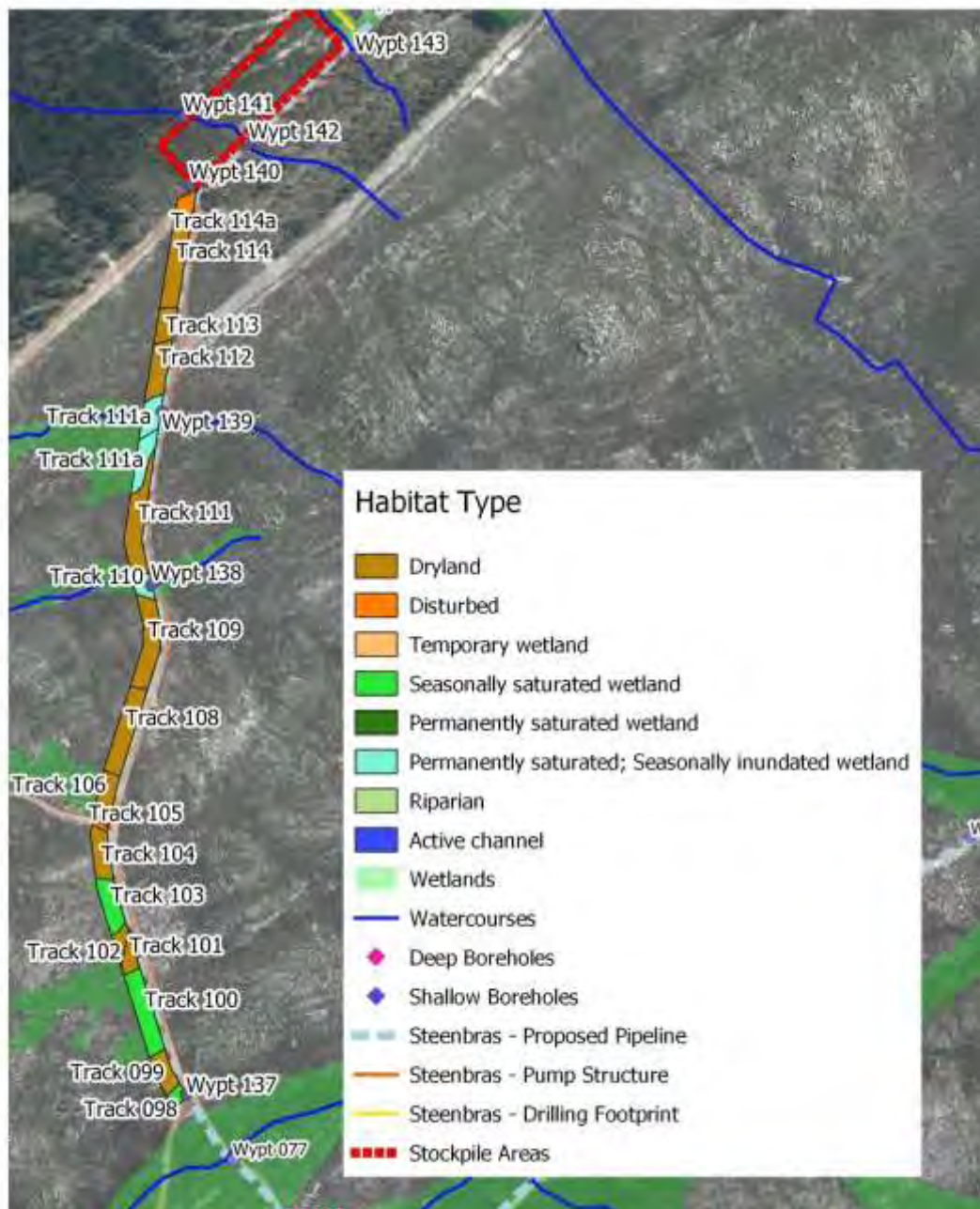


Figure 2.25 Management Unit 11: Spatial extent of Habitat Types.

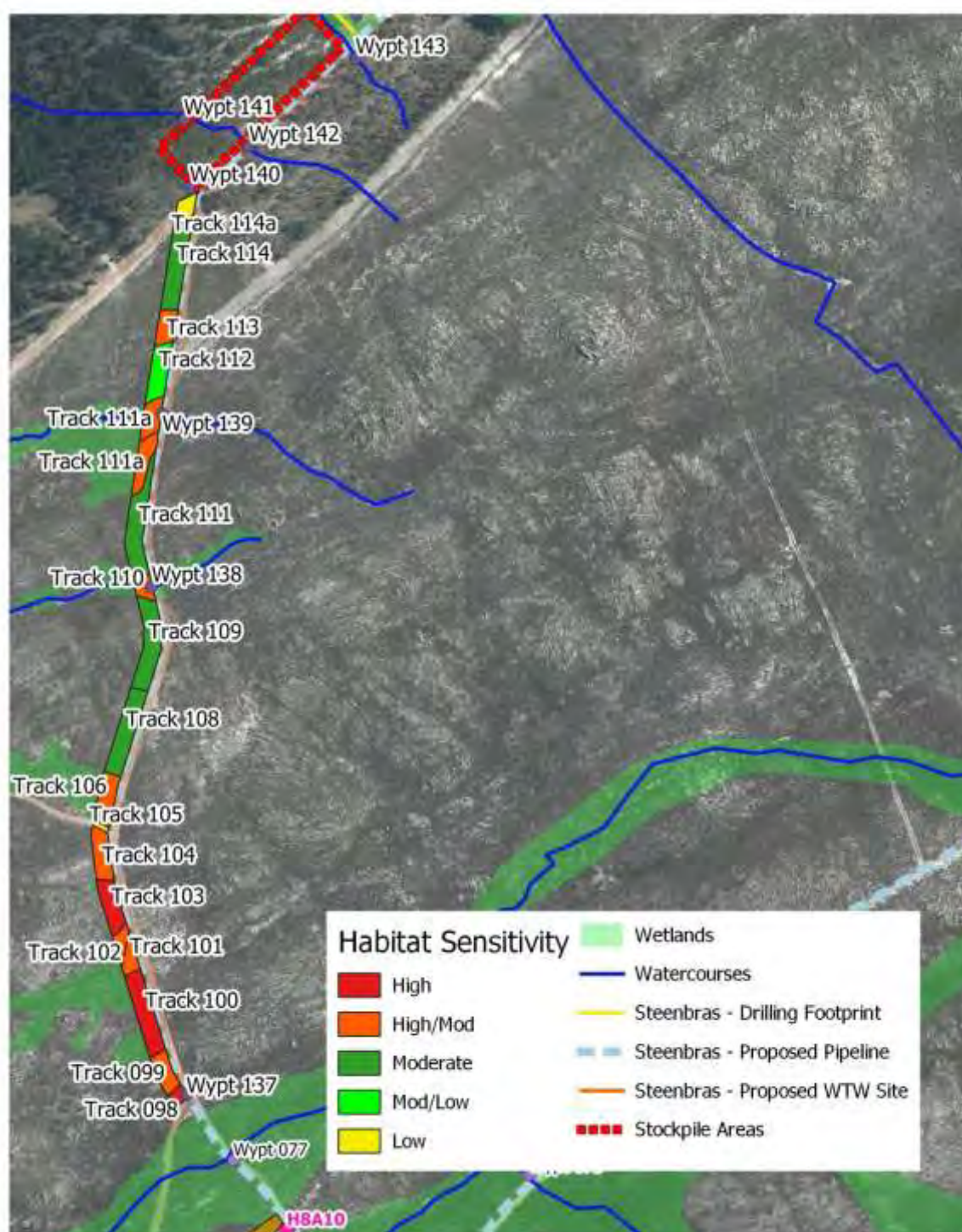


Figure 4.26 Management Unit 11: Habitat Sensitivity.

Table 4.12 MU 11: Characteristics of Habitats types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 098	Wetland (seep)	Natural	seasonally saturated	<i>Berzelia lanuginosa</i> , <i>Diospyros glabra</i> , <i>Hypodiscus aristatus</i> , <i>Mimetus cuallatus</i> , <i>Stoebe cinerea</i> , <i>Searsia skytophylla</i> , <i>Erica labialis</i> , <i>Erica ericoides</i> , <i>Erica pulchella</i>	Class A: habitat in good condition	High	High	Natural veg with rock outcrops
Track 099	Dry land	Natural	N/A	<i>Tetraria thermalis</i> , <i>Metasias cephalotes</i> , <i>Stoebe cinerea</i>	Class A: habitat in good condition	High	High/Moderate	
Track 100	Wetland (seep)	Natural	seasonally saturated	<i>Stoebe cinerea</i> , <i>Diospyros glabra</i> , <i>Willdenowia teres</i> , <i>Cliffortia atrata</i> , <i>Restio perplexus</i> , <i>Erica ericoides</i>	Class A: habitat in good condition	High	High	Temporary wetland habitat - i.e. marginal between wet and dry land but habitat intact. Edge effect from road extends about 2,5 m into the habitat so road margin is already disturbed.
Track 101	Dry land	Rocky outcrop	N/A	<i>Aristida junciformis</i> , <i>Diospyros glabra</i> , <i>Thamnochortus gracilis</i>	Class A: habitat in good condition	High	High/Moderate	Rocky outcrop - disturbed within 2,5 meters of the road but sensitive habitat - disturbed edge is about 2,5 m
Track 102	Dry land	sandy - natural	N/A	<i>Erica calycina</i> , <i>Erica ericoides</i> , <i>Willdenowia teres</i> , <i>Diosma oppositifolia</i> , <i>Pelargonium angulosum</i> , <i>Stoebe cinerea</i> , <i>Erica pulchella</i> , <i>Erica serrata</i>	Class A: habitat in good condition	High	High/Moderate	Sandy substrate
Track 103	Wetland (seep)	Natural	seasonally saturated	<i>Restio perplexus</i> , <i>Stoebe cinerea</i> , <i>Willdenowia teres</i> , <i>Aristida junciformis</i>	Class A: habitat in good condition	High	High	Seasonally saturated on sandy substrate
Track 104	Dry land	Natural	N/A	<i>Erica ericoides</i> , <i>Restio occultus</i> , <i>Pentameris thurii</i> , <i>Erica pulchella</i> , <i>Metasias cephalotes</i> , <i>Diospyros glabra</i> , <i>Stoebe cinerea</i> , <i>Thamnochortus gracilis</i>	Class A: habitat in good condition	High	High/Moderate	Dry land on road margin but wetland beyond
Track 105	Disturbed	Disturbed	N/A	none - road	Class F: road	Low	Low	road - can be used as bypass
Track 106	Dry land	Natural	N/A	<i>Diospyros glabra</i> , <i>Thamnochortus lanaria lanata</i> , <i>Cliffortia atrata</i> , <i>Stoebe plumosa</i> , <i>Willdenowia glomerata</i> , <i>Carpobrotus edulis</i> , <i>Searsia skytophylla</i>	Class A: habitat in good condition	High	High/Moderate	Disturbance from road up to 5 m into habitat
Track 107/108	Dry land	Natural	N/A	<i>Cliffortia atrata</i> , <i>Eragrostis curvula</i> , <i>Thamnochortus argenteus</i> , <i>Diospyros glabra</i> , <i>Pentameris curvifolia</i> , <i>Willdenowia teres</i> , <i>Protea acaulos</i> , <i>Cliffortia juniperifolia</i>	Class B: Road disturbance	Moderate	Moderate	Dryland but on edge of wetland
Track 109	Dry land	Natural	N/A	<i>Cliffortia atrata</i> , <i>Cliffortia ruscifolia</i> , <i>Elegia thyrsefera</i> , <i>Cliffortia juniperifolia</i> , <i>Phaenocoma prolifera</i> , <i>Diospyros glabra</i> , <i>Elegia persistens</i> , <i>Lanaria lanata</i>	Class B: Road disturbance	Moderate	Moderate	road disturbance
Track 110	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Willdenowia teres</i> , <i>Psoralea pinnata</i> , <i>Cliffortia ruscifolia</i> , <i>Erica serrata</i> , <i>Cliffortia atrata</i> , <i>Tetraria capillacea</i>	Class B: Road disturbance	Moderate	High/Moderate	road disturbance
Track 111	Dry land	Natural	N/A	<i>Cliffortia atrata</i> , <i>Cliffortia ruscifolia</i> , <i>Elegia thyrsefera</i> , <i>Cliffortia juniperifolia</i> , <i>Phaenocoma prolifera</i> , <i>Diospyros glabra</i> , <i>Elegia persistens</i> , <i>Lanaria lanata</i>	Class B: Road disturbance	Moderate	Moderate	road disturbance
Track 111a	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Willdenowia teres</i> , <i>Psoralea pinnata</i> , <i>Cliffortia ruscifolia</i> , <i>Erica serrata</i> , <i>Cliffortia atrata</i> , <i>Tetraria capillacea</i>	Class B: Road disturbance	Moderate	High/Moderate	road disturbance
Track 112	Dry land	Recovered from plantation	N/A	<i>Erica serrata</i> , <i>Willdenowia teres</i> , <i>Stoebe plumosa</i> , <i>Phyllis buxifolia</i> , <i>Bulbiney sp.</i> , <i>Athanasia trifurcata</i> , <i>Aristida junciformis</i> , <i>Thamnochortus gracilis</i> , <i>Erica serrata</i> , <i>Cliffortia ruscifolia</i> , <i>Diospyros glabra</i> , <i>Lanaria lanata</i> , <i>Pentameris curvifolia</i>	Class C: road disturbance	Moderate-Low	Mod/Low	Sandy disturbed margin
Track 113	Dry land	Recovered from plantation - rocky	N/A	<i>Cliffortia ruscifolia</i> , <i>Lanaria lanata</i> , <i>Diospyros glabra</i> , <i>Searsia angustifolia</i>	Class B: secondary vegetation following pine removal	High	High/Moderate	Rocky outcrop, area has recovered after removal of pines
Track 114	Dry land	Recovered from plantation	N/A	<i>Cliffortia atrata</i> , <i>Stoebe plumosa</i> , <i>Erica pulchella</i> , <i>Acacia longifolia</i> , <i>Helicrysum crispum</i> , <i>Hymenolepis crithmifolia</i>	Class B: secondary vegetation following pine removal	Moderate	Moderate	Moribund dryland - hasn't been burned; was previously cleared of pines
Track 114a	Disturbed	Disturbed	N/A	Dirt track	Class F: road	Low	Low	Road - can be used as bypass

4.1.12 Management Unit 12 (Track 011 to 112)

MU12 is a short section within an existing sandy dryland pine plantation and seasonal wetland habitat invaded with juvenile alien trees of low sensitivity (Figure 4.27 and Figure 4.28, Table 4.13). This MU includes a small stretch of seasonal wetland habitat immediately downslope of the plantation that is of high to moderate sensitivity (Figure 4.28). The footprint of boreholes H8A6 and H8A9 were initially situated at the western end of this MU. Due to the presence of wetlands within the pine plantations immediately north of the borehole footprints, the boreholes were relocated further east away from the wetland seep habitat. Due to the sensitivity of the eastern portion of MU 13 (see section 4.1.13), a new alternative pipeline route from the new footprint of H8A6 and H8A9 through the pine plantation was considered (see MU 17, section 4.1.18).

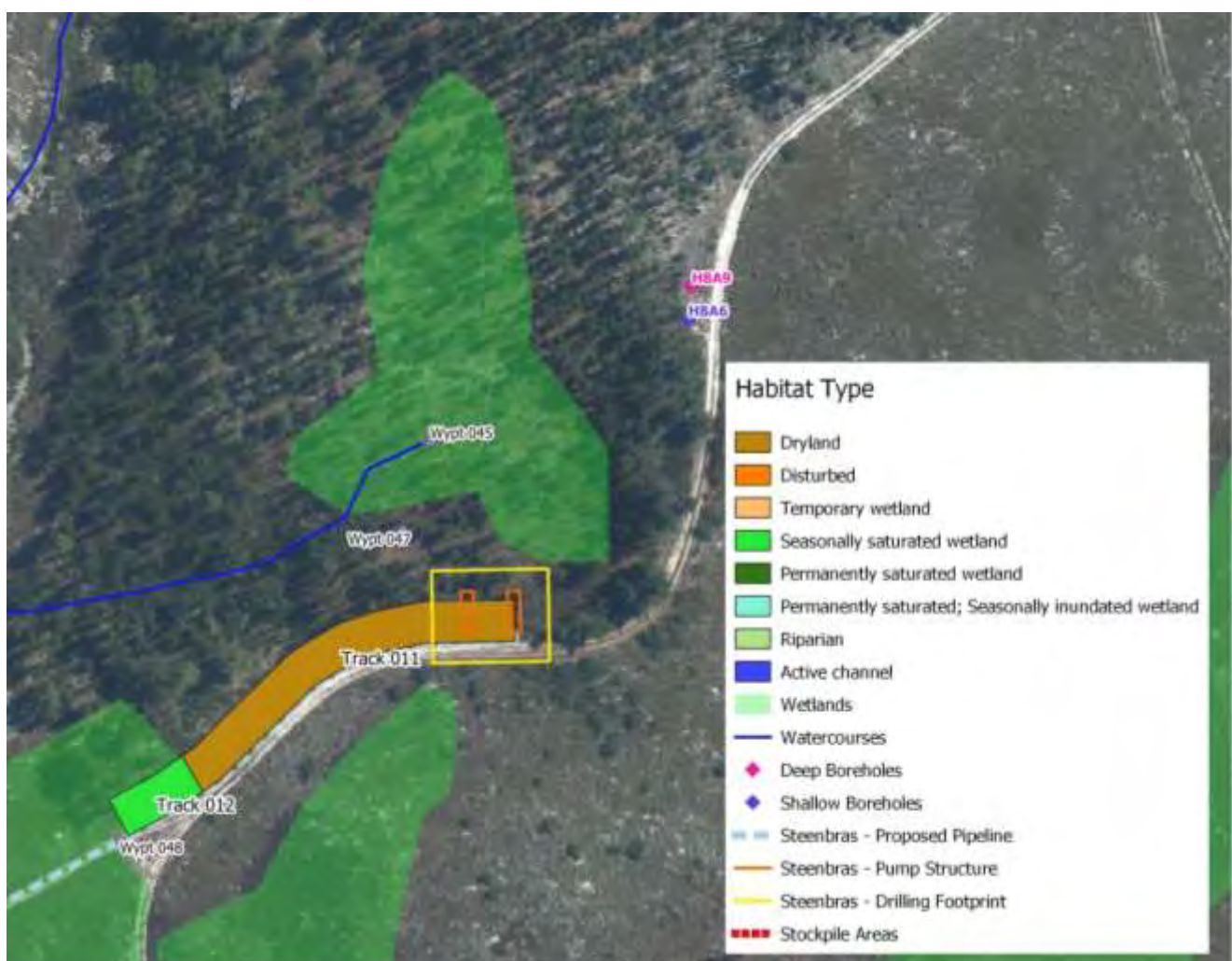


Figure 4.27 Management Unit 12: Spatial extent of Habitat Types in relation to the old footprint of H8A9 and H8A6 (yellow rectangle) and the new siting of these two boreholes as given by the labels.

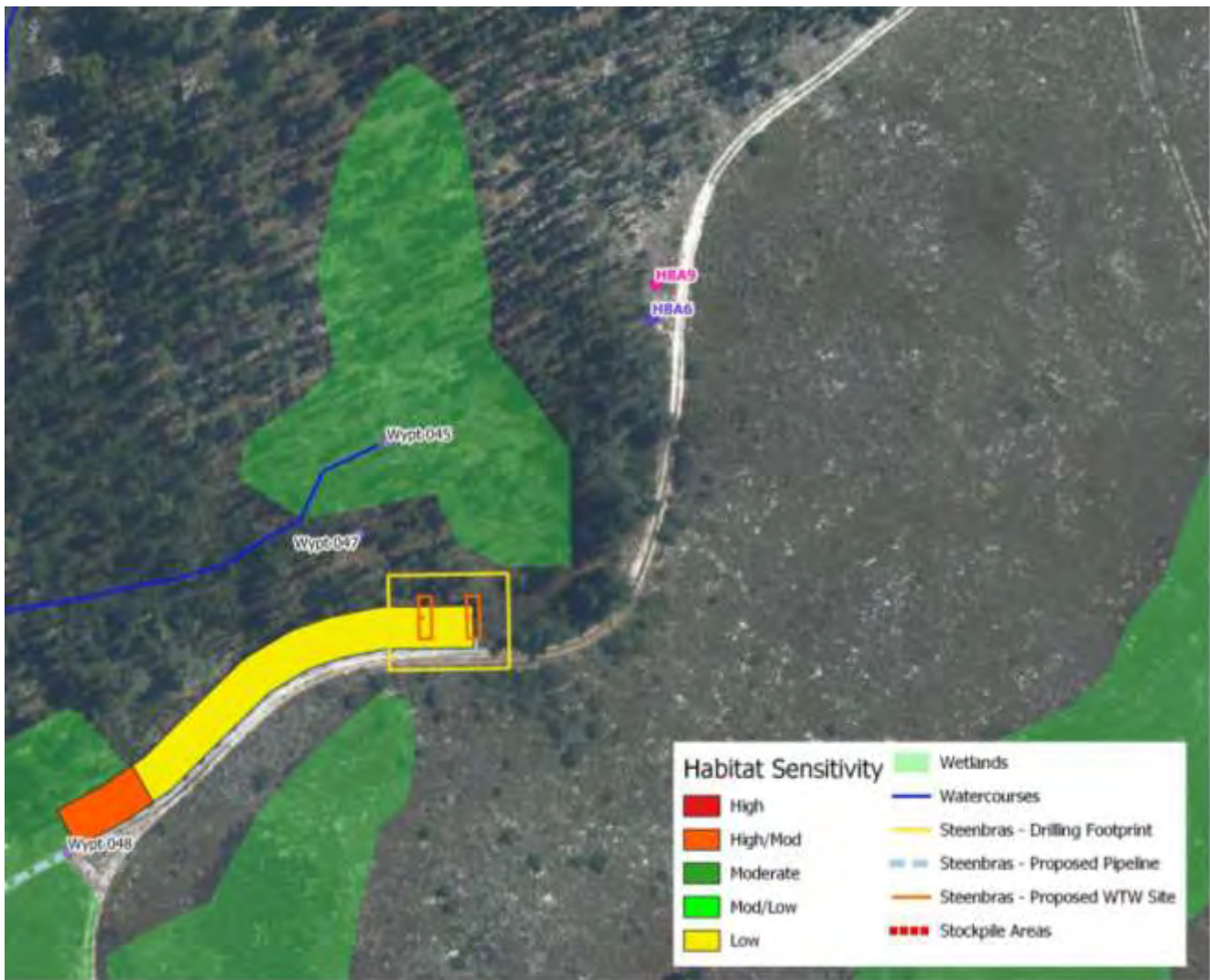


Figure 4.28 Management Unit 12: Habitat Sensitivity.

Table 4.13 MU 12: Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
WP045	Small stream	pine plantation and other aliens	ephemeral	Sandy channel (1.5m) wide within pine plantation. Flows into perennial river. Remnant indigenous species including <i>Elegia ebracteata</i> , <i>Berzelia alopecuroides</i> , <i>Isolepis digitata</i> , <i>Nevillea obtusissima</i> , <i>Erica hispidula</i>	Class C: within pine plantation; loss of indigenous riparian vegetation; bed and bank alteration due to down cutting	Moderate	High	Risk of erosion and contamination by pump test water associated with siting of H8A9
WP047	Dry land	pine plantation and other aliens	N/A	Shallow sands with some seasonal saturation but not true wetland habitat.	Class D: within pine plantation; invaded with <i>Acacia longifolia</i> , <i>Acacia mearnsii</i> and <i>Pinus pinaster</i>	Moderate	Moderate	This is the site of the footprint for H8A6 . Although invaded, natural seed bed is likely intact and natural veg community would reestablish if pines were removed
Track 011	Dry land	pine plantation and other aliens	N/A	Invaded by second generation pines. Margin is very disturbed	Class D: invaded with pines and no indigenous vegetation present	Low	Low	
Track 012	Wetland (seep)	Invaded	seasonally saturated	Invaded with <i>Pinus pinaster</i> but still has indigenous species: <i>Berzelia alopecuroides</i> , <i>Leucadendron salicifolium</i>	Class C: invaded with pines but indigenous vegetation present and provides habitat	Moderate	High/Moderate	Impacted but a threatened ecosystem type

4.1.13 Management Unit 13 (Track 013 to 036)

This MU is situated in largely pristine fynbos with a mix of dryland and wetland of high ecological importance and sensitivity (Figure 4.29 – Figure 4.32). The habitat is dominated by permanently saturated and seasonally saturated seeps where the greatest impact is due to hydrological alteration caused by the existing road. This area includes rare plants and search and rescue operations are essential prior to any construction activity.

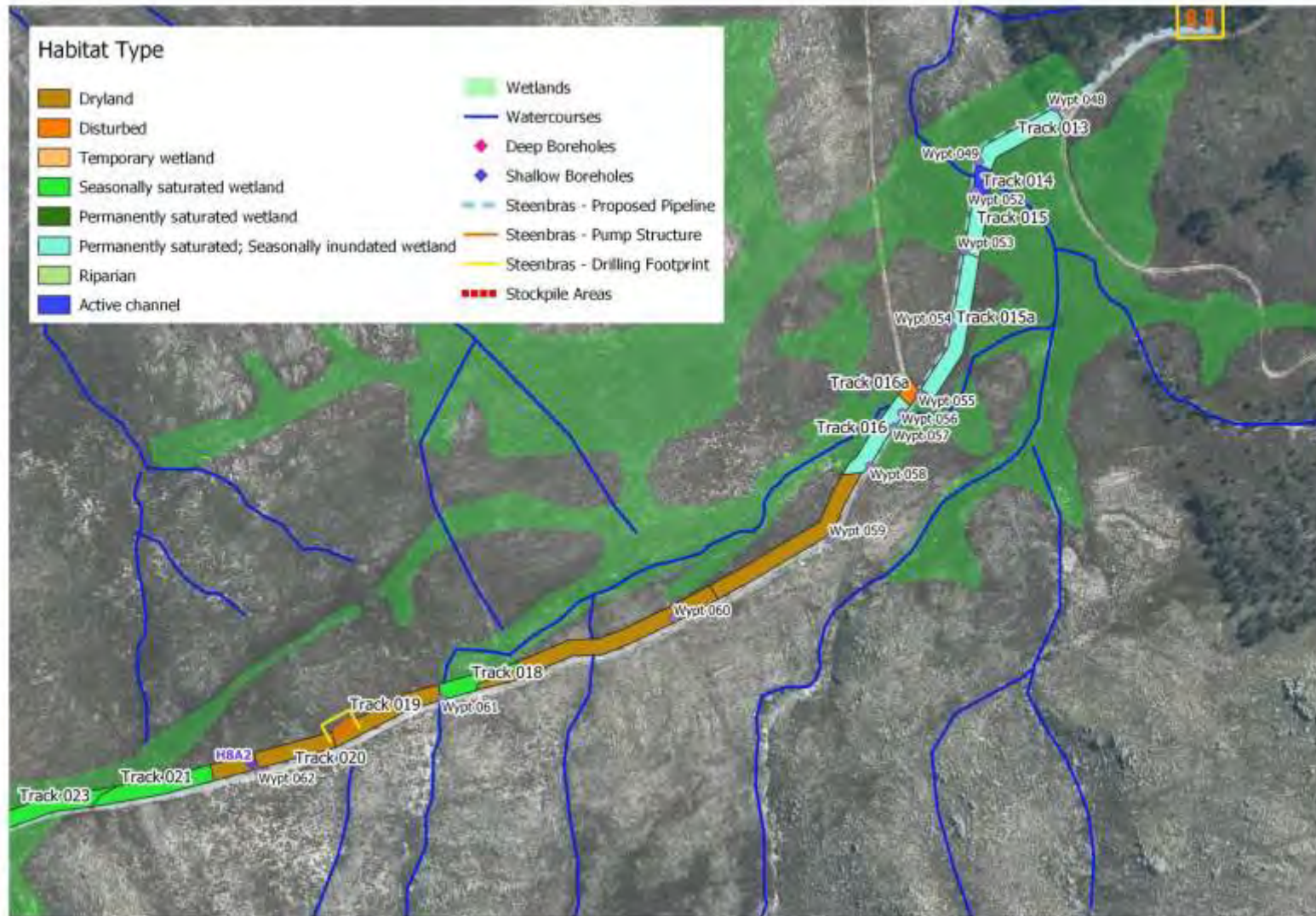


Figure 4.29 Management Unit 13a: Spatial extent of Habitat Type.

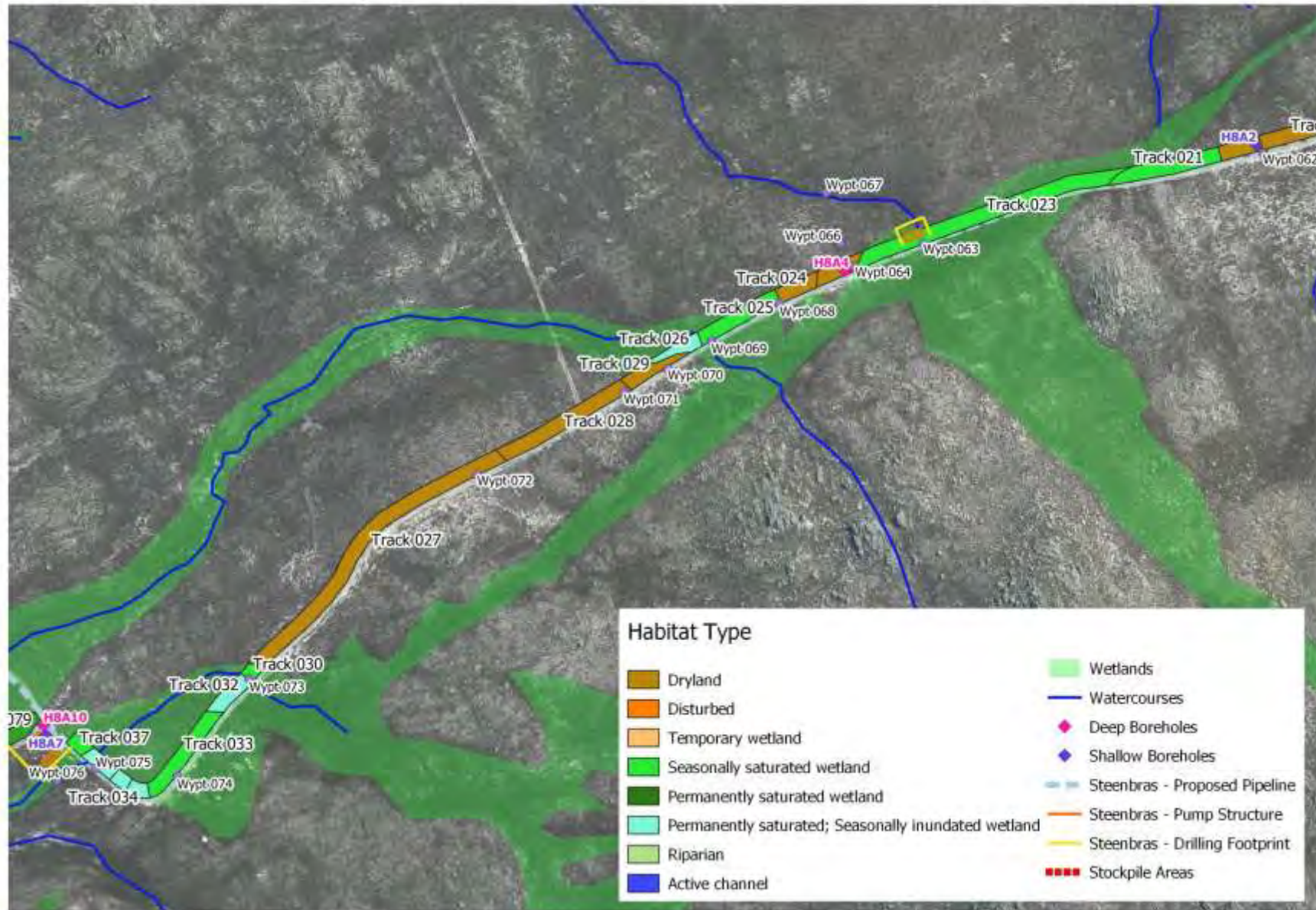


Figure 4.30 Management Unit 13b: Spatial extent of Habitat Type.

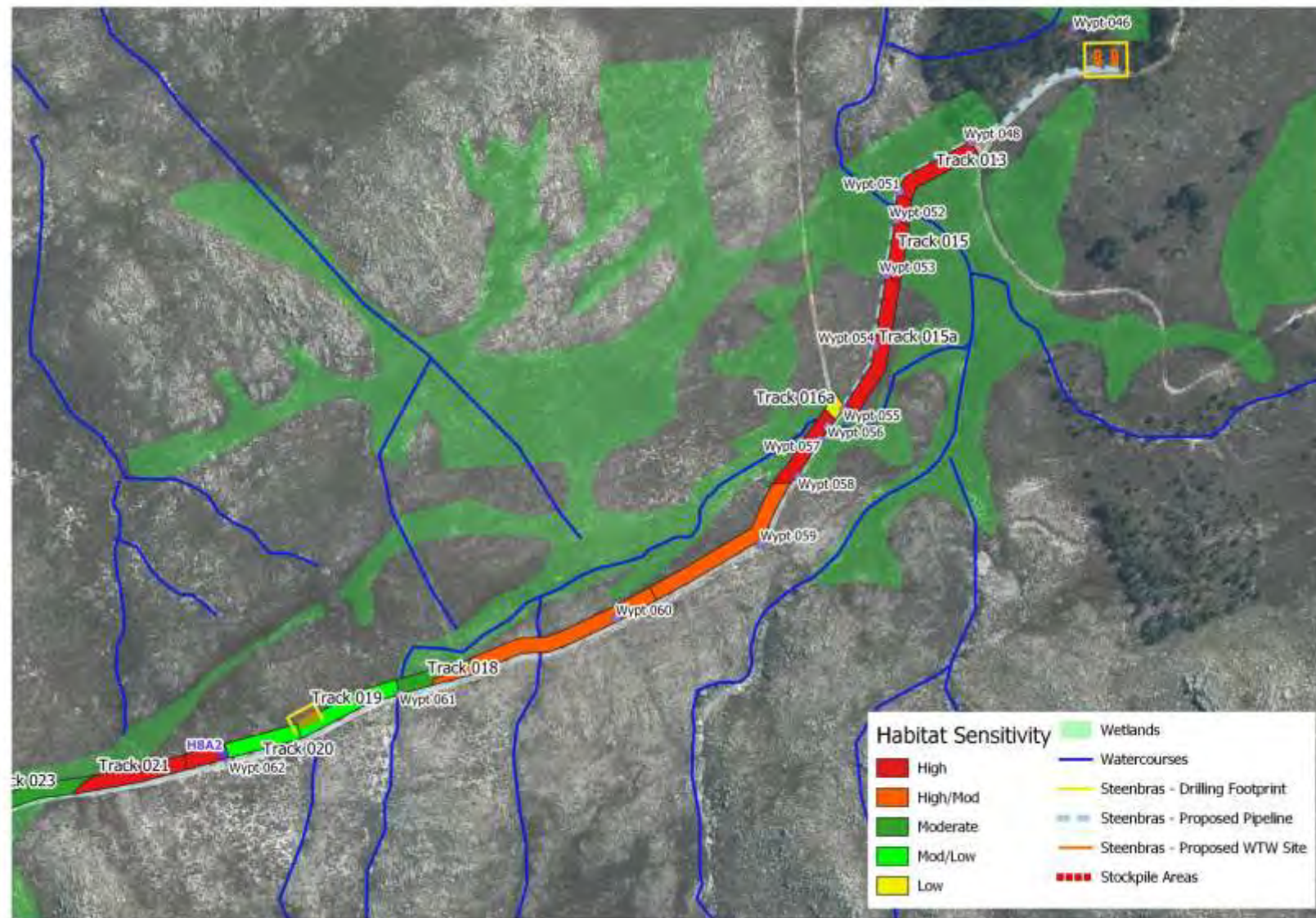


Figure 4.31 Management Unit 13a: Habitat Sensitivity.

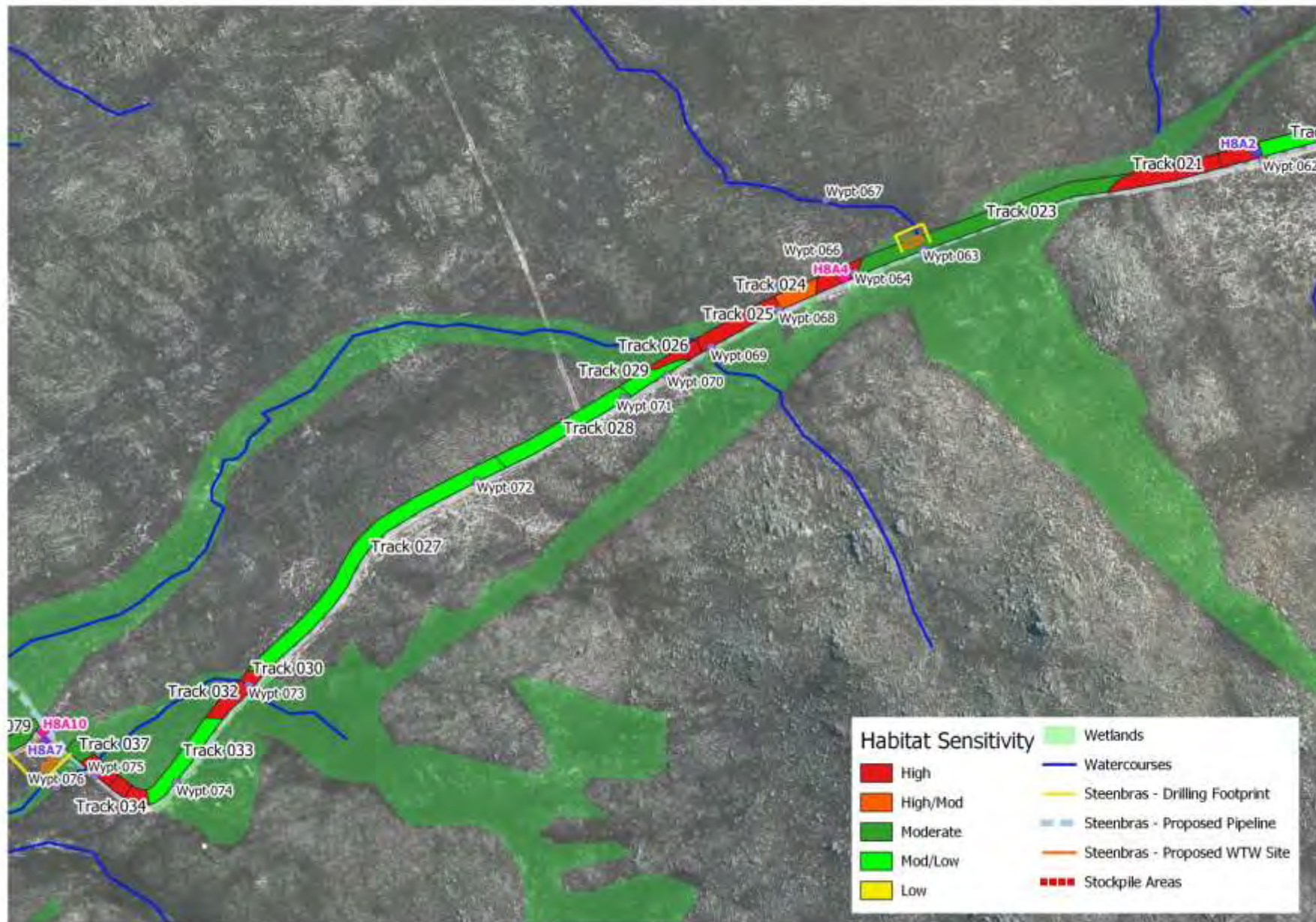


Figure 4.32 Management Unit 13b: Habitat Sensitivity.

Table 4.14 MU 13 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 013 & WP048	Wetland (Berzelia dominated seep)	Natural	permanently saturated; seasonally inundated	No aliens. Dominated by <i>Berzelia alopecuroides</i> with <i>Grubbia rosmarinifolia</i> and <i>Erica sessiliflora</i>	Class A/B: pristine wetland seep habitat. Some road impacts but minor.	High	High	Wetland habitat with good habitat integrity
Track 014 & WP049 & WP050 - WP052	Stream	Natural	Perennial	<i>Erica sessiliflora</i> & <i>Restio purpurascens</i> , <i>Erica campanularis</i> within the riparian area. Palmiet within the active channel.	Class A: Pristine foothill cobble bed river. Minor impacts associated with road crossing but the river is in good condition.	High	High	
Track 015	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Diastella thymelaeoides</i>	Class A/B: pristine wetland seep habitat. Some road impacts but minor.	High	High	Within the existing TMGA wetland monitoring site (H8_3b)
Track 015a	Wetland (seep)	Natural	Permanently saturated	<i>Diastella thymelaeoides</i>	Class A/B: pristine wetland seep habitat. Some road impacts but minor.	High	High	Slightly drier than 015
Track 016a	Disturbed	Natural	N/A	Road with no vegetation	Class F	Low	Low	At WP058 - stretch of rock at surface that will need to be broken up
Track 016	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Struthiola myrsinites</i> , <i>Erica hispidula</i> , <i>Brunia fragarioides</i> , <i>Ixia micrandra</i> , <i>Erica ericoides</i> - some aliens i.e. Australian myrtle.	Class A/B: pristine wetland seep habitat. Few aliens (probably from road) but very sparse	High	High	Wetland habitat with good habitat integrity Note: disturbed road (WP055 could be used for stockpiling or as a bypass)
Track 017	Dry land	Natural	N/A	<i>Adenandra marginata</i> , <i>Lanaria lanata</i> , <i>Hypodiscus aristatus</i> , <i>Phaenocoma prolifera</i> , <i>Cliffortia ruscifolia</i> and <i>Stoebe</i>	Class A: habitat in good condition	Moderate	High/Moderate	Natural dryland habitat in good condition - threatened habitat type . Wetland habitat (high sensitivity) extends to within 3 m from the road edge (WP060). WP059 - 10 m stretch of rock at surface
Track 018	Wetland (seep)	Natural	seasonally saturated	Deep sands	Class B: habitat impacted by hydrological changes due to lack of culverts below the road i.e. flows are impeded	High	Moderate	Road margin in impacted so the ES is considered moderate
Track 019	Dry land	Natural	N/A	<i>Thamnochortus</i> ; <i>Erica ericoides</i> . Some aliens i.e. <i>Acacia melanoxylon</i>	Class B: habitat previously disturbed	Moderate	Mod/Low	Disturbed
Track020	Dry land	Natural	N/A	<i>Thamnochortus</i> ; <i>Erica ericoides</i> . Some aliens i.e. <i>Acacia melanoxylon</i>	Class B: habitat previously disturbed	Moderate	Mod/Low	
Track 020a	Dry land	Natural	N/A	<i>Erica ericoides</i> , <i>Elegia filacea</i> , <i>Erica pulchella</i> , <i>Hypodiscus aristatus</i> , <i>Cliffortia atrata</i> , <i>Anthochortus crinalis</i> , <i>Thamnochortus gracilis</i> , <i>Restio occultus</i>	Class A: habitat in good condition	High	High	
WP062	Dry land	Natural	N/A	<i>Erica ericoides</i> , <i>Elegia filacea</i> , <i>Erica pulchella</i> , <i>Hypodiscus aristatus</i> , <i>Cliffortia atrata</i> , <i>Anthochortus crinalis</i> , <i>Thamnochortus gracilis</i> , <i>Restio occultus</i>	Class A: habitat in good condition	High	High	Edge of drill site for H8A2 . Vegetation community in good condition and irreplaceable and thus impact is significant

Table 4.14 continued MU 13 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 021 & 022	Wetland (seep)	Natural	seasonally saturated	Sandy ericoid restio flats in good condition.	Class A: habitat in good condition	High	High	Area is a mosaic of wet and dry areas thus high habitat diversity
Track 023	Wetland (seep)	Natural	seasonally saturated	Sandy ericoid restio flats with <i>Restio bibarius</i> , <i>Anthochortus crinalis</i> , <i>Leucadendron adscendens</i>	Class A: habitat in good condition	High	Moderate	Road margin in impacted so the ES is considered moderate
WP 063	Stream	Natural	ephemeral	Narrow ephemeral channel with sandy banks and gravel substratum. <i>Restio purpurascens</i> characteristic.	Class A: natural	High	High	
WP 067	Stream	Natural	ephemeral	Narrow ephemeral channel with sandy banks and gravel substratum. <i>Restio purpurascens</i> characteristic.	Class B/C: Channel is downcut (about 1 m into organic wetland soils) due to concentration of flow at the road - evidence of wetland margins drying out	High	High	Erosion gully from road which has concentrated flow. Very high risk of erosion. Concern around pump test water from H8A4
Track 023a	Dry land	Natural	N/A	No vegetation - borehole footprint	unknown but likely in good condition (Class A/B)	High	High	ES is based on the fact that the site is already cleared and has been for awhile but it would have represented a threatened ecosystem type and can be rehabilitated so EI is high
Track 024	Dry land	Natural	N/A	<i>Hypodiscus aristatus</i> , <i>Cliffortia</i> , <i>Serruria</i> and <i>Restio curviramis</i>	Class B	Moderate	High/Moderate	
Track 025	Wetland (seep)	Natural	seasonally saturated	<i>Restio occultus</i> , <i>Restio purpurascens</i>	Class A: habitat in good condition	High	High	Channelised flow downstream will continue to cause downcutting and erosion
Track 026	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Stoebe plumosa</i> , <i>Berzelia lanuginosa</i> , <i>Restio occultus</i> , <i>Erica labialis</i> , <i>Erica coccinea</i> , <i>Erica hispidula</i> , <i>Erica pulchella</i> , <i>Willdarnowia teres</i> , <i>Restio curviramis</i> , <i>Staberoha cernua</i> , <i>Hypodiscus aristata</i> , <i>Drosera aliciae</i> , <i>Ehrharta ramosa</i>	Class A: habitat in good condition	High	High	
Track 027 & 028 & 029	Dry land	Natural	N/A	<i>Cliffortia ruscifolia</i> dominant (indicative of disturbance) with aliens i.e. <i>Carpobrotus edulis</i> (probably planted along road when road was constructed to stabilise disturbed habitat). Some indigenous components include <i>Protea acualos</i> , <i>Athanasia trifurcata</i> (indicative of shales)	Class B/C: Dryland margin with disturbance along the road edge	Moderate	Mod/Low	Possibilities for stockpiling
Track 030	Wetland (seep)	Natural	seasonally saturated		Class A: habitat in good condition	High	High	
WP073	Small stream	Natural	ephemeral		Class A: habitat in good condition	High	High	Flowing at the time of site visit
Track 032	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Erica ericoides</i>	Class A: habitat in good condition	High	High	
Track 033	Wetland (seep)	Natural	seasonally saturated	<i>Restio bifarius</i> ; <i>Cliffortia atrata</i>	Class B: Impacted along the road. Hydrologically impacted by road	Moderate	Mod/Low	Margin is disturbed and dominated by <i>Cliffortia</i>
Track 034	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Tetraria fasciata</i> , <i>Erica hispidula</i> , <i>Erica fastigiata</i> , <i>Berzelia lanuginosa</i> , <i>Diastella thymelaeoides</i> , <i>Restio pedicellatus</i>	Class A: habitat in good condition	High	High	
Track 035 & 036	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Restio bifarius</i> , <i>Erica ericoides</i>	Class A: habitat in good condition	High	High	Track 035 is a short section that is slightly drier i.e. a mosaic of wet and dry habitat.
WP075	Small stream	Natural	ephemeral	<i>Restio occultus</i> , <i>Erica fastigiata</i> along the channel margin; <i>Restio purpurascens</i> , <i>Berzelia lanuginosa</i> , <i>Erica hispidula</i> , <i>Erica sessiliflora</i>	Class A: habitat in good condition	High	High	Flowing at the time of site visit
Track 037	Wetland (seep)	Natural	seasonally saturated		Class B/C: habitat is disturbed along the road margin (about 3 m) - possibly due to vehicular activity associated with H8A10	High	Moderate	
WP076	Wetland (seep)	Natural	seasonally saturated	Sand on sandstone, mixture of moist and dry wetland; Moist species include <i>Diastella thymelaeoides</i> , <i>Erica ericoides</i> , <i>Hypodiscus aristatus</i> , <i>Erica imbricata</i> , <i>Cliffortia atrata</i> , <i>Leptocarpus</i> . Dry land species include <i>Tetraria thermalis</i> , <i>Salteria sarcocolla</i> and <i>Serruria elongata</i>	Class A: habitat in good condition	High	High	Footprint of H8A7 already disturbed by pegs so extension of site towards the ephemeral channel into pristine habitat

4.1.14 Management Unit 14 (Track 037 to 039)

This is largely pristine fynbos of high ecological importance and sensitivity. The habitat is dominated by permanently saturated and seasonally saturated seeps where the greatest impact is due to hydrological alteration caused by the existing road. This area includes rare plants and search and rescue operations are essential prior to any construction activity.

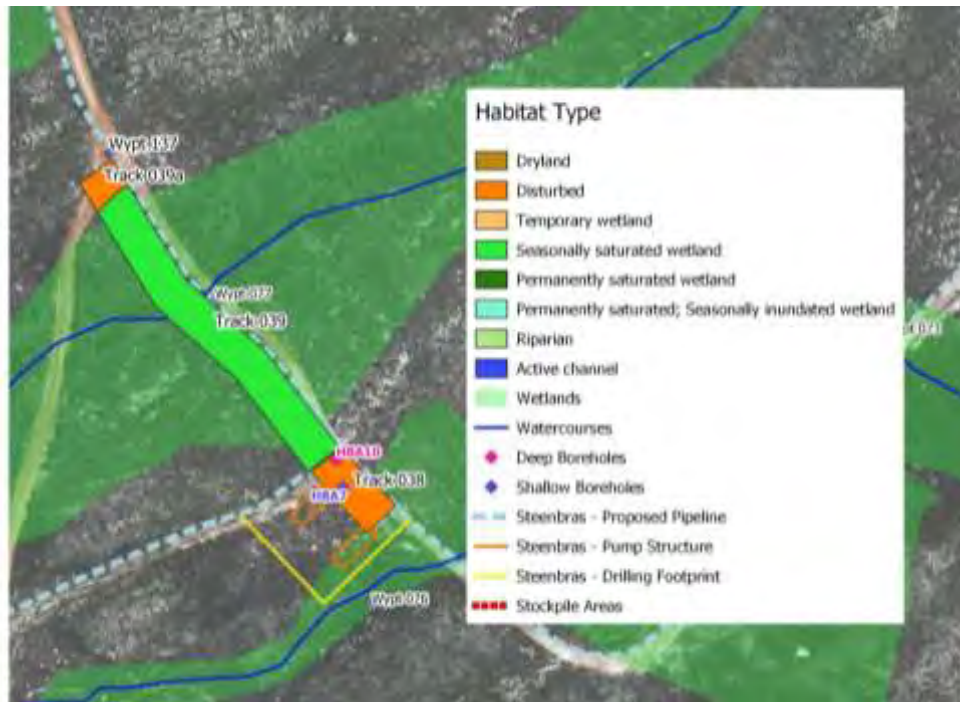


Figure 4.33 Management Unit 14: Spatial extent of Habitat Type.

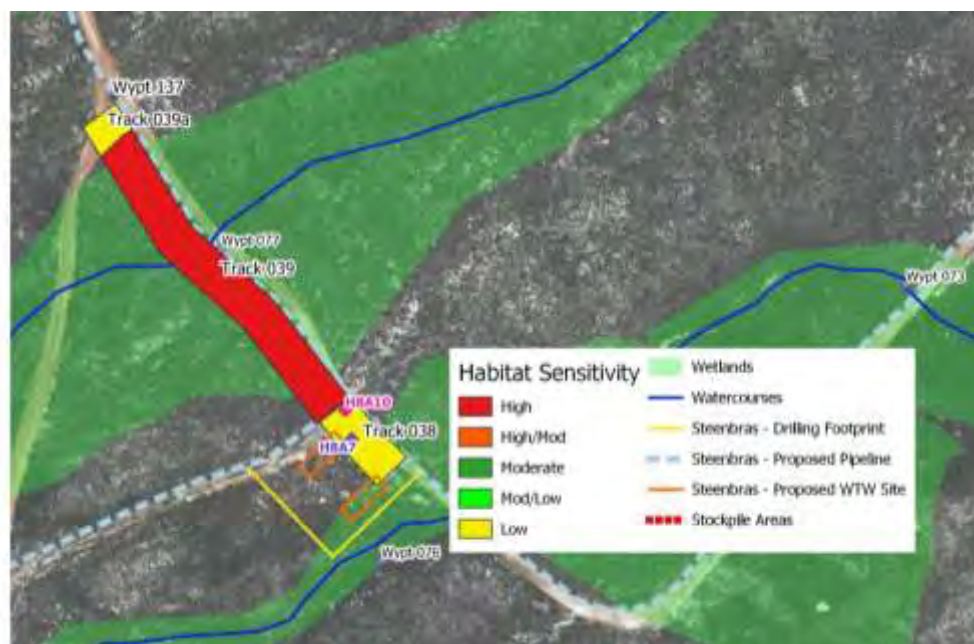


Figure 4.34 Management Unit 14: Habitat Sensitivity.

Table 4.15 MU 14 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 038	Disturbed	Natural	N/A	No vegetation - borehole footprint	Class F	Low	Low	
Track 039	Wetland (seep)	Natural	seasonally saturated	Sandstone mixed wetland with dry areas - mosaic; <i>Cliffortia</i> , <i>Erica ericoides</i>	Class A: habitat in good condition	High	High	
WP077	Small stream	Natural	ephemeral	<i>Restio occultus</i> , <i>Erica fastigiata</i> along the channel margin; <i>Restio purpurascens</i> , <i>Berzelia lanuginosa</i> , <i>Erica hispidula</i> , <i>Erica sessiliflora</i>	Class A: habitat in good condition	High	High	Flowing at the time of site visit
Track 039a	Disturbed	Natural	N/A	Road	Class F	Low	Low	

4.1.15 Management Unit 15 (Track 082 to 097)

Despite some edge effects from the road, this management unit falls within pristine habitat. From south east to north west, the habitat along the route changes from a mix of seasonally saturated and inundated wetland habitat interspersed by rocky outcrops and sandy dryland to a large *Berzelia* dominated wetlands that is seasonally inundated and permanently saturated (Figure 4.35; Table 4.16). The existing road through this wetland has affected the surface and subsurface flows through this habitat with a system that appears slightly dryer along the road margin to the north as flows would natural move from south west to north east through this area. Also, runoff is directed from the south of the road via a drain and then a culvert (Wypt 131 in Table 4.16) which has led to down cutting and loss of naturally dispersed runoff from the wetlands to the south of this area.

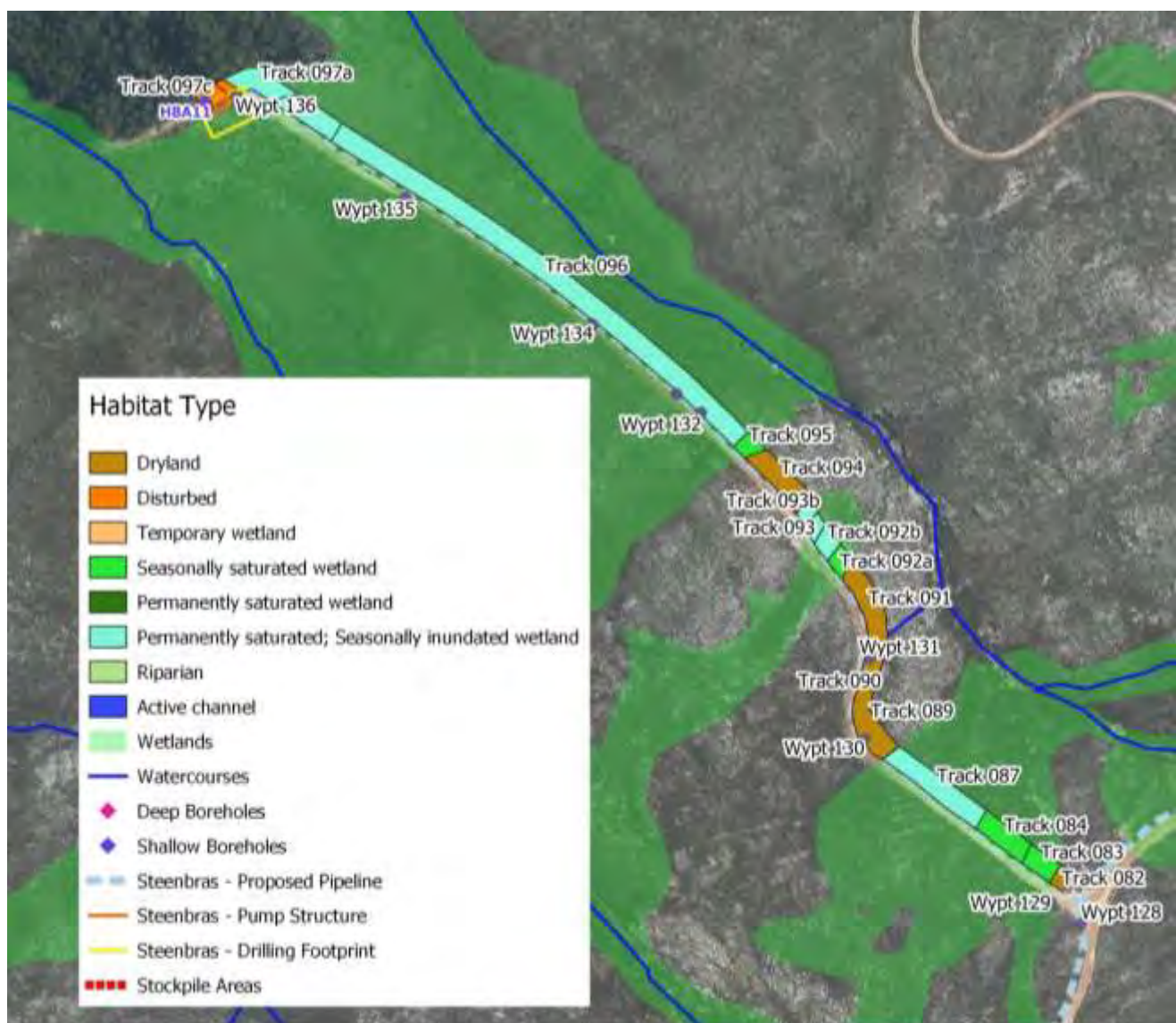


Figure 4.35 Management Unit 15: Spatial extent of Habitat Type.

Despite these impacts, most habitats in this MU are in good condition with a moderate to high or high Ecological Importance and Sensitivity (Table 4.16; Figure 4.36). The footprint of H8A11 is situated at the northern extent of this MU within a gum plantation, separated from the *Berzelia* seep by a disturbed firebreak which would naturally have formed part of the wetland. While it is likely that the gum plantation was part of the *Berzelia* wetland historically, most of the topsoil in this area has been lost, together with the seed bank. Due to the level of degradation of this area, the site is considered of low ecological sensitivity.

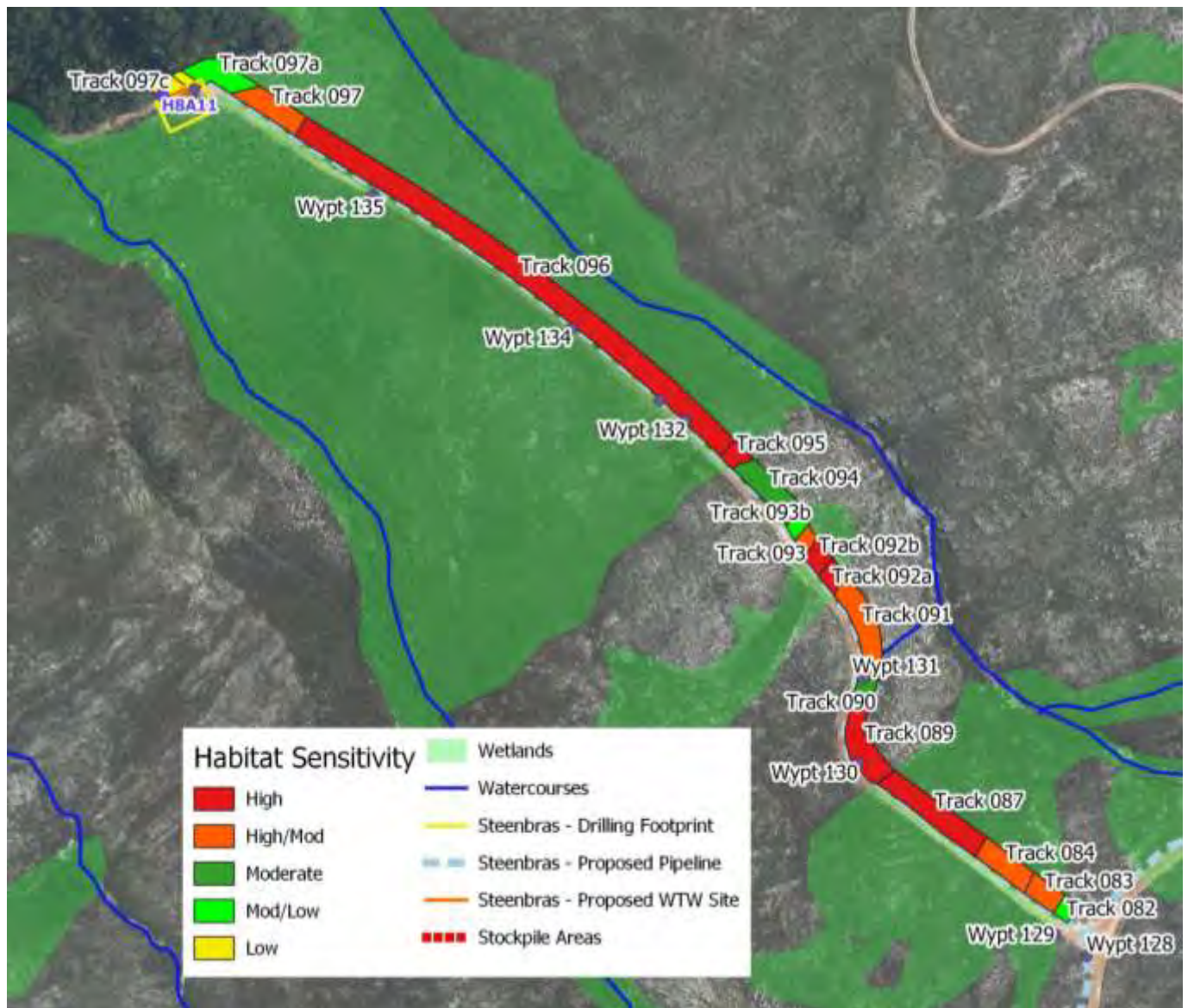


Figure 4.36 Management Unit 15: Habitat Sensitivity.

Table 4.16 MU 15 Characteristics of Habitat types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track o82	Dry land	Natural	N/A	<i>Hymenolepis crithmifolia</i> , <i>Carpobrotus edulis</i> , <i>Diospyros glabra</i> , <i>Willdenowia teres</i> , <i>Aristida junceaformis</i> , <i>Seriphium cinereum</i> , <i>Stoebe plumosa</i>	Class C: Disturbed edge	Moderate	Mod/Low	disturbed by road material along margin; This area could be used as a bypass
Track o83	Wetland (seep)	Natural	Seasonally saturated	<i>Erica serrata</i> , <i>Leucadendron gandogeri</i> , <i>Bleria ericoides</i> , <i>Stoebe plumosa</i> , <i>Restio bifarius</i> , <i>Thamnochortus gracilis</i> , <i>Anthospermum aethiopicum</i> , <i>Hypodiscus aristatus</i> , <i>Athanasia trifurcata</i> , <i>Acacia cyclops</i> , <i>Hypolaena digitata</i>	Class B: Disturbed edge	High	High/Moderate	disturbed by road material along margin but natural wetland further downslope. Wetland is however impacted by change in hydrology (drying out) due to road impeding drainage
Track o84	Wetland (seep)	Natural	seasonally saturated	<i>Leucadendron xanthoconus</i> , <i>Leucadendron gandogeri</i> , <i>Erica serrata</i> , <i>Spatalla mollis</i> , <i>Pentameris thurarii</i> , <i>Erica pulchella</i> , <i>Hypolaena digitata</i> , <i>Tetraria capillacea</i> . Some small <i>Acacia cyclops</i> (aliens)	Class A/B: habitat in good condition - some road disturbance but minimal	High	High/Moderate	some dryland taxa may be indicative of drying out.
Track o85, o86, o87 & o88	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Spatalla mollis</i> , <i>Hypolaena digitata</i> , <i>Diospyros glabra</i> , <i>Leucadendron gandogeri</i> , <i>Tetraria flexuosa</i> , <i>Diastella thymelaoides</i> , <i>Leucadendron xanthoconus</i> , <i>Erica serrata</i> , <i>Cliffortia atrata</i> , <i>Anthospermum aethiopicum</i> , <i>Stoebe plumosa</i> , <i>Berzella lanuginosa</i>	Class A: habitat in good condition	High	High	Good habitat in good condition with high sensitivity to disturbance
Track o89	Dry land	natural - rocky outcrop	N/A	<i>Hypolaena digitata</i> , <i>Leucadendron gandogeri</i> , <i>Diastella thymelaoides</i> , <i>Cliffortia atrata</i> ; <i>Protea cynaroides</i>	Class A: habitat in good condition with several rocky outcrops	High	High	Sensitive habitat and rocky nature of the area will end with a large impact if the pipeline passes through this area i.e. will be difficult if not impossible to rehabilitate effectively
Track o90	Dry land	sandy disturbed habitat	N/A	<i>Erica serrata</i> , <i>Diastella thymelaoides</i> , <i>Cliffortia atrata</i> , <i>Staberoha cernua</i> , <i>Willdenowia teres</i> , <i>Anthochortus crinalis</i> , <i>Hypodiscus aristatus</i> , <i>Thamnochortus gracilis</i> , <i>Phaenocoma prolifera</i> , <i>Gnidia pinifolia</i>	Class B: Disturbed sandy area	Moderate	Moderate	can be used as a bypass
Track o91	Dry land	Natural	N/A	<i>Phaenocoma prolifera</i> , <i>Cliffortia atrata</i>	Class A: habitat in good condition	High	High/Moderate	has rare plant species in it but should be easy to restore
WP 131	Artificially created ephemeral drainage line from culvert flows	Natural	ephemeral	<i>Restio occultus</i> , <i>Mimetes cucullatus</i> , <i>Phaenocoma prolifera</i> , <i>Thamnochortus gracilis</i> <i>Hypodiscus argenteus</i> , <i>Erica serrata</i> , <i>Restio bifarius</i> , <i>Hypolaena digitata</i> , <i>Metasia densa</i> <i>Erica ericoides</i> , <i>Corymbium spp</i> , <i>Elegia thyrsefera</i> , <i>Laneria lanata</i>	N/A	Moderate	Moderate	Artificial channel
Track o92a	Wetland (seep)	Natural	seasonally saturated	<i>Restio occultus</i> , <i>Hypodiscus aristatus</i> , <i>Cliffortia ruscifolia</i> , <i>Willdenowia teres</i>	Class A: habitat in good condition	High	High	
Track o92b	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Berzella</i> , <i>Restio occultus</i> , <i>Hypodiscus aristatus</i>	Class A: habitat in good condition	High	High	
Track o93	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Diospyros glabra</i> , <i>Erica pulchella</i> , <i>Athanasia trifurcata</i> , <i>Tribolium uniolae</i>	Class B: Disturbed by road	High	High/Moderate	disturbed wetland - some hydrological changes due to road.
Track o93b	Wetland (seep)	Natural	permanently saturated; seasonally inundated	Bare area with few emergent wetland species	Class D: Veg removed	Moderate-Low	Mod/Low	cleared area with some emergent veg - would revegate with time but currently very disturbed. Could place a bypass here
Track o94	Dry land	natural - rocky outcrop	N/A	<i>Saltera sarcocolla</i> , <i>Cliffortia atrata</i> , <i>Thamnochortus gracilis</i> , <i>Erica serrata</i> , <i>Restio occultus</i> , <i>Restio bifarius</i> , <i>Phaenocoma prolifera</i> , <i>Pteridium aquilinum</i> , <i>Diospyros glabra</i>	Class B: Road disturbance	Moderate	Moderate	Rocky outcrop - disturbed within 3 m of the road
Track o95	Wetland (seep)	Natural	seasonally saturated	<i>Restio occultus</i> , <i>Hypodiscus aristatus</i> , <i>Cliffortia ruscifolia</i> , <i>Willdenowia teres</i>	Class A: habitat in good condition	High	High	Wetland margin
Track o96	Wetland (seep)	Natural	permanently saturated; seasonally inundated	Dominated by <i>Berzella</i> and <i>Mimetes cucullatus</i> . Other taxa include: <i>Restio purpurascens</i> , <i>Berzella lanuginosa</i> , <i>Pteridium aquilinum</i> , <i>Erica viscaria</i> , <i>Erica serrata</i> , <i>Diospyros glabra</i> , <i>Mimetes cucullatus</i> , <i>Cassytha ciliolata</i>	Class A: habitat in good condition	High	High	Good habitat in good condition with high sensitivity to disturbance
Track o97	Wetland (seep)	Natural	permanently saturated; seasonally inundated	<i>Aristida junceaformis</i> , <i>Metasia densa</i> , <i>Willdenowia teres</i> , <i>Eucalyptus diversicolor</i> , <i>Hypolaena digitata</i> , <i>Erica hispida</i> , <i>Protea acualos</i> , <i>Leucadendron salicifolium</i> , <i>Pteridium aquilinum</i> , <i>Protea lepidocarpodendron</i> . Juvenile blue gums encroaching	Class B: Disturbed by road	High	High/Moderate	Wetlands on Shale; Quite disturbed by hydrological changes due to road i.e.; wetland is dryer than it should be. Alien trees (blue gums) encroaching
Track o97a	Wetland (seep)	Firebreak	permanently saturated; seasonally inundated	<i>Pteridium aquilinum</i>	Class D: within fire break	Moderate-Low	Mod/Low	Veg has been cleared, but is returning, Could be used as a bypass
Track o97b	Disturbed	Road	N/A	Gravel Road	N/A	Low	Low	
Track o97c	Disturbed	Plantation	N/A	Prior to clearing for H&A11 footprint, the site was characterised by dense invasion of alien blue gums.	Class E: Was in Eucalyptus forest recently cleared for borehole drilling	Low	Low	Top material is not intact (even prior to borehole) so difficult to rehabilitate without significant input

4.1.16 Management Unit 16 (Track 041 to Track 079)

This Unit falls within pristine habitat of the Kogelberg Biosphere Reserve. It characterises the mosaic natural of wet and dry habitats that typical of the north facing footslopes of the Hottentots-Holland Mountains of the area and contributes to the high diversity of the area. Numerous seasonal or ephemeral drainage channels traverse the area with flows from south to north towards the dam (Figure 4.37 and 4.38). There are also two perennial, rocky transitional streams with well-developed riparian zones that flow from south to north across this MU (Figure 3.38, Wypts: 122 and 127). Most of the wetlands appear to be seasonally saturated systems dominated by restios and ericas, although some are seasonally inundated and likely remain saturated throughout the dry season. These systems were generally dominated by larger wetland shrubs such as *Mimetes cuculatus* and *Berzelia lanuginosa*. Some rocky outcrops within dry land habitat were evident along the route assessed.

The existing road and thus pipeline/powerline route bisects these habitats. Although many of the seasonal and ephemeral watercourses are natural, some have been created by concentration of runoff from the south via numerous culverts. Thus, naturally diffuse runoff is somewhat impeded by the road through this area. Unless disturbed by existing roads and edge effects from the road, all habitats were identified as either of high or moderate to high ecological sensitivity (Table 4.16; Figure 3.39 and Figure 4.40).

There are three borehole footprints (and thus pump structures) along the route within MU16. The footprint of H3A1 is situated at the western extent of this MU within pristine wetland habitat interspersed by rocky dry areas that supports rare plant species and is likely to support faunal communities of conservation value. This site is of high ecological importance and is sensitive to anthropogenic disturbance.

The footprint of H8A5 is also within an area that was, prior to emergency drilling operations and spillage of effluent into the natural environment in early 2018, pristine Fynbos. It is situated between two ephemeral channels associated with seasonal wetland habitat. Die off of vegetation over the last year, the bloom of algae in the wetland over the wet season and persistence of drilling fines, emphasises the sensitivity of these habitats to drilling operations.

The footprint of H8A8 was originally situated within pristine wetland habitat in close proximity to a perennial stream (Table 4.16; Figure 4.38: Wypt 123) but was shifted further east away from the river. The footprint effect was further minimised through re-shaping the site such that it exists as an elongated site along the road, thus minimising the extent of encroachment into the natural habitat. Nevertheless, prior to the recent clearing of the site, this area supported pristine Fynbos of high ecological importance and sensitivity (Table 4.16).

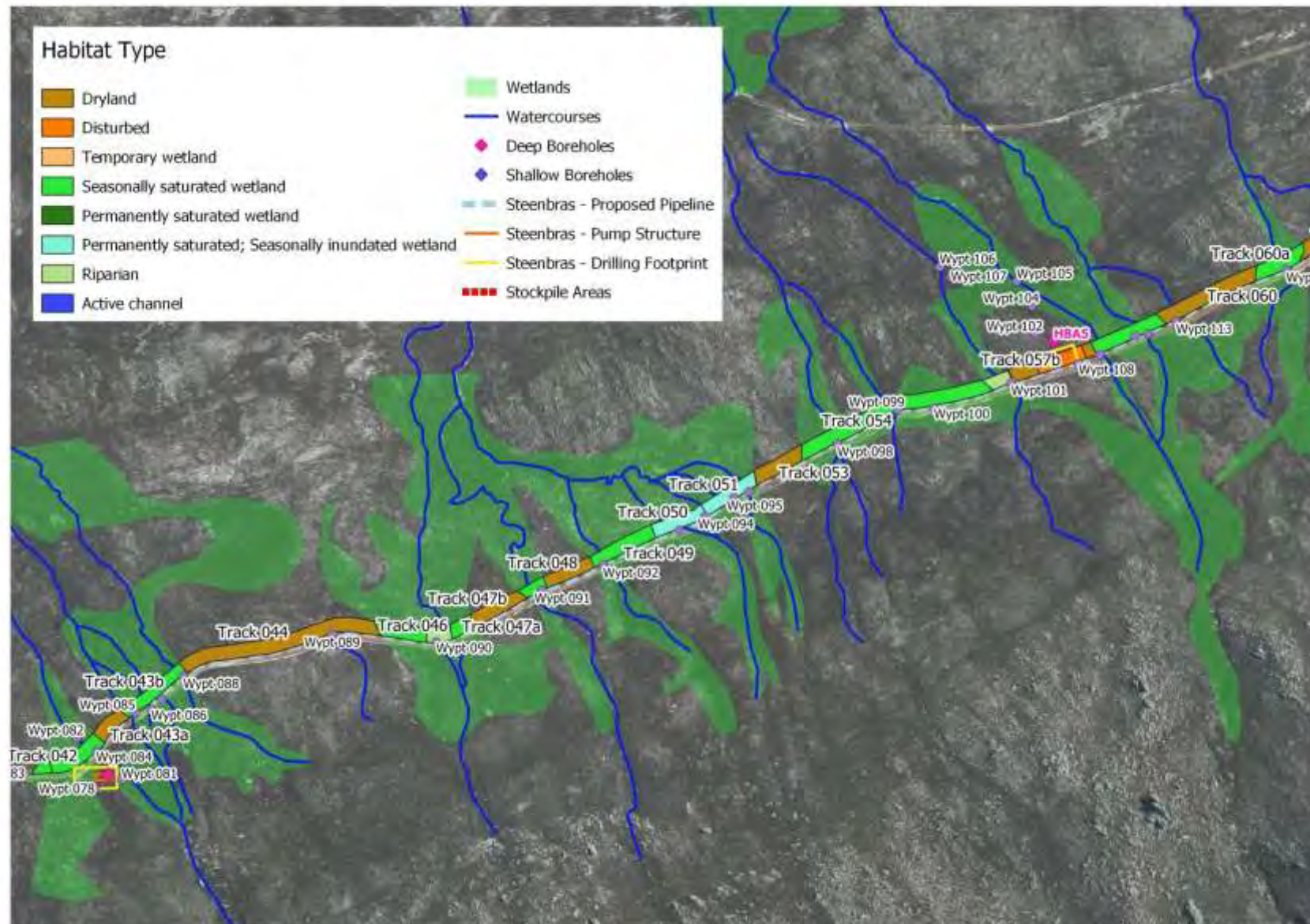


Figure 4.37 Management Unit 16a: Spatial extent of Habitat Type.

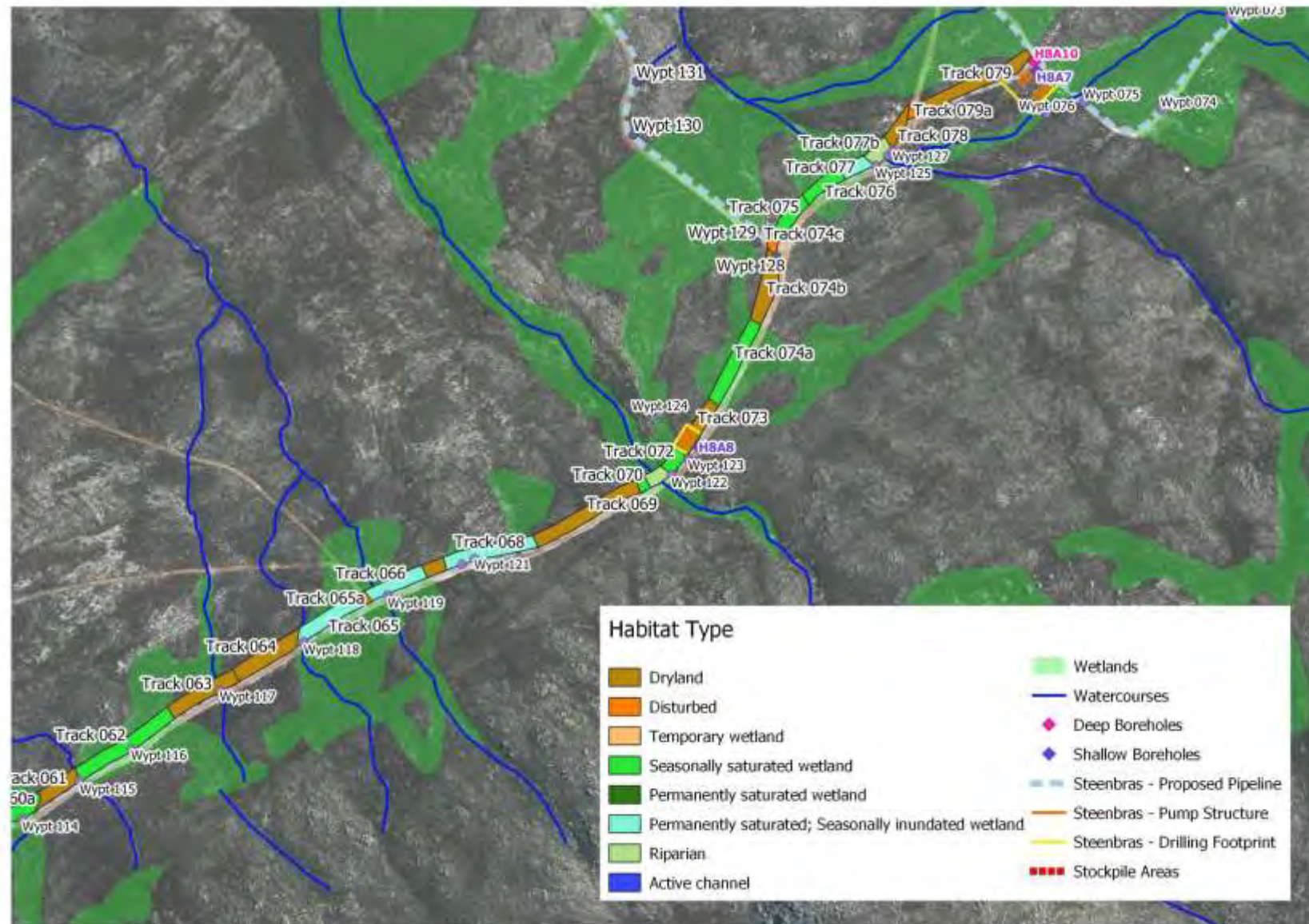


Figure 4.38 Management Unit 16b: Spatial extent of Habitat Type.

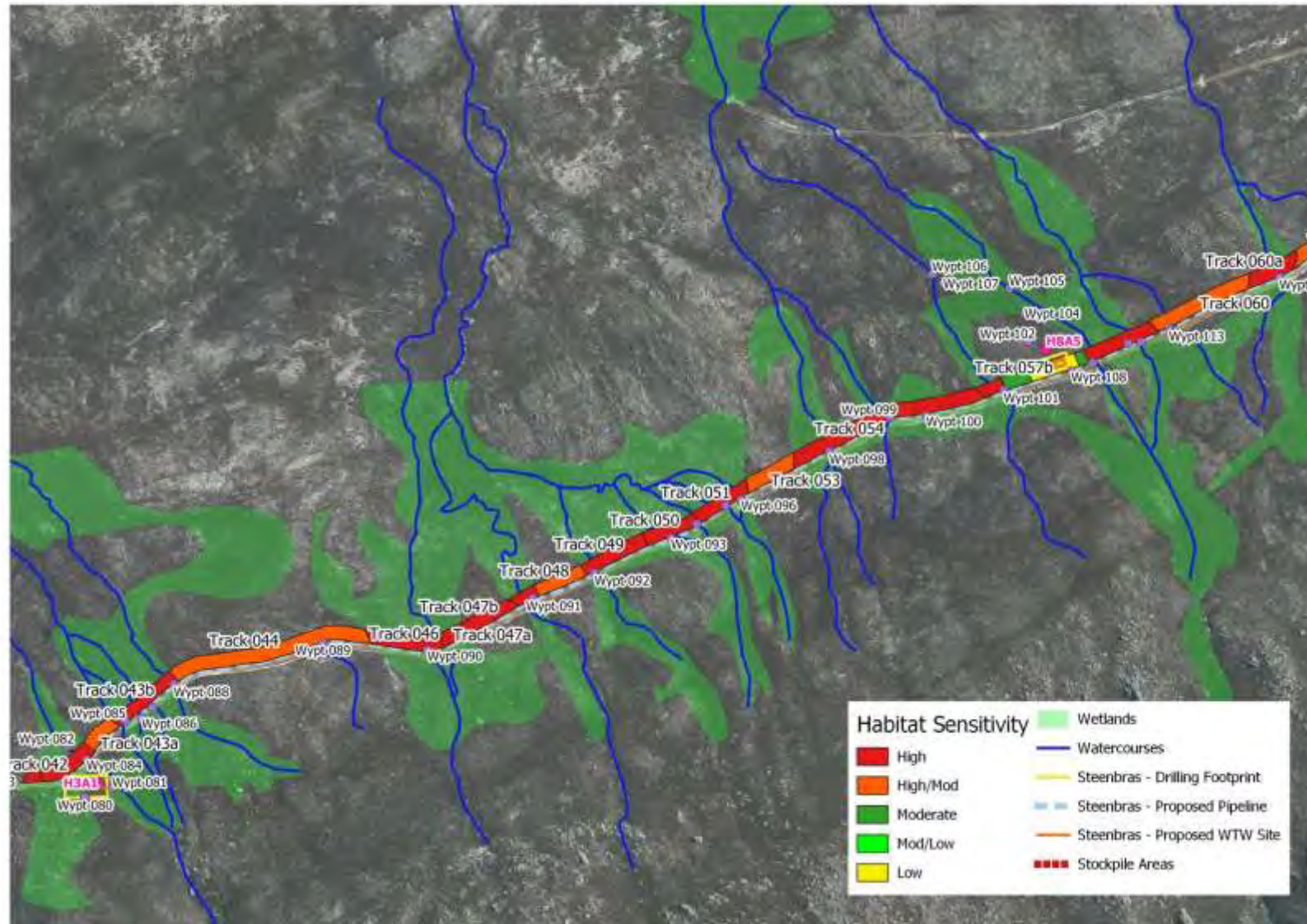


Figure 4.39 Management Unit 16a: Habitat Sensitivity.

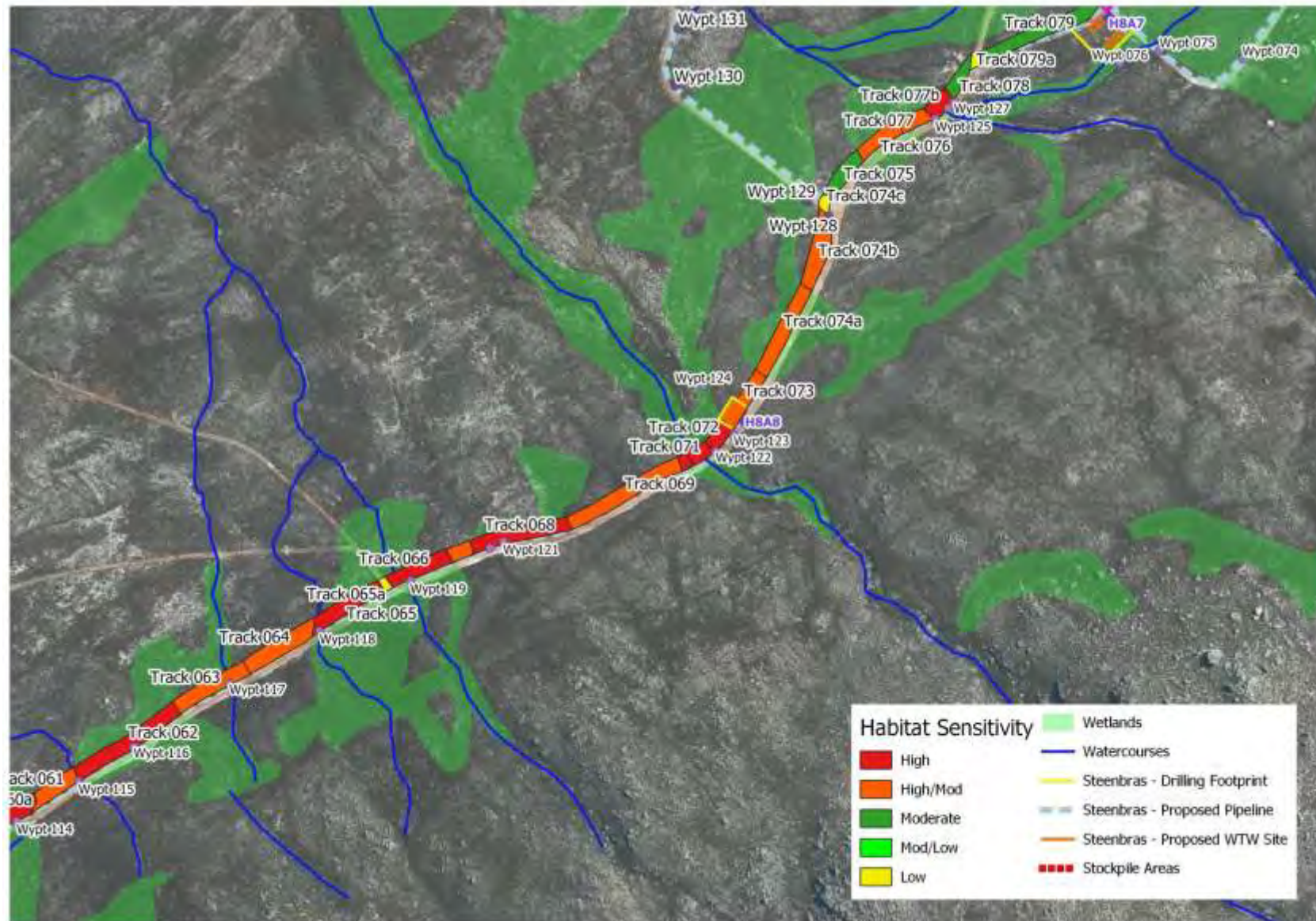


Figure 4.40 Management Unit 16b: Habitat Sensitivity.

Table 4.17 MU 16 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
WPo83	Wetland (seep)	natural habitat	seasonally saturated	<i>Elegia asperiflora</i> , <i>Seriphium cinereum</i>	Class A: habitat in good condition	High	High	This area coincides with the BH footprint as indicated on the map
Track 041& 042	Wetland (seep)	natural habitat	seasonally saturated	<i>Stoebe plumosa</i>	Class A: habitat in good condition	High	High	
WPo80 & 081	Wetland (seep)	natural habitat	permanently saturated; seasonally inundated	The site includes seasonally inundated area adjacent to ephemeral stream but there are dry components. <i>Leucadendron gandogerii</i> , <i>Erica fastigiata</i> . 081 is very close to the ephemeral stream	Class A: habitat in good condition	High	High	This is the site of the footprint for H3A1. Note: the pegs show the site is upslope of the road but the map shows it downslope of road. Impact is high due to very good habitat and species.
WPo82 & 084	Small stream	natural habitat	ephemeral	<i>Restio purpurascens</i> , <i>Brunia fragarioides</i> , <i>Erica hispidula</i> , <i>Erica fastigiata</i> , <i>Restio bifarius</i> along channel margin	Class A: habitat in good condition	High	High	
Track 043a	Dry land	natural habitat	N/A	<i>Leucadendron gandogerii</i> , <i>Restio bifarius</i> , <i>Elegia persistens</i> , <i>Thamnochortus gracilis</i> , <i>Erica serrata</i>	Class A: habitat in good condition	High	High	
WPo85	Small stream	natural habitat	ephemeral	<i>Phaenocoma prolifera</i> along channel margins	Class A: habitat in good condition	High	High	Flowing narrow channel
WPo86 & WPo87	Small stream	natural habitat	ephemeral	Part of a braided system. No flow at the time of the site visit because no pipe or culvert under the road	Class B: habitat in good condition but hydrologically altered due to road	High	High	No flow at the time of the site visit because no pipe or culvert under the road
WPo88	Small stream	natural habitat	ephemeral	<i>Restio purpurascens</i> , <i>Berzelia ecklonii</i> , <i>Erica fastigiata</i> , <i>Hypodiscus argenteus</i> , <i>Erica hispidula</i> , <i>Brunia fragarioides</i> , <i>Erica serrata</i> , <i>Restio occultus</i> , <i>Restio bifarius</i> , <i>Erica obtusissimus</i> and <i>Erica longifolia</i>	Class A: habitat in good condition	High	High	Flowing narrow channel
WPo89	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
Track 043b	Wetland (seep)	natural habitat	seasonally saturated	<i>Leucadendron gandogerii</i> , <i>Restio bifarius</i> , <i>Elegia persistens</i> , <i>Thamnochortus gracilis</i> , <i>Erica serrata</i>	Class A: habitat in good condition	High	High	
Track 044	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	
Track 045	Wetland (seep)	natural habitat	seasonally saturated		Class A: habitat in good condition	High	High	
Track 046	Riparian	natural habitat	permanently saturated		Class A: habitat in good condition	High	High	
WPo90	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
Track 047a	Wetland (seep)	natural habitat	seasonally saturated	<i>Nevillea obtusissimus</i>	Class A: habitat in good condition	High	High	
Track 047b	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	
Track 047c	Wetland (seep)	natural habitat	seasonally saturated	<i>Nevillea obtusissimus</i>	Class A: habitat in good condition	High	High	
WPo91	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
Track 048	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	

Table 4.16 continued 1 MU 16 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
WP092	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
Track 049	Wetland (seep)	natural habitat	seasonally saturated	Slightly raised area which has a mixture of wetland and dry land. Main species include: <i>Saltera sarcocolla</i> , <i>Leucadendron gandogeri</i> , <i>Willdenowia teres</i> , <i>Erica coccinea</i> , <i>Thamnochortus gracilis</i> , <i>Erica hispidula</i> , <i>Cliffortia atrata</i> , <i>Hypodiscus aristatus</i>	Class A: habitat in good condition	High	High	
Track 050	Wetland (seep)	natural habitat	Permanently saturated; seasonally inundated	<i>Ixia micrandra</i> , <i>Erica corifolia</i>	Class A: habitat in good condition	High	High	
WP093	Small stream	natural habitat	ephemeral	<i>Restio bifarius</i> , <i>Elegia asperiflora</i>	Class A: habitat in good condition	High	High	Flowing narrow channel
WP094	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
Track 051 and 052	Wetland (seep)	natural habitat	Permanently saturated; seasonally inundated		Class A: habitat in good condition	High	High	
WP095	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
WP096	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing narrow channel
Track 053	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	big boulders will need to be moved during piping
Track 054 & 055	Wetland (seep)	natural habitat	seasonally saturated	<i>Restio-Erica</i> habitat with <i>Searsia</i> .	Class A: habitat in good condition	High	High	note: disturbance at WP100 may be good for bypass
WP098	Small stream	natural habitat	ephemeral	<i>Erica fastigiata</i>	Class A/B: habitat in relatively good condition	High	High	Flowing narrow channel
WP099	Small stream	natural habitat	ephemeral		Class A/B: habitat in relatively good condition	High	High	Flowing narrow channel
Track 056	riparian	natural habitat	Permanently saturated; seasonally inundated		Class A: habitat in good condition	High	High	Riparian fringe associated with ephemeral stream
WP101	Small stream	natural habitat	seasonal		Class A: habitat in good condition	High	High	
Track 057a	Dry land	natural habitat	N/A	<i>Phaenocoma prolifera</i> , <i>Restio bifurcus</i> , <i>Restio egregius</i> , <i>Elegia thyrsoifera</i> , <i>Erica serrata</i>	Class A: habitat in good condition	Moderate	Moderate	
Track 057b	Dry land	Borehole site	N/A	No vegetation - cleared for borehole siting	Class C/D: disturbed habitat but would have been Class A	High	High	Area impacted by footprint of H8A5
Track 058 & 059	Wetland (seep)	natural habitat	seasonally saturated	<i>Nevillea obtusissimus</i> , <i>Hypodiscus aristatus</i> , <i>Berzelia ecklonii</i> , <i>Restio egregius</i>	Class A: habitat in good condition	High	High	
WP109	Small stream	natural habitat	ephemeral		Class B: impacted by road	High	High	Bigger culvert under road necessary.
WP110	Small stream	natural habitat	ephemeral		Class A/B: impacted by road	High	High	Culvert blocked
WP111	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	
WP113	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	
Track 060	Dry land	natural habitat	N/A	<i>Phaenocoma prolifera</i> , <i>Erica serrata</i> , <i>Erica fastigiata</i>	Class A: habitat in good condition	Moderate	High/Moderate	
Track 060a	Wetland (seep)	natural habitat	seasonally saturated		Class A: habitat in good condition	High	High	
WP114	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	
Track 061	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	

Table 4.16 continued2 MU 16 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity (ES)

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
WP115	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	Flowing strongly at time of site visit
Track 062	Wetland (seep)	natural habitat	seasonally saturated	<i>Mimetes cucullatus</i> wetland; also <i>Erica serrata</i>	Class A: habitat in good condition	High	High	
WP117	Small stream							
Track 063 & 064	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	
Track 065 & 066	Wetland (seep)	natural habitat	Permanently saturated; Seasonally inundated wetland	<i>Mimetes cucullatus</i> , <i>Restio purpurascens</i> , <i>Berzella lanuginosa</i> , <i>Erica hispida</i> , <i>Hypodiscus aristatus</i> , <i>Elegia asperiflora</i> , <i>Anthochortus crinalis</i>	Class A: habitat in good condition	High	High	
Track 065a	Disturbed	road	N/A		Class F: road	Low	Low	
WP118	Small stream	natural habitat	ephemeral		Class A: habitat in good condition	High	High	
WP119	Small stream	natural habitat	ephemeral	<i>Erica pageana</i>	Class A: habitat in good condition	High	High	
Track 067	Dry land	natural habitat	N/A	<i>Cliffortia</i> , <i>Leucadendron adscendens</i> , <i>Willdenowia teres</i>	Class A: habitat in good condition	Moderate	High/Moderate	
Track 068	Wetland (seep)	natural habitat	Permanently saturated; Seasonally inundated wetland	<i>Restio bifarius</i> , <i>Erica pulchella</i> , <i>Elegia asperiflora</i>	Class A: habitat in good condition	High	High	WP121 - <i>Cliffortia</i> proliferates on road edge showing disturbance
Track 069	Dry land	natural habitat	N/A	<i>Leucadendron gandogerii</i> , <i>Erica serrata</i> , <i>Hypodiscus digitata</i> , <i>Hypodiscus aristatus</i> , <i>Erica imbricata</i> , <i>Phaenocoma prolifera</i> , <i>Lanaria lanata</i> , <i>Serruria elongata</i>	Class A: habitat in good condition	Moderate	High/Moderate	
Track 070	Wetland (seep)	natural habitat	seasonally saturated		Class A: habitat in good condition	High	High	
Track 071	riparian	natural habitat	permanently saturated	<i>Berzella lanuginosa</i> , <i>Leucadendron salicifolium</i> , <i>Carpha glomerata</i> , <i>Blechnum</i> , <i>Prionium serratum</i> , <i>Brunia africana</i> , <i>Erica caffra</i> , <i>Neesenbeckia punctata</i> , <i>Restio purpurascens</i> , <i>Psoralea aphylla</i>	Class A: habitat in good condition	High	High	This is the riparian habitat flanking stream 5 which is a perennial stream
WP 122	Transitional Stream	natural habitat	perennial	This is stream 5. Active channel is approximately 17 m wide at the bridge crossing. Channel is a transitional stream with boulders and bedrock. In channel vegetation is dominated by <i>Prionium serratum</i>	Class A/B: habitat in good condition but some disturbance from existing bridge	High	High	Bridge is very broken and may need repair/replacement.
Track 072	Wetland (seep)	natural habitat	seasonally inundated	<i>Erica fastigiata</i> , <i>Elegia ebracteata</i> , <i>Berzella lanuginosa</i> , <i>Diastella thymelaoides</i> , <i>Thesium euphorbioides</i> , <i>Mimetes cucullatus</i> , <i>Hypolaena digitata</i> , <i>Erica ericoides</i> , <i>Erica serrata</i> , <i>Panaea mucronata</i> , <i>Erica sessiliflora</i> , <i>Elegia asperiflora</i> , <i>Erica imbricata</i>	Class A: habitat in good condition	High	High	this seep is partially within the footprint for H8A8 and thus pristine habitat of high conservation value will be lost i.e Impact is high
Track 073	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	This is the site of the footprint for H8A8. Note: the pegs show the site is upslope of the road but the map shows it downslope of road. Impact is high due to very good habitat and species.
Track 074a	Wetland (seep)	natural habitat	seasonally saturated		Class A: habitat in good condition	High	High	
Track 074b	Dry land	natural habitat	N/A		Class A: habitat in good condition	Moderate	High/Moderate	
Track 074c	Dry land	natural habitat	N/A	Disturbed road	Class E: road	Low	Low	
Track 075	Wetland (seep)	natural habitat	seasonally saturated		Class C: Impacted by road.	Moderate	Moderate	
Track 076	Wetland (seep)	natural habitat	seasonally saturated	<i>Aristida junceaformis</i> , <i>Berzella lanuginosa</i> , <i>Stoebe cinerea</i> , <i>Elegia asperiflorum</i>	Class B/C: Impacted by road	Moderate	High/Moderate	
Track 077	Wetland (seep)	natural habitat	permanently saturated	<i>Restio purpurascens</i> , <i>Prionium</i> , <i>Berzella lanuginosa</i> , <i>Berzella alopecuroides</i> , <i>Brunia africana</i> , <i>Psoralea pinnata</i> , <i>Diospyros glabra</i> , <i>Erica labialis</i>	Class B: some disturbance along road edge	High	High/Moderate	Road margin impacted by road material dumped along the edge
Track 077b	riparian	natural habitat	permanently saturated	Dominated by <i>Berzella</i>	Class A: habitat in good condition	High	High	
WP 125	Transitional Stream	natural habitat	perennial	This is stream 4. The active channel is approximately 18 m wide although flow during the dry season is limited to approximately 5 m of channel. The channel is dominated by bedrock and boulders with some <i>Prionium</i> and <i>Isolepis digitata</i> in the active channel	Class A/B: habitat in good condition but some disturbance from existing bridge	High	High	
Track 078	Dry land	natural habitat	N/A	<i>Erica longifolia</i> , <i>Erica pulchella</i> , <i>Cliffortia ruscifolia</i> , <i>Phaenocoma prolifera</i>	Class B: some disturbance along road edge	Moderate	Moderate	
Track 079	Dry land	natural habitat	N/A	<i>Cliffortia ruscifolia</i>	Class B: Disturbed edge	Moderate	Moderate	Road margin impacted by road material dumped along the edge
Track 079a	Disturbed	Road	N/A	Disturbed road	Class E: road	Low	Low	

4.1.17 Management Unit 17 (Track 212 to 227)

This management unit includes an alternative route to the section of pipeline/powerline between H8A9 and H8A6 and H8A2 (i.e. MU 12 and the eastern portion of Mu13) due the sensitivity of the latter through highly sensitivity pristine Fynbos. Also, some concerns around disturbance to the existing wetland seep monitoring site within this area were also raised.

The majority of Management Unit 17 includes sandy dryland through mature pine plantations with small sections through seasonally saturated wetland habitat (Figure 4. 41). There are a few rocky areas, particularly adjacent to the dirt road (Track 224) where the pipeline/powerline route would traverse a rocky outcrop with large boulders of Moderate to High sensitivity (Figure 4.42; Table 4.17).



Figure 4.41 Management Unit 17: Spatial extent of Habitat Type.

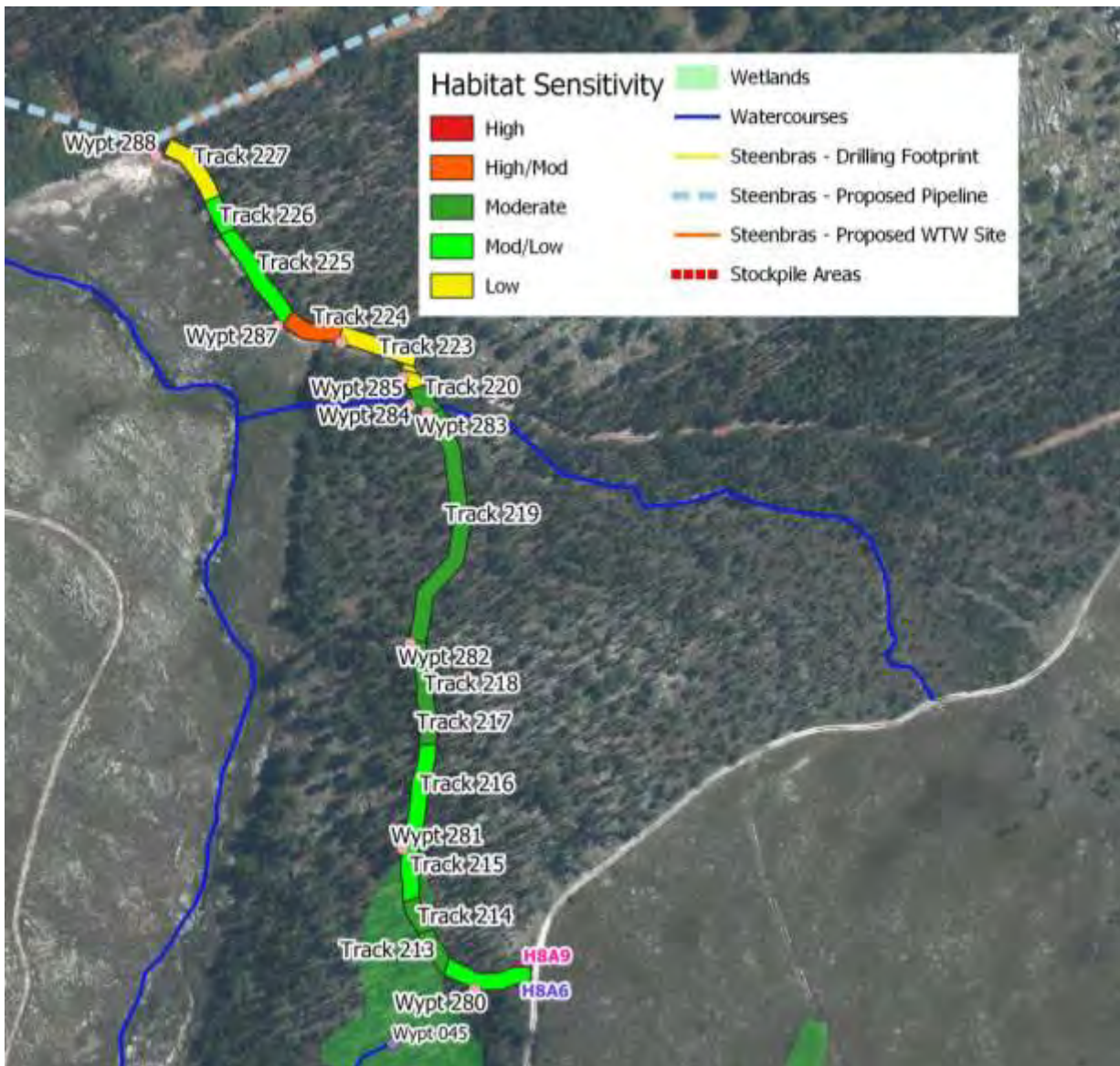


Figure 4.42 Management Unit 17: Habitat Sensitivity.

Table 4.18 MU 17 Characteristics of Habitat Types together with Ecological Condition, Ecological Importance (EI) and Ecological Sensitivity

Track or waypoint	Affected habitat	Setting	Hydroperiod	General description	Ecological Condition	EI	ES	Comment
Track 212	Dryland	Pine plantation	N/A	End of rocky outcrop from the east with some fynbos elements still evident within the pine plantation including: <i>Hypodiscus aristatus</i> , <i>Aspalathus</i> sp. cf. <i>ternata</i> , <i>Phylla buxifolia</i> , <i>Willdenowia teres</i>	Class D: largely modified by pine plantation	Moderate	Mod/Low	
Track 213 and WP280	Wetland (seep)	Pine plantation	Permanently saturated	<i>Elegia mucronata</i> , <i>Stoebe cinerea</i> , <i>Acacia longifolia</i> (indicates wetness), <i>Pinus pinaster</i> .	Class C: modified by pine plantation but there are still natural elements	High	Moderate	This is the upper end of the wetland at the base of the rocky outcrop
Track 214	Wetland (seep)	Pine plantation	Permanently saturated	<i>Acacia longifolia</i> among pines	Class D: largely modified by pine plantation	High	Moderate	Although the system has lost most of its natural vegetation, this system would recover if aliens are removed thus it is sensitive to potential hydrological changes.
Track 215 and WP 281	Dryland	Pine plantation	N/A	Deeper sands compared to Track 212. <i>Mastersiella digitata</i> , <i>Erica ericoides</i> , <i>Willdenowia teres</i> , <i>Leucadendron gandogerii</i> , <i>Ficinia radiata</i> , <i>Cliffortia ruscifolia</i> , <i>Ursinia crithmifolia</i> , <i>Helipterum zeyheri</i> .	Class D: largely modified by pine plantation	Moderate	Mod/Low	
Track 216	Dryland	Pine plantation	N/A	Dry area between rocky outcrops. Includes: <i>Hermas villosa</i> , <i>Ursinia paleacea</i> , <i>Tetralia compar</i> , <i>Cliffortia ruscifolia</i> , <i>Lanaria lanata</i>	Class D: largely modified by pine plantation	Moderate	Mod/Low	
Track 217	Wetland (seep)	Pine plantation	Seasonally saturated	<i>Empleurum uncapulare</i> , <i>Acacia longifolia</i> (indicates wetness), <i>Pinus pinaster</i>	Class D: largely modified by pine plantation	High	Moderate	
Track 218	Dryland	Pine plantation	N/A	Rocky area with <i>Serruria elongata</i> , <i>Lanaria lanata</i> , <i>Stoebe cinerea</i> , <i>Pinus pinaster</i> , <i>Acacia longifolia</i> (indicates wetness), <i>Hypodiscus aristatus</i>	Class D: largely modified by pine plantation	High	Moderate	
WP 282	channel	Pine plantation	ephemeral	no natural vegetation and appears to have been straightened or	Class E: no natural features	Low	Mod/Low	Channel with wet habitat skirting rocks
Track 219	Dryland	Pine plantation	N/A	<i>Serruria elongata</i> , <i>Pinus pinaster</i> , <i>Stoebe cinerea</i> , <i>Elegia asperifolia</i> , <i>Tetralia cuspidata</i> , <i>Gnidia pinifolia</i> , <i>Passerina corymbosa</i> , <i>Ficinia bracteata</i> , <i>Hypodiscus aristatus</i> , <i>Ursinia paleacea</i> , <i>Anthochortus crinalis</i> , <i>Tetralia compar</i> , <i>Diastella thymelaeoides</i> (SOCC).	Class D: largely modified by pine plantation	Moderate	Moderate	Poor fynbos cover with termite mounds
Track 220; WP 283	Wetland (seep)	Pine plantation	Permanently saturated	<i>Cliffortia ruscifolia</i> , <i>Tetralia compar</i>	Class D: largely modified by pine plantation	High	Moderate	Although the system has lost most of its natural vegetation, this system would recover if aliens are removed thus it is sensitive to potential hydrological changes.
WP 284	channel	Pine plantation	Seasonal	Eroded channel about 50 cm wide with cobble and sandy bottom, flanked by <i>Berzelia lanuginosa</i> , <i>Acacia longifolia</i> (indicates wetness), <i>Leucadendron salicifolium</i> , <i>Empleurum uncapulare</i>	Class D: largely modified by pine plantation	High	Moderate	This was likely a seep with diffuse flow under natural conditions. Loss of veg due to pines has led to erosion and downcutting
Track 221	Wetland (seep)	Pine plantation	Permanently saturated	No natural vegetation, only <i>Acacia longifolia</i> indicates wetness	Class E: no natural features	Moderate	Low	
Track 222	Disturbed	Pine plantation	N/A	Road (sandy track through pines)	Class E: no natural features	Low	Low	
Track 223	Dryland	Pine plantation	N/A	Sandy area to the north of the existing track	Class D: largely modified by pine plantation	Moderate	Low	
Track 224	Dryland	Pine plantation	N/A	Rocky habitat with large boulders along the road margin including <i>Lanaria lanata</i> , <i>Corybium glabrum</i> , <i>Restio gaudichaudianus</i> , <i>Diospyros glabra</i> , <i>Ceratocaryum argenteum</i> , <i>Stoebe cinerea</i> , <i>Saltea sarcocaulon</i> , <i>Cliffortia ruscifolia</i> .	Class C/D: modified but rocks retain habitat for natural vegetation	High	High/Mod	
Track 225	Dryland	Pine plantation	N/A	Rocky with small coarse sand in parts but no very large boulders Includes: <i>Ursinia crithmifolia</i> , <i>Cliffortia ruscifolia</i> , <i>Lanaria lanata</i> , <i>Ursinia paleacea</i> , <i>Restio gaudichaudianus</i> , <i>Saltea sarcocaulon</i> , <i>Leucadendron salignum</i> , <i>Metastasia capitata</i> , <i>Hypodiscus aristatus</i> , <i>Senecio erubescens</i> , <i>Erica serrata</i> .	Class D: largely modified by pine plantation	Low	Mod/Low	
Track 226	Wetland (seep)	Pine plantation	Seasonally saturated	<i>Ursinia paleacea</i> , <i>Restio egregius</i> , <i>Leucadendron salicifolium</i> , <i>Cliffortia atrata</i> , <i>Berzelia lanuginosa</i> , <i>Diospyros glabra</i> , <i>Stoebe plumosa</i> .	Class D: largely modified by pine plantation	Moderate	Mod/Low	Impacted by road which has affected drainage
Track 227	Dryland	Pine plantation	N/A	Dry course sand with pebbles and cobbles with an eroding side drain adjacent to the road. Vegetation includes <i>Ehrharta ramosa</i> , <i>Diospyros glabra</i> , <i>Ursinia paleacea</i> , <i>Lobelia pinifolia</i> , <i>Stoebe cinerea</i> , <i>Tribolium uniolae</i> .	Class E: due to drainage ditch	Low	Low	

5 IDENTIFICATION OF KEY IMPACTS ASSOCIATED WITH WELL FIELD DEVELOPMENT

This section highlights the key impacts to both aquatic and dry land ecosystems considered for each development component associated with wellfield development in Steenbras. **Section 5.1** describes impacts associated with the siting or footprint of the 16 production boreholes. **Section 5.2** addresses operational impacts, particularly pump testing from each borehole planned for this area. **Section 5.3** describes impacts associated with the infrastructure route, including the below ground pipeline route, the above ground transmission line, river crossings and stockpile areas. The siting of pump structures is also addressed in this section. Lastly, **Section 5.4** describes impacts associated with the proposed Water Treatment Facility. Alternatives and recommended mitigation measures are discussed where relevant within each of these sections.

5.1 Impacts associated with Borehole Drilling

5.1.1 Borehole footprint

The most obvious and direct potential impact associated with drilling activities is the loss of habitat within the footprint of the drilling rig and associated infrastructure, including the construction of sumps or placement of structures to contain water and debris within aquatic or dry land habitats of moderate or high ecological importance and sensitivity.

Sensitive habitats are also potentially impacted by runoff of oils and fuel associated with construction vehicles and the use of the area for personal ablutions.

The duration of any resultant impact depends on the severity of clearing, trampling or contamination, which is influenced by the intensity of the activity and the sensitivity of the environment. For instance, digging of construct sumps in natural habitat of high or moderate sensitivity is likely to result in medium to long term impacts of high intensity, whereas trampling by personnel within these areas is likely be a short term impact of low or moderate intensity. Also, leakage of oils, fuels and/or human waste may be short term in perennial or seasonal rivers that are flushed in the winter months, but medium to long term in terrestrial areas, wetlands or ephemeral channels.

The increased activity in the nature reserve and associated noise pollution from drilling operations is also likely to negatively impact on biota in the area.

5.1.2 Drilling effluent during percussion drilling

Percussion drilling uses a heavy bit that is repeatedly lifted and dropped that crushes and breaks the underlying formations. If the borehole is dry, water is added to form a slurry of water, rock cuttings and fine materials that

either leaks out or is blown from the hole by adding more water. A surfactant, known as Rotafoam² is also added to the water to facilitate the drilling process. The result is large volumes of water laden with suspended solids, and containing Rotafoam. This effluent is discharge into the environment in a downstream direction, and periodically “blown” from the borehole over a radius of ~30 m, if not mitigated. Overland flow or blow of drilling effluent can adversely affect habitat integrity through a change in chemistry and/or smothering by fine material.

Table 5.1 Summary of the habitat type, Ecological Sensitivity and Area of each borehole footprint as an indication of the extent of loss/destruction of habitat. Note: the footprint of the pump stations for each borehole will be a maximum of 60 m² and falls within the disturbance footprint for drilling operations (see section 5.3.3). This area will be permanently lost while the remaining area disturbed during drilling will be rehabilitated.

Borehole	MU	Setting	Affected habitat	ES	Disturbance footprint (area in m ²)
H1A1	1	Pine plantation	Seasonally saturated wetland seep	Moderate	752
H1A3b	8	Pine plantation	Seasonally saturated wetland seep	Moderate	415
H1A4a	9	Firebreak	Dryland	Low	803
H1A4b	9	Firebreak	Dryland	Low	576
H8A12	10	Pine plantation	Dryland	Low	444
H8A13	10	Eucalyptus plantation	Seasonally saturated wetland seep	Low	976
H8A9;H8A6	12	Pine plantation	Dry land	Mod/Low	949
H8A2	13	Natural	Dry land	High	327
H8A4	13	Natural	Dry land	High	900
H8A7; H8A10	13	Natural	Permanently saturated wetland seep	High	606
H8A11	15	Eucalyptus plantation	Dry land	Low	247
H3A1	16	Natural	Seasonally saturated wetland seep	High	900
H8A5	16	Natural	Dry land	High	332
H8A8	16	Natural	Dry land	High/Mod	900

5.1.2.1 The potential effects of a change in pH

The aquatic ecosystems at Steenbras are acidic (pH = 3.7 and 4.5). Available data suggest that the drilling effluent has a pH of 6-7.

pH is a log scale, so change of one pH unit is equivalent to a ten-fold change in hydrogen ion concentration (Dallas and Day 2004). pH values in rivers and wetlands of the south-western Cape fluctuate by more than one pH unit on a seasonal basis (Rivers Database), but aseasonal changes in pH affect the ionic and osmotic balance of aquatic organisms and can result in short-term effects on survival, and long term impacts on growth rate and

² Rotafoam is a highly concentrated blend of ethoxylated alkyl ether sulphates, with a half-life in the environment of 56 days, which is used to facilitate the borehole drilling process. It is an alkaline product with a pH of 9-10 (Information taken from the EMSDS provided by SamChem, 2007).

fecundity, of aquatic fauna (Dallas and Day 2004). pH levels also affect the solubility of elements and compounds, and so can have a profound influence on overall chemistry. Periphyton (benthic algae), which is the major food source for aquatic grazers in open-canopied streams and wetlands characteristic of those in Steenbras, is particularly sensitive to pH changes in the south-western Cape and changes in periphyton could have knock-on effects through the entire aquatic ecosystem, and beyond.

5.1.2.2 The potential effects of a nutrient concentrations

The aquatic ecosystems at Steenbras are oligotrophic (i.e., nutrient poor) in terms of both phosphates and nitrates.

The drilling effluent is relatively rich in phosphates relative to the surrounding streams and wetlands. A spill of drilling effluent into a small perennial stream in Steenbras in December 2017 led to significantly higher phosphate concentrations (Ewart-Smith 2018), although it is not clear whether this was a product of the Rotafoam or whether high suspended solids increased the transport and availability of nutrients to the system. Regardless, the increased phosphates caused a bloom of red algae, which completely changed the composition of the food sources in the stream and coated the rocks, reducing habitat availability and quality for grazers.

Considering the ecological importance and sensitivity of the aquatic and dry land habitats of the Steenbras Area, impacts due to water quality changes from drilling effluent are generally of high intensity but the duration of the impact depends on the extent to which water chemistry is reset following the high flow season in streams. The effects in wetlands however, may endure in the long term.

5.1.2.3 The potential effects of sediments

As observed in the small perennial stream impacted by drilling effluent in Steenbras following runoff of drilling effluent from H8A7 during December 2017, fine sediments blanket the substrata resulting in a shift in habitat from a system of bedrock/boulder cascades and cobble runs and pools to a system dominated by sandy runs and pools with some silt-laden cascades. Beside the direct loss of habitat, sediments smother aquatic and riparian vegetation, fish and amphibian eggs as well as benthic invertebrates. As aquatic biota are smothered and die, oxygen levels drop in the water column due to decay of a large biomass of organic material which in turn impacts on the water chemistry and thus biotic community of these systems. Sediments also smother benthic diatoms which drive productivity in these systems and thus indirectly impact aquatic fauna through the loss of a primary food source for grazers. These unnaturally fine sediments are unlikely to flush completely from the system, even following the wet season and thus the impact is considered a medium to long term impact. Depending on the sensitivity of the habitat, the intensity of the impact may vary but is generally of high significance in Steenbras due to the near natural condition and high ecological importance and sensitivity of these habitats.

5.1.3 Mitigation measures to address Borehole Drilling related impacts

There is no mitigation that will offset the loss of pristine wetland habitat of high conservation value and ecological sensitivity associated with the footprint of some boreholes (Table 5.1). In particular, H3A1 and the

recent loss of seasonal wetland habitat at H8A5 associated with effluent runoff. Potentially also H8A8, H8A10/H8A7, H8A4 and H8A2. It is likely that loss of wetland and dry land of high ecological importance and sensitivity will require an offset. Offset requirements can only be determined once the footprints of all borehole sites have been determined.

With regards to borehole sites within disturbed wetland and/or dryland habitat with rehabilitation potential, particularly with regards to alien invasion (e.g. H1A1, H1A3b, H8A13, H8A11), it is recommended that all alien trees within a band of 30 m from the footprint be cleared to allow rejuvenation of seed within the topsoil. Within the footprint itself, all sump material must be returned to the sump pits with top material used for final shaping as part of the rehabilitation process. Where necessary, topsoil and mulch will need to be added and impacted areas revegetated with appropriately specified plants.

The impacts associated with the “blow” of drilling effluent can be somewhat minimized by the use of a rubber ‘sleeve’ surrounding the drill bit such that the extent of the material spread from the borehole is reduced. While the impacts of drilling effluent spilling into sensitive habitats can be reduced by the use of sumps, together with plastic lined trenches and/or pipes that direct effluent directly to the dam, there are still instances where flows of effluent cannot be effectively contained and thus still pose a risk of contamination to ecologically sensitive habitats. In instances where spillage into watercourses or wetlands (e.g. H8A7, H8A4a and H8A4b) has occurred, it is recommended that the extent of the impact is measured in terms of water quality, aquatic fauna and flora and geomorphological (habitat) changes. It is further recommended that remediation measures (e.g. the removal of sediments) under the guidance of a specialist be implemented and that the recovery of the system following the event is monitored.

It should be noted that while this report addresses impacts to natural watercourses, wetlands and drylands, the potential impacts associated with the direct discharge of drilling effluent into the Steenbras Dam have not been addressed here but will be dealt with in a separate study.

5.2 Impacts associated with Pump testing from boreholes

Pump testing involves the discharge of large but varying volumes of water (up to 50-60 l/s) into the environment for 2-4 weeks. This would likely have water-quality and water-quantity related impacts on the receiving aquatic ecosystems, although the intensity would vary depending on location.

5.2.1 Erosion of watercourse and wetlands

Elevated discharge into a small river is likely to cause erosion of the bed and banks, destruction of some habitats and reduce quality of others. Even short-term increases in discharge can be expected to result in long-term impacts. Where the receiving streams are bedrock and boulder dominated, obvious erosion would be less, but the relatively rare and productive sand and gravel deposits would be washed away, changing habitat diversity, and thus biodiversity. Where the receiving area is dominated by gravel and sandy substrates, e.g., in wetlands, dongas could form, affecting not only the habitat directly, but also indirectly affecting the whole wetland by

permanently changing the flow of water through the system. Thus the intensity of the erosion impacts on these systems is generally high and would persist in the long term.

5.2.2 Hydrological changes and the disruption of natural aquatic ecosystem processes

Aquatic fauna of the western Cape are adapted to naturally dry summers with few small flood events (or freshets), and wet winters with frequent high flood events. Lifecycle events (such as spawning and emergence) are cued by the natural hydrological cycle. Aseasonal discharges will disrupt these natural patterns associated with specific life cycle events which would affect natural functioning of the ecosystem. Provided these are short-lived events, the overall impact is likely to be of low intensity and short-term.

5.2.3 Change in water chemistry in wetlands and streams

Besides differences in pH between surface waters and groundwater in Steenbras, water chemistry data from borehole sites within Steenbras suggest elevated levels of metals, relative to surface waters. In particular, samples indicate iron (Fe) and manganese (Mn) concentrations in groundwater that are significantly greater than that of surface waters. Concentrations of these metals do however vary considerably between boreholes as indicated by recent data. Both Fe and Mn are known to be toxic to aquatic organisms in high concentrations (Dallas and Day 2004) and thus changes in the concentration of metals in streams and wetlands poses a significant risk to the integrity of these systems.

5.2.4 Effects on dry land flora/fauna

Many of the impacts of pump testing noted above will also be significant in the context of the dry land fauna and flora. These impacts include physical erosion of substrate, physical erosion of microfauna and soil stored seed and bulbs, changes to soil pH, and possible temporary waterlogging of habitats not normally waterlogged. The seasonality of the additional water would also be important, as the extra water in the dry season may interfere with germination or growth patterns, but could arguably also be beneficial for certain taxa. On balance the pump testing waterflows are likely to be significantly less negative for the dry land fauna and flora than the drilling outflows, due to the far lower sediment load, and lack of Rotafoam, and the significance is likely to be Low or Medium in most cases.

5.2.5 Mitigation measures to address Pump Testing related impacts

Feasible mitigation measures considered for reducing the potential environmental impacts of pump testing include:

- Discharge groundwater into the Steenbras Dam via a pipe system
- Discharge during mid-winter into perennial, bedrock/boulder streams when the flows in the systems would be naturally elevated to reduce disruption of flow/water-linked processes.

While the hydrological impacts associated with discharge of groundwater can be mitigated through discharge into perennial rivers during mid-winter, this would not necessarily offset the impacts associated with water

quality changes to these systems. This would depend on the actual concentration of metals in groundwater and the ability of the surface water system to dilute these concentrations. Nevertheless, direct discharge of groundwater to the Steenbras Dam will reduce the impacts to sensitive habitats associated with pump testing to very low or negligible with any residual impacts related to the laying of the pipe system. These impacts can be avoided through laying of the pipe system within the current road network as far as possible.

The potential impacts associated with the direct discharge of groundwater into the Steenbras Dam have not been addressed here but will be dealt with in a separate study.

5.3 Impacts associated with the infrastructure network through Steenbras

Required infrastructure for the development of the Well-field at Steenbras includes the laying of a pipeline route for the transfer of groundwater from each of the 16 boreholes to a Water Treatment Facility located near the head of the upper Steenbras Dam. Associated with the pipeline route is an underground electrical cable that will run within the same trench as the pipeline route. Also, the infrastructure network includes a short section of overhead electrical cabling immediately south and parallel to the Rock View Dam with a below ground cable that links with the cabling of each of the boreholes. The majority of the infrastructure route is located adjacent to or within the existing road network. The construction phase of the infrastructure route will include stockpiles located within firebreaks or roads. Besides the construction of the Water Treatment Facility, infrastructure associated with Well-field development in Steenbras includes the construction of 16 pump houses within the current borehole drilling footprint. Details of the infrastructure network are given in Section 2.

5.3.1 Below ground pipeline/powerline route impacts

The most obvious and direct impacts associated with the construction of the pipeline/powerline is the loss of wetland and dry land habitats of moderate to high ecological importance and sensitivity during trench construction and associated pipeline/powerline laying operations. The estimated working width for the pipeline/powerline installation is of 5 m along the road with an estimated 10 m width for portions of MU 17 within the plantation. Encroachment into natural habitat varies, however, and is given for each section of the route summarised for each of the 17 Management Units identified. A total of 64865 m² of habitat will be lost to accommodate the footprint of the pipeline/powerline route in Steenbras (Table 5.2). A breakdown of the aerial extent of encroachment into different habitat types within each Management Unit is provided in Table 5.2. Also, the number of watercourses that will be traversed by the pipeline/powerline route is indicated in Table 5.2. Based on the spatial extent of habitats affected, it is evident that the majority of habitat impacted is dryland (37656 m²), with a large proportion of seasonally saturated wetland habitat lost by the pipeline/powerline route (13230 m²). In total, 25406.5 m² of wetland habitat will be lost to accommodate the below ground pipeline/powerline route.

Approximately 50% of the habitat lost to accommodate the pipeline/powerline route is considered of Moderate, High/Moderate or High Ecological Sensitivity (Table 5.3). This is considered a permanent impact of high intensity at a regional scale and thus is a negative impact of high significance.

Besides the loss of sensitive habitat, the pipeline/powerline route would result in hydrological changes to wetlands due to compaction of the trench as well as placement of an obstacle in the flow path of subsurface flows in wetlands. Furthermore, adjacent habitat will be at risk of disturbance through trampling and runoff of poor quality water during construction. In instances where dewatering of wetlands will be required during construction, there is also a potential risk of sedimentation of adjacent and/or downstream wetland habitat. Without mitigation, these impacts could be permanent and of high to moderate intensity at a regional scale and are thus considered impacts of high significance. The implementation of appropriate mitigation measures may reduce the significance of these impacts although the significance of residual impacts will depend on the extent to which mitigation measures can be feasibly implemented (see section 5.3.2).

Table 5.2 indicates that a large number of seasonal/ephemeral watercourses will be traversed by the pipeline/powerline route. The route also crosses a total of six perennial streams of high ecological importance and sensitivity (Table 5.2). Most of the watercourse crossings will be placed below the ground level, particularly in the case of narrow, seasonal/ephemeral systems with sandy/gravel substrata. The pipeline/powerline traversing the perennial systems will be above ground.

In terms of the below ground crossings, the likely impacts include:

- Disturbance to channel banks and beds at crossing points;
- Potential erosion of the channel margins.
- Construction-related water quality impacts.

Potential impacts associated with above ground crossings include:

- Disturbance to channel banks and beds at crossing points;
- Potential erosion of the channel margins.

If unmitigated, these negative impacts could endure in the long term and result in moderate to high intensity impacts of moderate to high significance. However, through the implementation of appropriate mitigation measures, these impacts can be significantly reduced (see section 5.3.2).

5.3.2 Above ground transmission line impacts

A short section of overhead transmission cabling is required through an area downstream of the Rock View Dam that is largely pristine with ecologically sensitive habitats. Description of these habitats is provided in Section 4 (Table 4.4). It is estimated that a working width of 20 m is required for the installation of the overhead transmission line and thus, a corridor of 20 m will be disturbed during the construction phase. The aerial extent of the habitat types will be affected by the transmission line is given in Table 5.4, while the extent of sensitive habitats potentially disturbed during installation is provided in Table 5.5. Impacts include:

- the permanent loss of ecologically sensitive habitat from the placement of pylons to support the overhead cables,
- trampling and disturbance of natural habitat as cabling is hauled by foot through sensitive habitat,
- Vehicular activity in sensitive habitats required to transport cabling and other construction related material.

While measures can be implemented to reduce the intensity and spatial extent of the impact within the affected corridor, the loss of habitat associated with the pylons and the hauling of cables would result in a negative impact of high significance.

5.3.3 Impacts associated with the pump stations

The maximum footprint of each borehole will be approximately 60 m² and will depend on the final design of each unit. The exact location of each pump station is yet to be determined although the footprint will be located around each of the 16 boreholes. Thus, many of the pump stations will replace natural habitat (both wetland and dry land) of moderate or high ecological importance and sensitivity (see Table 5.1). Also, many of these sites are located very close to channels and seeps in some areas. Thus, besides the permanent loss of ecologically significant habitat, the pump stations may result in localized changes in the runoff that may promote erosion and contaminate these systems through increasing sediment loads into natural systems (particularly during construction). Furthermore, operation of groundwater pumps may affect the use of adjacent habitat by aquatic and semi-aquatic biota in wetlands and terrestrial fauna in dryland areas due to noise disturbance.

While construction phase impacts can be mitigated to some extent, the loss of ecologically sensitive habitat to accommodate the footprint of the 16 pump stations would be a permanent impact at a regional scale and is thus considered a negative impact of high significance.

5.3.4 Impacts associated with the Water Treatment Facility

Functional wetland habitat is currently impacted by siting of the contractor's camp within seeps and the construction of drainage ditches to accommodate vehicle activity (hydrological impacts) (PES = C/D) but Ecological Importance is high and sensitivity is Moderate to High. Although the site was impacted by plantations and mowing prior to these activities, it still provides functional habitat that supports rare plant species (e.g. *Wachendorfia* sp.) and is thus considered wetland habitat of moderate to high ecological importance. Siting of the Water Treatment Facility in this area will result in:

- Loss of functional seep wetland habitat (permanently saturated, seasonally inundated wetland habitat) of moderate to high ecological importance and sensitivity associated with the footprint.
- Water quality pollution and sedimentation of wetlands downstream of the site as a result of runoff from the construction site.
- Changes in hydrology (i.e. increased flows), as a result of runoff from the construction site.

These negative impacts are considered permanent and of moderate intensity at the regional scale and thus are likely to result in an impact to freshwater ecosystems of high significance.

5.3.5 *Impacts related to the stockpiling of material*

All proposed stock pile areas fall with existing firebreaks, roads or highly degraded dryland habitat within plantations. Therefore, there are no direct impacts associated with the siting of stockpiles. Some stockpile areas are however located in close proximity to watercourses or wetlands that may be impacted by sediment laden runoff that could potentially impact on these systems. While these impacts may persist in the medium terms resulting in negative impacts of medium significance, these impacts are easily mitigated through the implementation of general construction impact control measures (see section 5.3.6 below).

It should be noted that impacts to natural surface water habitats associated with abstraction have not been considered to date. Evaluation of the potential impact of large scale abstraction requires greater understanding of the underlying hydrogeology at each site, which will also be provided through drilling and pump-testing.

5.3.6 *Mitigation measures to address impacts associated with the infrastructure route.*

Infrastructure related impacts within Steenbras cannot be avoided by relocating the infrastructure route elsewhere and thus, in keeping with the mitigation hierarchy, it is recommended that the areal extent of habitat disturbed by the infrastructure route should be minimised as far as possible, particularly in habitats of moderate and high ecological sensitivity. In an attempt to minimise footprint impacts associated with the pump stations, it is recommended that micro-siting of these structures takes place to minimize the permanent loss of ecologically important habitat and to maximize distance from aquatic ecosystems that may be impacted by runoff from these structures.

Recommendations for where this is most relevant are specific to each of the defined 17 Management Units (MUs) and described in more detail in Tables 5.6 to Table 5.22.

Besides efforts to minimise the working width in sensitive habitats, it is recommended that the following measures are implemented:

- Search and Rescue of plant material as well as seed collection must be undertaken within the disturbed areas prior to commencement of construction activities. This will be specific to particular MUs as indicated in Tables 5.6 to 5.22.
- All alien vegetation within a band of 25 m from the infrastructure route must be cleared prior to trench excavation. This activity is specific to those areas that are currently invaded with alien vegetation and/or plantations and the details of such are indicated in Tables 5.6 to 5.22.
- Trench excavation must take place in short sections with the storage of top soil adjacent to the excavated trench.
- Top material must then be returned to the same habitat from which it was removed following pipe/cable laying, making sure that bed material and top soils are not compacted more than they are naturally.
- Ensure that the profile of the trench once top material is returned has the same cross section profile as it was prior to trench excavation. Thus, any excess material would need to be disposed of elsewhere, so that a raised mound is not created along the pipeline.

- Where the footprint of the pylons are placed for the overhead transmission line (MU 4), top material must be removed and stored for use in similar habitats elsewhere.
- Following the return of top soils, it is important that areas affected by the infrastructure route are rehabilitated as far as possible through replanting of indigenous vegetation within the affected areas. This may include a mix of locally indigenous plants that are functional (to stabilise the habitat) as well as replacement of conservation worthy vegetation. The details of rehabilitation are given in a separate report and are specific to each MU as indicated in Tables 5.6 to 5.22.

To mitigate against potential hydrological changes to wetlands and watercourse associated with obstructed flow, it is important that the pipeline/powerline is placed as deep as possible. More specifically, the top of the pipe should be at least 50m below ground level (i.e. top material following construction should be at least 50 cm above the top of the pipe) to reduce or minimise changes in the nature of subsurface flows through wetland habitats.

In terms of the impacts associated with below ground watercourse crossings, these can be mitigated by implementation of the following measures:

- The pipe must be placed such that cover material is returned to the natural level of the channel such that flow is not impeded.
- The disturbed area must be revegetated to ensure re-establishment and stabilisation of slopes.
- No concrete to be used within the active channel.

With regards to the above ground watercourse crossings it is recommended that placement of concrete columns within the active channel for the support of above ground stream crossings is avoided as far as possible. Through onsite discussions with the engineering team, it is evident that this is easily achievable in most instances. Where not possible, concrete and cement must be contained as far as possible to prevent contamination of the aquatic habitat. Furthermore, any disturbance to the riparian margin must be rehabilitated through stabilisation and revegetation of the channel banks.

In the case of both below and above ground crossings, it is recommended that construction be undertaken during the dry season as far as possible when risk of contamination is minimised. Also, work areas must be confined to minimise the negative effects of trampling. Bank rehabilitation would require the input of a restoration botanist / freshwater ecologist.

Although it is recommended that micro-siting of the pump stations is undertaken to minimise direct and indirect impacts to ecologically sensitivity habitats, runoff from the hardened surfaces associated with these structures must to managed in such a way that watercourses and wetlands are not the recipients in an attempt to minimise both hydrological and water quality related impacts to these systems.

Impacts to wetlands within the current Water Treatment Facility can be minimised by relocating the treatment plant into the existing pine forest or into the island between the forestry building entrance and exit roads. It is further recommended that alien trees (mostly Pines) within a radius of 30 m from wetland habitat is cleared to

improve the ecological functioning of these systems as a means to improve the hydrological functioning of the areas. Also, existing wetlands impacted by recently dug drainage ditches should be rehabilitated thus reinstating their hydrological functioning with allowance for planting of the rehabilitated area with appropriate indigenous vegetation. Depending on the location of treatment facility, storm water runoff and any waste products associated with the operational phase will need to be managed such that wetlands and watercourses are not the recipients of poor quality runoff.

General construction impact control measures are relevant to all aspects of the infrastructure route proposed for Steenbras as follows:

- Basic Best Practice construction measures should be included in the CEMP for the construction process, specifying measures to ensure that stockpiles and construction material are not located within 40m of any watercourse, or such that they will contaminate such areas through uncontrolled runoff or wind erosion;
- Construction of the pipeline should take place in the dry season, when damage to wetland areas as a result of churning up of muddy areas is least likely;
- Dewatering of water accumulating in the pipeline trenches should be designed to allow collection of sediment and control of runoff velocities, ideally promoting diffuse infiltration of dewatered liquids, rather than channelled flow into watercourses;
- Following construction, all construction-associated waste (litter, excess pipes, etc.) should be removed from the construction area, and from any watercourse or other sensitive ecosystems.

Despite attempts to minimise, rehabilitate and mitigate against impacts associated with the infrastructure route through Steenbras, there is no mitigation that will offset the loss of wetland and dryland habitat of high Ecological Importance and Sensitivity. In particular, the below ground pipeline/powerline route, (Table 5.2 and 5.3), the overhead transmission line (Table 5.4 and 5.5) and the pump stations. Thus it is likely that the loss of these ecologically sensitive habitats will require an offset by legally securing areas elsewhere for conservation and management for the protection of biodiversity and ecological functions. Offset requirements outside of Steenbras may however be rationalized through the implementation of measures to address existing impacts to sensitive habitats within Steenbras. In particular, reinstating the flow paths of wetlands currently impacted by roads adjacent to the pipeline route would significantly improve their hydrological functioning and thus their overall condition, and it is strongly recommended that these measures be implemented accordingly.

Lastly, impacts to natural surface water habitats associated with abstraction have not been considered to date. Evaluation of the potential impact of large scale abstraction requires greater understanding of the underlying hydrogeology at each site, which will also be provided through drilling and pump-testing.

Table 5.2 A breakdown of the aerial extent (m²) of different habitats provides an indication of the level of encroachment into these areas to accommodate the underground pipeline/power line route. The number of water courses that will be affected along these routes is also indicated.

Habitat type (area in m ²)	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	MU10	MU11	MU12	MU13	MU14	MU15	MU16	MU17	Total area
Dryland	2300.50	1223.5	2148.0	N/A	N/A	N/A	453.5	2090.5	4761.0	10394.5	1826.0	455.0	1240.5		799.5	4890.5	5073.0	37656.0
Disturbed			105.0	N/A	N/A	N/A		126.5		704.0	89.0		153.5	141.5	111.5	340.5	31.0	1802.5
Temporary wetland	714.00		949.0	N/A	N/A	N/A												1663.0
Seasonally saturated wetland		280.5		N/A	N/A	N/A	1672.0	2358.0		2398.0	437.0	104.5	779.5	425.0	374.0	4074.5	327.0	13230.0
Permanently saturated wetland	395.50			N/A	N/A	N/A		1143.0							2249.5	126.0	902.0	4816.0
Permanently saturated; Seasonally inundated wetland	1011.50	338	262.5	N/A	N/A	N/A	873.0			254.5	296.5		413			1383.5		4832.5
Riparian				N/A	N/A	N/A		234.0		83.5						422		739.5
Active channel			87.0	N/A	N/A	N/A				38.5								125.5
Total area	4421.5	1842.0	3551.5	0.0	0.0	0.0	2998.5	5952.0	4761.0	13873.0	2648.5	559.5	2586.5	566.5	3534.5	11237.0	6333.0	64865.0
Habitat type (number)	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	MU10	MU11	MU12	MU13	MU14	MU15	MU16	MU17	Total number
Perennial watercourse	0	0	1	N/A	0	0	0	1	0	1	0	0	0	0	0	2	0	5
Ephemeral/Seasonal watercourse	1	0	0	N/A	0	0	3	2	0	3	2	1	3	1	1	22	2	41
Artificially created drainage channel	1	0	2	N/A	2	0	2	6	0	7	0	0	0	0	0	0	0	20
Total number	2	0	3	N/A	2	0	5	9	0	11	2	1	3	1	1	24	2	66

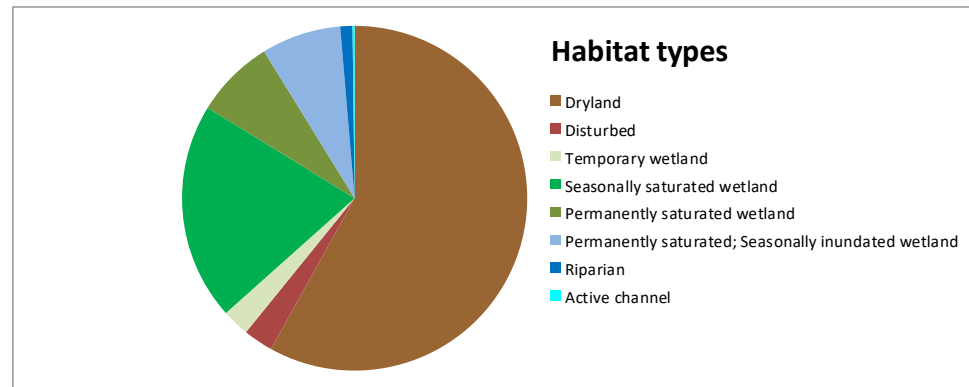


Table 5.3 A breakdown of the aerial extent (m²) of habitats that will be lost to accommodate the underground pipeline/power line route (given in Table 5.1) in terms of their Ecological Sensitivity.

Habitat type (area in m ²)	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	MU10	MU11	MU12	MU13	MU14	MU15	MU16	MU17	Total area
High				N/A	N/A	N/A		962.5		122	437		770.5	425	2167	5361.5		10245.5
High/Mod	148.50		87	N/A	N/A	N/A	873	2052.5		346.5	914	104.5	143		749.5	4593	337	10348.5
Moderate	1972.50	618.5		N/A	N/A	N/A	1459.5	1881.5	232.5		1048		73.5		251.5	942	2886	11365.5
Mod/Low	1077.00		262.5	N/A	N/A	N/A	666	458.5	3940.5	1203.5	160.5		1446		255		2089	11558.5
Low	1223.5	1223.5	3202	N/A	N/A	N/A		597	588	12201	89	455	153.5	141.5	111.5	340.5	1021	21347.0
Grand Total	4421.50	1842	3551.5	N/A	N/A	N/A	2998.5	5952	4761	13873	2648.5	559.5	2586.5	566.5	3534.5	11237	6333	64865.0

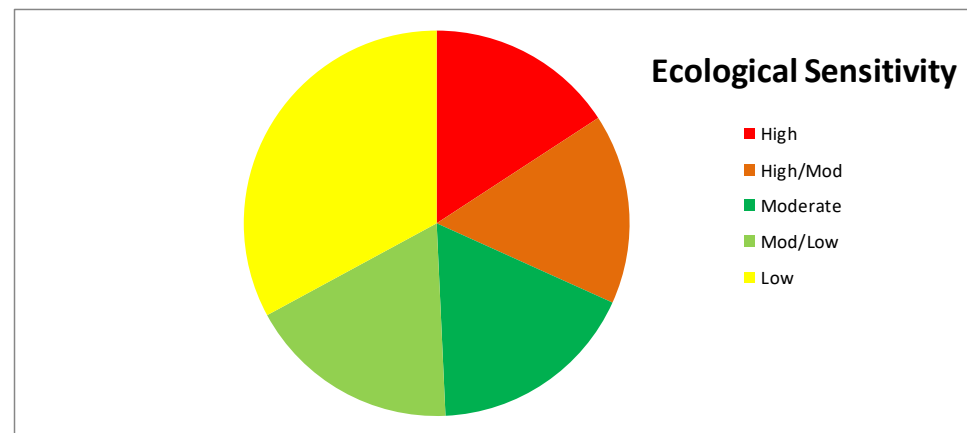


Table 5.4 A breakdown of the aerial extent (m²) of different habitats affected by the overhead transmission line within MU 4. The number of water courses that will be affected along this route is also indicated

Habitat type (area in m ²)	MU4
Dryland	3404.0
Disturbed	876.0
Temporary wetland	0.0
Seasonally saturated wetland	0.0
Permanently saturated wetland	0.0
Permanently saturated; Seasonally inundated wetland	2242.0
Riparian	0.0
Active channel	364.0
Total area	6886.0
Habitat type (number)	MU4
Perennial watercourse	1
Ephemeral/Seasonal watercourse	0
Artificially created drainage channel	0
Total number	1

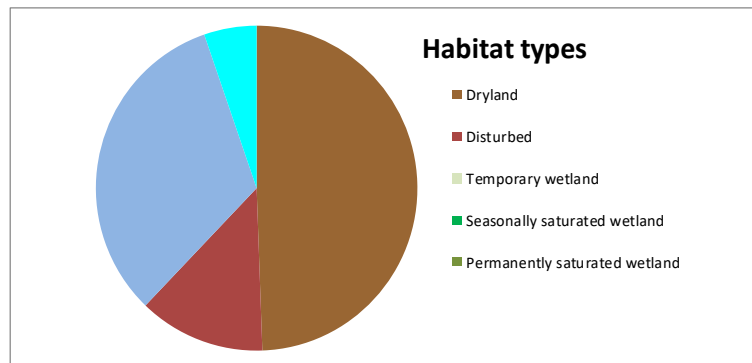


Table 5.5 A The aerial extent (m²) of habitats affected by the overhead transmission line within MU 4, in terms of Ecological Sensitivity.

Habitat type (area in m ²)	MU4
High	5646
High/Mod	364
Moderate	
Mod/Low	
Low	876
Grand Total	6886

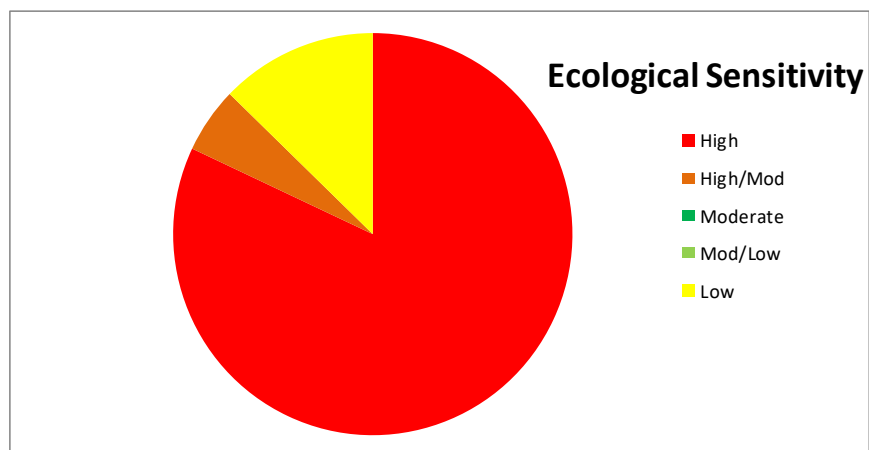


Table 5.5 MU 1: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 125	Wetland (seep)	Seasonally saturated	Moderate	752	Borehole drilling site and pump house	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H1A1 = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the wetland as possible
Track 126	Wetland (seep)	Permanently saturated; seasonally inundated	High/Moderate	148.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	2.5 m trench (no stockpiling of bed material)
WP 157	Stream	Seasonal	High		Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	NA	Trench to be dug by hand to minimise working width as far as possible
Track 127	Wetland (seep)	Temporary	Moderate	714	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	3.5 m trench (no stockpiling of bed material)	Not specified
Track 128	Wetland (seep)	Permanently saturated; seasonally inundated	Moderate	155	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	3.5 m trench (no stockpiling of bed material)	Not specified
WP 159	Stream	Seasonal	High/Moderate		Below ground pipeline crossing	Below channel crossing	NA	Trench to be dug by hand to minimise working width as far as possible
Track 129	Wetland (seep)	Permanently saturated; seasonally inundated	Moderate	117	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	3.5 m trench (no stockpiling of bed material)	Not specified
Track 130/131	Dryland	N/A	Mod/Low	1077	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	5 m (including trench and stockpiling of bed material)	Not specified
Track 132	Wetland (seep)	Permanently saturated; seasonally inundated	Moderate	253	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	3.5 m trench (no stockpiling of bed material)	Not specified
WP 160	Artificially created drainage channel	Seasonal	High/Moderate		Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Reinstate natural drainage by removing the culvert, creating a flow path across the road to direct runoff to the wetlands to the west that are currently drying out due to diversion.

Table 5.6 MU 2: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Extent of affected habitat (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 133	Dryland	N/A	Low	195	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench south west of gravel road (road is 4-5 m wide), with 3,5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Use existing drainage ditch on north east of road for pipeline and backfill
Track 134/135	Wetland (seep)	Seasonally saturated	Moderate	280,5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench south west of gravel road (road is 4-5 m wide), with 3,5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Use existing drainage ditch on north east of road for pipeline and backfill
Track 136	Wetland (seep)	Permanently saturated; seasonally inundated	Moderate	338	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench south west of gravel road (road is 4-5 m wide), with 3,5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Use existing drainage ditch on north east of road for pipeline and backfill
Track 137	Dryland	N/A	Low	1028,5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench south west of gravel road (road is 4-5 m wide), with 3,5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Use existing drainage ditch on north east of road for pipeline and backfill

Table 5.7 MU 3: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Extent of affect area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 138	Wetland (seep)	Temporary	Low	266.5	Pipeline/Below ground electricity (DN550)	Excavation of pipeline trench north of gravel road (road is 5 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Use existing drainage ditch for pipeline and backfill
WP 165	Artificially created drainage channel	Ephemeral	Low		Below ground pipeline crossing	Below channel crossing	3.5 m trench (no stockpiling of bed material)	Need to manage erosion. Rehabilitate through dissipation of flows downstream to prevent further down-cutting and drying out of adjacent wetland
Track 139	Wetland (seep)	Permanently saturated	Mod/Low	262.5	Pipeline/Below ground electricity (DN550)	Excavation of pipeline trench north of gravel road (road is 5 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	
Track 140	Dryland	N/A	Low	506.5	Pipeline/Below ground electricity (DN550)	Excavation of pipeline trench north of gravel road (road is 5 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	
Track 141	Wetland (seep)	Temporary	Low	682.5	Pipeline/Below ground electricity (DN550)	Excavation of pipeline trench north of gravel road (road is 5 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	
WP 166/track 142	Stream	Perennial	High/Moderate	87	Above ground pipeline crossing	Above ground pipe crossing stream with concrete pedestals spaced 12-15 m either side of active channel.	refer to onsite recommendations - minimise working width as far as possible	Avoid placing pedestals within the active channel
Track 143	Dryland	N/A	Low	1641.5	Pipeline/Below ground electricity (DN550)	Excavation of pipeline trench north of gravel road (road is 5 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	
Track 143a	Disturbed	N/A	Low	105	Pipeline/Below ground electricity (DN550)	Excavation of pipeline trench north of gravel road (road is 5 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	
WP 169	Artificially created drainage channel	Ephemeral	Low		Below ground pipeline crossing	Below channel crossing	3.5 m trench (no stockpiling of bed material)	Need to manage erosion and prevent down-cutting of channel. Implement measures to dissipate flows downstream of the road

Table 5.8 MU 4: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affect area (m ²) 20m corridor	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
WP 193 & Track 164a	stream	perennial	High/Moderate	364	Overhead powerline	Dragging of transmission cables - 20 m wide disturbance corridor	N/A	Not specified but working width must be minimised as far as possible
Track 164b	Disturbed	N/A	Low	876	Overhead powerline	20 m wide disturbance corridor	N/A	Not required
Track 164c	Dry land	N/A	High	2224	Overhead powerline	Excavation of pylons (5) to support the overhead transmission cables, Dragging of transmission cables - 20 m wide disturbance corridor	N/A	Not specified but working width must be minimised as far as possible
Track 165	Wetland (seep)	Permanently saturated	High	2242	Overhead powerline	Excavation of pylons(P6) to support the overhead transmission cables, Dragging of transmission cables - 20 m wide disturbance corridor	N/A	Not specified but working width must be minimised as far as possible
Track 166	Dry land	N/A	High	1180	Overhead powerline	Dragging of transmission cables - 20 m wide disturbance corridor	N/A	Not specified but working width must be minimised as far as possible

Table 5.9 MU 5: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affect Area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 167	Dry land	N/A	High	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 168	Wetland (seep)	permanently saturated; seasonally inundated	High	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 169	Dry land	N/A	Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 170	Wetland (seep)	permanently saturated; seasonally inundated	Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road. Consider improving drainage across the road.
Track 171	Wetland (seep)	permanently saturated; seasonally inundated	High	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road. Consider improving drainage across the road.
WP 200	Artificially created drainage channel	ephemeral	High	zero	Below ground powerline crossing	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road. Prevent turbid runoff entering the watercourse
Track 172	Wetland (seep)	seasonally saturated	High/Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 173	Wetland (seep)	seasonally saturated	High/Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road. Consider erosion control along the road margin.
Track 174	Dry land	N/A	High/Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 175	Dry land	N/A	Mod/Low	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 176	Wetland (seep)	seasonally saturated	Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
WP 204	Artificially created drainage channel	ephemeral	High/Moderate	zero	Below ground powerline crossing	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road. Prevent turbid runoff entering the watercourse
Track 177	Dry land	N/A	Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 178	Dry land	N/A	High/Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 179	Dry land	N/A	High/Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 180	Wetland (seep)	seasonally saturated	High/Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.

Table 5.10 MU 6: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 181a	Dry land	N/A	Low	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 181b	Wetland (seep)	permanently saturated; seasonally inundated	Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
Track 181c	Dry land	N/A	Low	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.
WP 213	Wetland (seep)	seasonally saturated	Moderate	zero	Below ground powerline	Excavation of powerline trench within gravel road (3 m from western edge) with no extension into natural habitat	N/A	Ensure all construction activities are confined to the existing road.

Table 5.11 MU 7: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 144	Wetland (seep)	Seasonal wetland	Moderate	1459.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Not specified
WP 170	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	3.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
WP 171	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	3.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
Track 145	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	431.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WP 172	stream	ephemeral	High/Moderate		pipeline crossing	below channel crossing	3.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
Track 146	Dryland	N/A	Mod/Low	350	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	Not specified
WP 173	stream	ephemeral	High/Moderate		pipeline crossing	below channel crossing	3.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road; Trench to be dug by hand to minimise working width as far as possible
Track 147	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	94	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 148	Wetland (seep)	seasonally saturated	High/Moderate	347.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Not specified
WP 174	stream	ephemeral	Moderate		pipeline crossing	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
Track 149	Dryland	N/A	Mod/Low	103.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4-5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	Not specified
Track 150	Wetland (seep)	seasonally saturated	Mod/Low	208	borehole siting and pump testing	clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H1A3b = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the wetland and seasonal watercourse as possible

Table 5.12 MU 8: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 205	Riparian	permanently saturated	High	234	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width; Trench to be dug by hand to minimise working width as far as possible
WP 227	stream	perennial	High		pipeline - above river crossing	Placement of concrete pedestals 12 - 15 m apart on rocky outcrops along the active channel.	N/A	No pedestals within the active channel (siting has been done with engineers on site). Work to take place in the dry season when flows are at their lowest to minimise risk of contamination by concrete in the
Track 206	Wetland (seep)	permanently saturated	High	193.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width; Trench to be dug by hand to minimise working width as far as possible
Track 207	Dryland	N/A	High/Moderate	260	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width
Track 208	Wetland (seep)	seasonally saturated	High/Moderate	163	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width
WP 228	Artificially created drainage channel	ephemeral	High/Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Reduce working width; Need to manage erosion, dissipate runoff downstream of road and possibly ensure diffuse runoff across the road instead of concentrated flows via a single culvert
Track 209	Wetland (seep)	seasonally saturated	Moderate	836.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
WP 229	Artificially created drainage channel	ephemeral	High/Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road and possibly ensure diffuse runoff across the road instead of concentrated flows via a single culvert
Track 210	Dryland	N/A	High/Moderate	238	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 211	Dryland	N/A	Low	250.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	Not specified
Track 211a	Disturbed		Low	126.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	Not specified
Track 163a	Wetland (seep)	seasonally saturated	Mod/Low	279.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 163	Dryland	N/A	Low	118	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	Not specified
WP 182	stream	seasonal	Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 162	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	135	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 161	Dryland	N/A	Moderate	134.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 160	Wetland (seep)	seasonally saturated	High/Moderate	365	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 159	Dryland	N/A	Moderate	300	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 158	Wetland (seep)	seasonally saturated	High/Moderate	389.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 157	Dryland	N/A	Moderate	331	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 156	Wetland (seep)	seasonally saturated	High/Moderate	295.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Put road on rock blanket to return runoff from upslope of the road to diffuse instead of concentrated flows
WP 181	Artificially created drainage channel	ephemeral	Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
Track 155	Dryland	N/A	Mod/Low	134	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
WP 180	Wetland (seep)	seasonally saturated	Low		Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width;
Track 154	Wetland (seep)	seasonally saturated	High/Moderate	206.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width;
WP 179	Artificially created drainage channel	ephemeral	High/Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
Track 153	Dryland	N/A	Mod/Low	324.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Reduce working width;
WP 178	Artificially created drainage channel	ephemeral	High/Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road
WP 177	Artificially created drainage channel	ephemeral	Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Reduce working width; Need to manage erosion, dissipate runoff downstream of road
WP 176	stream	seasonal	High/Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Reduce working width; Above ground crossing with no pedestals recommended
Track 152	Wetland (seep)	permanently saturated; seasonally inundated	High	535	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench north of gravel road (road is 4.5 m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Reduce working width; Trench to be dug by hand to minimise working width as far as possible
Track 151	Wetland (seep)	seasonally saturated	Moderate	208	Borehole siting and pump house	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from HIA3b - potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the wetland and seasonal watercourse as possible

Table 5.13 MU 9 Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Proposed mitigation/action
Track 182 and WP 214	Dry land	N/A	Moderate	88	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 182a	Disturbed	N/A	Low	98	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 183	Dry land	N/A	Low	803	Borehole siting and pump testing	creation of sumps, storage of materials and vehicular activity. Effluent from H8A4a = potential contamination of the river to the east. Erosion and risk of donga formation due to pump testing.	N/A	Contain effluent within the plastic lined trench within the firebreak and pump directly to dam.
Track 184	Dry land	N/A	Moderate	144.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond road
Track 185	Dry land	N/A	Mod/Low	178	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond road
Track 186	Dry land	N/A	Low	73	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 187	Dry land	N/A	Mod/Low	104.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 188	Dry land	N/A	Mod/Low	190	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 189	Dry land	N/A	Mod/Low	1584	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
WP 219	Dryland	N/A	Low	576	Borehole siting and pump testing	creation of sumps, storage of materials and vehicular activity. Effluent from H8A4b = potential contamination of the river to the east. Erosion and risk of donga formation due to pump testing.	N/A	Contain effluent within the plastic lined trench within the firebreak and pump directly to dam.
Track 190	Dryland	N/A	Mod/Low	297	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 191	Dryland	N/A	Low	234.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 192	Dryland	N/A	Mod/Low	488.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Note: all restios to be rescued during the winter
Track 193	Dryland	N/A	Low	103.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 194/195/196	Dryland	N/A	Mod/Low	573	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Note: all restios to be rescued during the winter
Track 197	Dryland	N/A	Low	525.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified

Table 5.14 MU 10: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 115	Dry land - sandy	N/A	Low	599	Stockpile	Storage of bed material during trench construction	N/A	contain stockpile material through bunding to prevent runoff into watercourse
WP 142	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
WP 143	watercourse	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
Track 116	Wetland (seep)	Seasonally saturated	Low	157.5	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
WP 144	Wetland (seep)	Seasonally saturated	Low	976	Borehole footprint: H8A13	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Erosion and risk of donga formation due to pump testing.	N/A	Dissipate pump test water or direct to dam via pipes to prevent donga formation.
WP 145	watercourse	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
Track 117	Wetland (seep)	Seasonally saturated	Low	582	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
WP 146	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
Track 118	Dry land	N/A	Low	681	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
Track 119	Wetland (seep)	Seasonally saturated	Low	769	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
Track 120	Dry land	N/A	Low	4031.5	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
WP 147	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
WP 149	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
WP 150	Stream	ephemeral	Mod/Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
WP 151	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
WP 152	Artificially created drainage channel	ephemeral	Low		pipeline crossing	below channel crossing	5 m (including trench and stockpiling of bed material)	Need to manage erosion
Track 120a	Disturbed	N/A	Low	45	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	N/A	Not specified
Track 121	Wetland (seep)	Seasonally saturated	High/Moderate	92	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	2.5 m trench (no stockpiling of bed material)	Restrict working width
Track 122	Riparian	permanently saturated	High	44.5	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	2.5 m trench (no stockpiling of bed material)	Restrict working width; Trench to be dug by hand to minimise working width as far as possible
Track 122b	Riparian	permanently saturated	High	39	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	2.5 m trench (no stockpiling of bed material)	Restrict working width; Trench to be dug by hand to minimise working width as far as possible
Track 123	Active channel	Perennial	High	38.5	pipeline crossing	Above ground pipe crossing stream with concrete pedestals spaced 12-15 m either side of active channel.	N/A	Search and rescue ferns and pronium prior to construction activities
Track 124	Wetland (seep)	seasonally saturated	Mod/Low	157.5	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	3.5 m trench (no stockpiling of bed material)	Restrict working width
Track 124b	Dryland	N/A	Low	466	Borehole footprint: H8A12	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Erosion and risk of donga formation due to pump testing.	N/A	Dissipate pump test water or direct to dam via pipes to prevent donga formation.
Track 198	Dryland	N/A	Low	219	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
Track 199	Dryland	N/A	Low	3544	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
Track 200	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	254.5	pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Need to manage erosion, dissipate runoff downstream of road and possibly ensure diffuse runoff across the road instead of concentrated flows via a single culvert; trench to be dug by hand to minimise working width as far as possible
Track 201	Wetland (seep)	seasonally saturated	Low	640	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
WP 224	Artificially created drainage channel	ephemeral	High/Moderate		pipeline crossing	Below ground crossing	2.5 m trench (no stockpiling of bed material)	Restrict working width; Need to manage erosion, dissipate runoff downstream
Track 202	Dryland	N/A	Mod/Low	515	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	3.5 m trench (no stockpiling of bed material)	Restrict working width
Track 203	Dryland	N/A	Low	407	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
Track 204	Dryland	N/A	Mod/Low	531	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	3.5 m trench (no stockpiling of bed material)	Restrict working width
Track 204a	Disturbed		Low	60	Pipeline/Below ground electricity (DN 450)	Excavation of pipeline trench east of gravel road (road is 5 m wide), with 5 m extending beyond the road	N/A	Not specified

Table 5.15 MU 11: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 098	Wetland (seep)	seasonally saturated	High	43	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 099	Dry land	N/A	High/Moderate	112,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 100	Wetland (seep)	seasonally saturated	High	243,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 101	Dry land	N/A	High/Moderate	67	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 102	Dry land	N/A	High/Moderate	56,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 103	Wetland (seep)	seasonally saturated	High	150,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 104	Dry land	N/A	High/Moderate	141,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width
Track 105	Disturbed	N/A	Low	15	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	N/A	Not specified
Track 106	Dry land	N/A	High/Moderate	141,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 107/108	Dry land	N/A	Moderate	253,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 109	Dry land	N/A	Moderate	266	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 110	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	65,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width; Trench to be dug by hand to minimise working width as far as possible
Track 111	Dry land	N/A	Moderate	277,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 111a	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	231	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2,5 m trench (no stockpiling of bed material)	Restrict working width; Trench to be dug by hand to minimise working width as far as possible
Track 112	Dry land	N/A	Mod/Low	160,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 113	Dry land	N/A	High/Moderate	98,5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 114	Dry land	N/A	Moderate	251	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	3,5 m trench (no stockpiling of bed material)	Restrict working width
Track 114a	Disturbed	N/A	Low	74	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	N/A	Not specified

Table 5.16 MU 12: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Proposed mitigation/action
WP045	Small stream	ephemeral	High	425	Borehole drilling site and pump house	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H8A9 = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Need to address site containment options during drilling and discharge of pump test water.
WP047	Dry land	N/A	Moderate	425	Borehole drilling site and pump house	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H8A6 = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Need to address site containment options during drilling and discharge of pump test water.
Track 011	Dry land	N/A	Low	104.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	5 m (including trench and stockpiling of bed material)	Not specified
Track 012	Wetland (seep)	seasonally saturated	High/Moderate	455	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench east of gravel road (road is 4 m wide), with 5 m extending into natural environment	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond road

Table 5.17 MU 13: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 013 & WP048	Wetland (Berzelia dominated seep)	permanently saturated; seasonally inundated	High	296.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible; Collection of geophytes essential; top material to be kept away from area invaded with aliens
Track 014 & WP049 & WP050 - WP052	Stream	Perennial	High	85	pipeline - above river crossing	Placement of concrete pedestals 12 - 15 m apart on rocky outcrops along the active channel (south of crossing).	NA	No pedestals within the active channel (siting has been done with engineers on site). Work to take place in the dry season when flows are at their lowest to minimise risk of contamination by concrete in the channel.
Track 015	Wetland (seep)	permanently saturated; seasonally inundated	High	190	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 015a	Wetland (seep)	Permanently saturated	High	461	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
Track 016a	Disturbed	N/A	Low	58	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	if the track is used for stockpiling, care must be taken to prevent runoff from stockpiles entering wetlands downslope
Track 016	Wetland (seep)	permanently saturated; seasonally inundated	High	281.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 017	Dry land	N/A	High/Moderate	1317	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
Track 018	Wetland (seep)	seasonally saturated	Moderate	188.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road. Culvert and/or drainage through road to be installed to ensure flow of water to the d/s wetland habitat
Track 019	Dry land	N/A	Mod/Low	368	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond road. Ensure that topsoil (which has alien seed) does not contaminate adjacent areas
Track020	Dry land	N/A	Mod/Low	327	Footprint of H8A2	Drilling and pump testing. Pump station footprint	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station
Track 020a	Dry land	N/A	High	141.5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
WP062	Dry land	N/A	High	327	borehole siting and pump testing	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H8A2 = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the wetland to the north as possible

Table 5.17cont MU 13: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 021 & 022	Wetland (seep)	seasonally saturated	High	356	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
Track 023	Wetland (seep)	seasonally saturated	Moderate	913	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
WP 063	Stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	N/A	Restrict working width as far as possible. Flow should be dissipated downstream of the road to the north to prevent concentration of flows which is currently down cutting the channel which has led to erosion of the channel further downstream at WP067.
WP 067	Stream	ephemeral	High	327	borehole siting and pump testing	pump testing effluent from H8A2	N/A	Ensure no runoff from the borehole site or pump testing enters this stream.
Track 023a	Dry land	N/A	High	900	borehole siting and pump testing	Clearing for footprint of borehole (this has already happened); creation of sumps, storage of materials and vehicular activity. Effluent from H8A4 = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the channel to the north as possible
Track 024	Dry land	N/A	High/Moderate	143	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
Track 025	Wetland (seep)	seasonally saturated	High	299	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width. WP069 - this section of road should be reconstructed with a rock blanket to allow diffuse movement of subsurface flows below the road.
Track 026	Wetland (seep)	permanently saturated; seasonally inundated	High	125	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond road; Trench to be dug by hand to minimise working width as far as possible
Track 027 & 028 & 029	Dry land	N/A	Mod/Low	1097.5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	3.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
Track 030	Wetland (seep)	seasonally saturated	High	58.5	pipeline	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
WP073	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	N/A	Restrict working width beyond the road
Track 032	Wetland (seep)	permanently saturated; seasonally inundated	High	156.5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road; Trench to be dug by hand to minimise working width as far as possible;
Track 033	Wetland (seep)	seasonally saturated	Mod/Low	348.5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road; Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road. The reinstated diffuse flow can then feed the once receiving wetland, which is now home to Cliffortia
Track 034	Wetland (seep)	permanently saturated; seasonally inundated	High	71.5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench east of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road; Trench to be dug by hand to minimise working width as far as possible
Track 035 & 036	Wetland (seep)	permanently saturated; seasonally inundated	High	60	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench east of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road; Trench to be dug by hand to minimise working width as far as possible
WP075	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	N/A	Restrict working width beyond the road; Trench to be dug by hand to minimise working width as far as possible
Track 037	Wetland (seep)	seasonally saturated	Moderate	73.5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench east of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
WP076	Wetland (seep)	seasonally saturated	High	606	borehole siting and pump testing	clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H8A7 & H8A10 = potential contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the channel to the south as possible

Table 5.18 MU 14: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 038	Disturbed	N/A	Low	102.5	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench west of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond the road
Track 039	Wetland (seep)	seasonally saturated	High	425	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench west of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WP077	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 039a	Disturbed	N/A	Low	39	Pipeline/Below ground electricity (DN 400)	Excavation of pipeline trench west of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	5 m (including trench and stockpiling of bed material)	Not specified

Table 5.19 MU 15: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 082	Dry land	N/A	Mod/Low	47.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Restrict working width beyond road as far as possible
Track 083	Wetland (seep)	Seasonally saturated	High/Moderate	97.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Ensure that diffuse drainage across the road is reinstated to prevent wetlands downslope from drying out. Install finger drains to ensure hydraulic connectivity between the wetlands across the road.
Track 084	Wetland (seep)	seasonally saturated	High/Moderate	162	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Ensure that diffuse drainage across the road is reinstated to prevent wetlands downslope from drying out. Install finger drains to ensure hydraulic connectivity between the wetlands across the road.
Track 085, 086, 087 & 088	Wetland (seep)	permanently saturated; seasonally inundated	High	313	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to limit working width as far as possible; Search and rescue to ensure rare species are removed
Track 089	Dry land	N/A	High	231	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Minimise work within the natural habitat - place pipe route within the road. Removal and placement of large rocks needs to be undertaken under supervision of a specialist
Track 090	Dry land	N/A	Moderate	51	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 091	Dry land	N/A	High/Moderate	269.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Search and rescue to ensure rare species are removed
WP 131	Artificially created ephemeral drainage line from culvert flows	ephemeral	Moderate		pipeline and above ground crossing over river	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	There is an opportunity to improve drainage of the area by creating permeability through the road. i.e. diffuse flow must be reinstated by blocking flow on the other side of the road.
Track 092a	Wetland (seep)	seasonally saturated	High	56	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 092b	Wetland (seep)	permanently saturated; seasonally inundated	High	65.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 093	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	43	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 093b	Wetland (seep)	permanently saturated; seasonally inundated	Mod/Low	43.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 094	Dry land	N/A	Moderate	200.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 095	Wetland (seep)	seasonally saturated	High	58.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 096	Wetland (seep)	permanently saturated; seasonally inundated	High	1443	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 097	Wetland (seep)	permanently saturated; seasonally inundated	High/Moderate	177.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 097a	Wetland (seep)	permanently saturated; seasonally inundated	Mod/Low	164	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Install pipe within or slightly above the existing road which is lower than the surrounding wetland. Finger drains can be installed at say 20 m intervals to ensure hydraulic connectivity between the wetlands across the road.
Track 097b	Disturbed	N/A	Low	31.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately east of 3.5 gravel road (2.5 m beyond road)	5 m (including trench and stockpiling of bed material)	Not specified
Track 097c	Disturbed	N/A	Low	247	Borehole footprint and pump station	Creation of sumps, storage of materials and vehicular activity. Effluent from H8A11 = potential source of contamination. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Opportunity to rehabilitate habitat within the borehole footprint.

Table 5.20 MU 16: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
WPo83	Wetland (seep)	seasonally saturated	High	900	borehole siting and pump testing	Clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H3A1= potential contamination of ephemeral stream. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the channel to the south as possible
Track 041& 042	Wetland (seep)	seasonally saturated	High	317.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
WPo80 & 081	Wetland (seep)	permanently saturated; seasonally inundated	High	900	borehole siting and pump testing	clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H3A1= potential contamination of ephemeral stream. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the channel to the south as possible
WPo82 & 084	Small stream	ephemeral	High		borehole siting and pump testing	potentially impacted by drilling effluent and/or pump testing	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam.
Track 043a	Dry land	N/A	High	149.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
WPo85	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
WPo86 & WPo87	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
WPo88	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
WPo89	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
Track 043b	Wetland (seep)	seasonally saturated	High	275	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
Track 044	Dry land	N/A	High/Moderate	866.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 045	Wetland (seep)	seasonally saturated	High	218	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 046	Riparian	permanently saturated	High	107.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WPo90	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 047a	Wetland (seep)	seasonally saturated	High	105	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 047b	Dry land	N/A	High/Moderate	226.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 047c	Wetland (seep)	seasonally saturated	High	91.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
WPo91	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Not specified
Track 048	Dry land	N/A	High/Moderate	196	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3.5 gravel road (2.5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified

Table 5.20cont12 MU 16: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
WP092	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Not specified
Track 049	Wetland (seep)	seasonally saturated	High	283	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 050	Wetland (seep)	Permanently saturated; seasonally inundated	High	219.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WP093	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WP094	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 051 and 052	Wetland (seep)	Permanently saturated; seasonally inundated	High	241.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WP095	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
WP096	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
Track 053	Dry land	N/A	High/Moderate	230.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 054 & 055	Wetland (seep)	seasonally saturated	High	866.5	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
WP098	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
WP099	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Construct a rock blanket so that seep flows are forced underneath instead of concentrating alongside the road
Track 056	riparian	Permanently saturated; seasonally inundated	High	98	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
WP101	Small stream	seasonal	High		Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 057a	Dry land	N/A	Moderate	162	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	3,5 m trench (no stockpiling of bed material)	Not specified
Track 057b	Dry land	N/A	High	900	borehole siting and pump testing	clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H8A5= potential contamination of ephemeral stream. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump station and site it as far from the channel to the south as possible
Track 058 & 059	Wetland (seep)	seasonally saturated	High	306.5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
WP109	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Bigger culvert under road necessary.
WP110	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	culvert needs to be cleared
WP111	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Flows must be dissipated d/s of road
WP113	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Flows must be dissipated d/s of road
Track 060	Dry land	N/A	High/Moderate	464	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
Track 060a	Wetland (seep)	seasonally saturated	High	225	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified
WP114	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2.5 m trench (no stockpiling of bed material)	Flows must be dissipated d/s of road
Track 061	Dry land	N/A	High/Moderate	199	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2.5 m trench (no stockpiling of bed material)	Not specified

Table 5.20cont23 MU 16: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
WP115	Small stream	ephemeral	High		Below ground crossing	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Flows must be dissipated d/s of road
Track 062	Wetland (seep)	seasonally saturated	High	490	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
WP117	Small stream				Below ground crossing	crossing of small ephemeral channel	2,5 m trench (no stockpiling of bed material)	Flows must be dissipated d/s of road
Track 063 & 064	Dry land	N/A	High/Moderate	673,5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 065 & 066	Wetland (seep)	Permanently saturated; Seasonally inundated wetland	High	556	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 065a	Disturbed	N/A	Low	30,5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	5 m (including trench and stockpiling of bed material)	If the road is used for stockpiling, make sure no runoff into surrounding wetland habitat
WP118	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2,5 m trench (no stockpiling of bed material)	Pipe to span the entire channel with no pedestals in the active channel - U-bend over the channel at road level
WP119	Small stream	ephemeral	High		Below ground crossing	crossing of small ephemeral channel	2,5 m trench (no stockpiling of bed material)	Pipe to span the entire channel with no pedestals in the active channel - U-bend over the channel at road level
Track 067	Dry land	N/A	High/Moderate	91	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 068	Wetland (seep)	Permanently saturated; Seasonally inundated wetland	High	366,5	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Trench to be dug by hand to minimise working width as far as possible
Track 069	Dry land	N/A	High/Moderate	480	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 070	Wetland (seep)	seasonally saturated	High	45	Pipeline/Below ground electricity (DN 200)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 071	riparian	permanently saturated	High	93	Placement of concrete pedestals 12 - 15 m apart on rocky outcrops along the active channel.	N/A	No pedestals within the active channel (siting has been done with engineers on site). Work to take place in the dry season when flows are at their lowest to minimise risk of contamination by concrete in the channel.	Trench to be dug by hand to minimise working width as far as possible
WP 122	Transitional Stream	perennial	High		Above ground crossing	One concrete pedestal will need to be placed within the active channel. A large boulder was identified on site as the most appropriate location. Concrete pedestals will be placed along the riparian edge beyond the active channel. The above ground pipeline will be placed at the same height as the low flow crossing, less than 0,5 m from the downstream edge.	N/A	Risk of concrete entering the watercourse. Work has to take place in the dry season. Remove all broken bridge material from the active channel
Track 072	Wetland (seep)	seasonally inundated	High	106,5	drilling and pump testing	Effluent from borehole = potential contamination. Erosion and risk of donga formation due to pump testing.	2,5 m trench (no stockpiling of bed material)	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam.
Track 073	Dry land	N/A	High/Moderate	332	borehole siting and pump testing	clearing for footprint of borehole; creation of sumps, storage of materials and vehicular activity. Effluent from H8A8= potential contamination of ephemeral stream. Erosion and risk of donga formation due to pump testing.	N/A	Contain drilling effluent and pump directly to dam via pipes. Pump test water contained and transported directly to the dam. Minimise the footprint of the pump
Track 074a	Wetland (seep)	seasonally saturated	High	366	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 074b	Dry land	N/A	High/Moderate	330	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 074c	Dry land	N/A	Low	51,5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench immediately north of 3,5 gravel road (2,5 m beyond road)	2,5 m trench (no stockpiling of bed material)	Not specified
Track 075	Wetland (seep)	seasonally saturated	Moderate	189,5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2,5 m trench (no stockpiling of bed material)	Restrict working width beyond road
Track 076	Wetland (seep)	seasonally saturated	High/Moderate	189,5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2,5 m trench (no stockpiling of bed material)	Restrict working width beyond road
Track 077	Wetland (seep)	permanently saturated	High/Moderate	126	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2,5 m trench (no stockpiling of bed material)	Restrict working width beyond road; Trench to be dug by hand to minimise working width as far as possible
Track 077b	riparian	permanently saturated	High	123,5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2,5 m trench (no stockpiling of bed material)	Restrict working width beyond road; Trench to be dug by hand to minimise working width as far as possible
WP 125	Transitional Stream	perennial	High		Above ground crossing	One concrete pedestal will need to be placed within the active channel near the left hand bank. This area is beyond the wetted perimeter in the dry summer months. The site of the pedestal identified on site. A second pedestal will be placed in the riparian area dominated by Berzelia on the right hand bank. The pipe line will be at the level of the low flow bridge, approximately 1 m from the d/s edge.	N/A	Some risk of concrete entering the watercourse. Work has to take place in the dry season
Track 078	Dry land	N/A	Moderate	128,5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2,5 m trench (no stockpiling of bed material)	Restrict working width beyond road
Track 079	Dry land	N/A	Moderate	462	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	2,5 m trench (no stockpiling of bed material)	Restrict working width beyond road
Track 079a	Disturbed	N/A	Low	43,5	Pipeline/Below ground electricity (DN 315)	Excavation of pipeline trench north of gravel road (road is 4m wide), with 5 m extending into natural environment (includes stockpiling of bed material adjacent to trench)	N/A	Not specified

Table 5.4 MU 17: Identified habitats together with the development component and recommended mitigation where applicable

Track or waypoint	Affected habitat	Hydroperiod	ES	Affected area (m ²)	Development component	Activity	Maximum allowable working width beyond road	Specific mitigation/action
Track 212	Dryland	N/A	Mod/Low	334	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	No existing road so total working width will be 10 m	Not specified
Track 213 and WP280	Wetland (seep)	Permanently saturated	Moderate	428	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	Reduce working width to 8m (no stockpiling of bed material)	Minimise working width as far as possible
Track 214	Wetland (seep)	Permanently saturated	Moderate	206	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	Reduce working width to 8m (no stockpiling of bed material)	Minimise working width as far as possible
Track 215 and WP 281	Dryland	N/A	Mod/Low	296	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	No existing road so total working width will be 10 m	Not specified
Track 216	Dryland	N/A	Mod/Low	637	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	No existing road so total working width will be 10 m	Not specified
Track 217	Wetland (seep)	Seasonally saturated	Moderate	118	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	Reduce working width to 8m (no stockpiling of bed material)	Minimise working width as far as possible
Track 218	Dryland	N/A	Moderate	493	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	No existing road so total working width will be 10 m	Not specified
WP 282	channel	ephemeral	Mod/Low		Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	Reduce working width to 8m (no stockpiling of bed material)	Minimise working width as far as possible
Track 219	Dryland	N/A	Moderate	1468	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	No existing road so total working width will be 10 m	Not specified
Track 220; WP 283	Wetland (seep)	Permanently saturated	Moderate	173	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	Reduce working width to 8m (no stockpiling of bed material)	Minimise working width as far as possible
WP 284	channel	Seasonal	Moderate		pipeline crossing	Below channel crossing	Reduce working width to 8m (no stockpiling of bed material)	Minimise working width as far as possible, manage erosion
Track 221	Wetland (seep)	Permanently saturated	Low	95	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	No existing road so total working width will be 10 m	Not specified
Track 222	Disturbed	N/A	Low	31	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	not specified	Not specified
Track 223	Dryland	N/A	Low	474	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench north of gravel road (road is 3 m wide), with 5 m extending beyond the road	5 m (including trench and stockpiling of bed material)	Not specified
Track 224	Dryland	N/A	High/Mod	337	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench north of gravel road (road is 3 m wide), with 5 m extending beyond the road	3,5 m trench (no stockpiling of bed material)	Rock material will need to be handled with care, measures to prevent erosion during construction will be necessary due to the steep nature of the slope.
Track 225	Dryland	N/A	Mod/Low	613	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench north of gravel road (road is 3 m wide), with 5 m extending beyond the road	3,5 m trench (no stockpiling of bed material)	Not specified
Track 226	Wetland (seep)	Seasonally saturated	Mod/Low	209	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench north of gravel road (road is 3 m wide), with 5 m extending beyond the road	3,5 m trench (no stockpiling of bed material)	Need to install drainage channels through the road to reinstate drainage
Track 227	Dryland	N/A	Low	421	Pipeline/Below ground electricity (DN 160)	Excavation of pipeline trench through pine plantation with a maximum working width of 10 m	5 m (including trench and stockpiling of bed material)	Not specified

6 CONCLUSIONS AND RECOMMENDATIONS

The Steenbras Area supports a relatively pristine environment with high levels of diversity and endemism across both aquatic and dryland ecosystems. An assessment of ecosystems potentially impacted by the development of a wellfield in Steenbras indicates that approximately 38 000 m² of dryland habitat listed as Threatened (Kogelberg Sandstone Fynbos) or Critically Endangered (Elgin Shale Fynbos) will be lost to accommodate the proposed infrastructure. Also, an additional 25 000 m² of wetland habitat ranging from temporarily saturated to permanently saturated and seasonally inundated habitat will be disturbed or lost to accommodate the wellfield development. Approximately 22 000 m² of the natural habitat in Steenbras is rated as either moderately or highly sensitive to anthropogenic disturbance, the loss of which would result in impacts of moderate to high significance.

Despite the high ecological sensitivity of habitats within the Steenbras Area, this evaluation identified a number of existing impacts associated with either forestry activities surrounding the dam or the existing road net through the area. Beside habitat loss to accommodate the road network, wetlands have been further impacted by alteration of their natural hydrological functioning and connectivity due to compaction from roads that traverse these areas. Also, culverts below the road tend to concentrate flows which would be naturally diffuse. In many areas, this has led to erosion and down-cutting to bed material with associated “drying out” of adjacent wetland habitat. Thus, development of a wellfield at Steenbras could provide opportunities to alleviate existing impacts within the Steenbras Area. Furthermore, extensive efforts to rehabilitate areas currently affected by pine and gum plantations may somewhat reduce the residual impacts associated with the wellfield development. It is therefore strongly recommended that efforts to alleviate existing impacts as well as rehabilitate both areas within plantations and pristine habitats disturbed to accommodate the wellfield are implemented. Considering the ecological importance of this area, however, it is likely that some residual impacts to both freshwater and dryland ecosystems will remain moderate or high. This assessment therefore confirms the initial findings of the Environmental Working Group which suggested that ecosystems with the Steenbras Area are highly sensitive to anthropogenic disturbance and that development of a wellfield within this area would result in residual impacts of high significance. Evidently, development of a wellfield at Steenbras will most likely necessitate ecological offsets to compensate for the loss of habitat of high ecological and functional importance.

Finally, it is important to emphasise that this evaluation does not include consideration of potential impacts associated with drawdown due to large scale abstraction from boreholes once the wellfield is in operation. This would require a greater understanding of the underlying geohydrology at each site and the extent of groundwater dependence of different ecosystem types. This can only be achieved through extensive efforts to monitor surface water-groundwater links and potential ecological changes associated with drawdown. It is therefore recommended that a monitoring programme that strives to understand the baseline relationship between groundwater and surface water is implemented prior to any abstraction from the Steenbras Wellfield.

7 REFERENCES

- Driver, A, Nel, J.L., Snaddon, K., Murray, K., Roux, D., Hill, L., Swartz, E.R., Manuel, J. and Funke, N. (2011). Implementation Manual for Freshwater Ecosystem Priority Areas. WRC Report No. 1801/1/11. ISBN 978-1-4312-0147-1. Pretoria.
- Department of Water Affairs and Forestry (DWAF). 2005. A practical field procedure for identification and delineation of wetlands and riparian areas.
- Department of Water Affairs and Forestry (DWAF). 1999. Resource Directed Measures for the protection of water resources. Version 1.0.
- Ewart-Smith, J. (2018a). Initial assessment of impacts to freshwater ecosystems associated with drilling operations within the Steenbras Catchment, with recommendations for remediation and monitoring. Prepared by Freshwater Consulting cc and submitted to Umvoto Africa (Pty) Ltd in January 2018.
- Ewart-Smith, J. (2018b). Emergency repair for stream crossings at Steenbras. Freshwater Ecological Input to design and construction. Prepared by Freshwater Consulting cc and submitted to Aurecon (Pty) Ltd in November 2018.
- Ewart-Smith, J. and Ractliffe, S.G. (2002). Assessment of the potential impacts of the proposed N1 / N2 Winelands Toll Highway Project on aquatic ecosystems. Specialist EIA report to Crowther Campbell & Associates, on behalf of the National Roads Agency. 132 pp.
- Freshwater Consulting Group (2014) – TMGA Ecological and Hydrological Monitoring (2010 -2013). Monitoring Report: Year 3 (2012/2013). Volume 1: Monitoring Framework and Protocol. Prepared for City of Cape Town, Infrastructure Planning.
- Granger, C. (2018). Comparison of SASS data collected from the Steenbras catchment: July and November 2018. Short note prepared on 15 November 2018. Umvoto Africa.
- Kleynhans C.J. (1996). A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu river (Limpopo system, South Africa). *Journal of Aquatic Ecosystem Health* 5: 41-54
- Kleynhans, CJ, Thirion, C and Moolman, J. (2005). *A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland*. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.
- Mossop, L., Wood, J. and Dorse, C. (2018). Steenbras drilling: Initial SASS5 river bioassessment report for stream near borehole H8A7. Report produced by the Biodiversity Management Branch of the City of Cape Town.
- Mucina L and Rutherford MC (eds) (2006). The Vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.
- Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report

Cape Nature (2018). TMGA Project Environmental Working Group: Summary of Screening Process, Findings and Recommendations. Compiled by the Focus Group Tasked with Screening Borehole sites in the TMGA. Draft Report prepared for the City of Cape Town.

Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A., and Manyama, P.A. (eds.) 2009. Red List of South African Plants 2009. Strelitzia 25. South African National Biodiversity Institute, Pretoria.