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Preston Industrial Park Structure Plan:

Water Resources and Vegetation Management Strategy

On behalf of :
DEPARTMENT OF PLANNING AND INFRASTRUCTURE

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

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In preparing the report, ENV has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to ENV.

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The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

1. INTRODUCTION

The Preston Industrial Park site is located on the eastern boundaries of the city of Bunbury, and lies within the City of Bunbury and Shire of Dardanup **(Figure 1).** The study area includes the localities of Picton, Davenport and has a total land area of 2,950ha. The site is currently used for grazing, industry and contains a few rural residential properties. The land has been identified as a future industrial site for the expansion of Bunbury. The Preston Industrial Park proposal is currently in the Structure Plan Stage.

The Industrial Park proposal has been reviewed by the Environmental Protection Authority (EPA) as a response to *Industry 2030 – Greater Bunbury industrial land and port access planning* (EPA, 1998). The EPA (1998) identified the major environmental issues associated with the site as:

- Buffer requirements for noise, air quality, and risk;
- Protecting regionally significant wetlands, watercourses and vegetation;
- Maintaining a sustainable groundwater balance;
- Protecting water quality in the Preston and Ferguson Rivers; and
- Solid and liquid waste disposal.

An assessment of buffer requirements has been conducted by SKM (2004). The aim of this document is to assess and determine management strategies for the issues associated with surface and groundwater, vegetation, water quality and liquid waste disposal for the Preston Industrial Estate.

The emphasis of this document is to provide best practice, yet practical, management strategies to address the constraints imposed by the water and vegetation aspects of the environment. The overall aim is that industrial development can proceed in the area in a manner that respects the sensitive environmental setting.

A number of judgements have been made in this document about the constraints and management responses. These reflect ENV's view of what would reasonably be endorsed by the regulatory authorities now and into the future. ENV has also made some predictions about changes to the requirements in the future, particularly in relation to water management, which is expected to evolve as DPI and other agencies progressively implement water aspects of a sustainability strategy.

ENV's judgements generally reflect a middle ground that should be amenable to most of the stakeholders now and into the future. While the strategies are clearly open to discussion and it is hoped that they there will be some constructive debate where views of stakeholders differ, ENV believes that the strategies provide a reasonable and technically defensible basis for planning development on the site.

This report contains a detailed botanical investigation and the complete botanical report is attached as **Appendix A**. The botanical survey forms a strong basis for management of vegetation and wetlands on the site and this level of botanical detail has not been previously available for the area.

Nine groundwater bores were installed across the site. It became clear as the project progressed that groundwater levels were crucial to development decisions and it was agreed that the monitoring and analysis of bores be expanded at the expense of surface water modelling.

The proposed surface water modelling using XP-STORM would have been required if a centralised drainage system was proposed to manage stormwater across the site and/or lower groundwater levels. However, the site by site water management approach presented in this report that preserves the pre-clearing hydrology obviates the need for surface water modelling at this stage.

The increased focus on groundwater quality provides a more comprehensive basis for understanding the hydrology and setting water quality targets in the Water and Nutrient Management Plan (WNMP) included in this document. The WNMP states the requirements for later, more detailed site-specific WNMPs at the development stage and proposes water quality targets to be achieved by the more detailed plans. The more detailed work would also adhere to the relevant guidelines for WNMPs that are in place for the area at the time and may have to incorporate overarching guidelines from the shire and state government departments. However, the guidance in the WNMP in this report sets the basic philosophical approach and some technical limits.

2. SITE ASSESSMENT

2.1 CLIMATE

The closest meteorological station to the site is located at Bunbury Post Office. The conditions at Bunbury are considered to be representative of the site. The climate of Bunbury can be described as Mediterranean, with 90% of the rain falling between April and October.

The average rainfall at Bunbury is 870.9mm, although rainfall has declined in the South West in recent years. Rainfall events may be long and intense with up to 115mm being recorded in one day. Summers are dry and evaporation exceeds rainfall for much of the year.

Drainage systems must be able to cope with these intense rain events and either hold the water for evaporation or treat it prior to discharge.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	***Total***
Rain (mm)	11.1	11.8	21.9	46.4	128.1	182.9	170.6	123.6	80.4	54.1	26.2	13.7	*870.9*

Table 1 Average Rainfall for Bunbury (Courtesy Bureau of Meteorology)

2.2 TOPOGRAPHY AND LANDFORM

The Preston area is predominantly flat with most of the site varying between 6 and 18m AHD (**Figure 2**). The area can be considered to be an alluvial coastal plain, sloping towards the Preston River in the western part of the site. The central and eastern part of the site also contains some discontinuous remnant sand dunes with heights up to 30m (AHD).

2.3 GEOMORPHOLOGY & GEOLOGY

The study area is located on a central section of the Swan Coastal Plain and is composed of three major physiographic units, consisting primarily of the alluvial Pinjarra Plain and largely covered by the discontinuous, irregular and mostly subdued Bassendean Dunes **(Figure 3)**. A small section of the extreme north west of the study area is within the Spearwood Dune System. These physiographic units can be further subdivided into five distinctive landform units (Department of Agriculture, Western Australia, 2003; Churchwood and McArthur, 1978). The landform units are:

Spearwood Dune System

1. Karrakatta Unit – undulating, well drained landscape with deep yellow brown and grey siliceous sands over limestone.

Pinjarra Plain

1. Guildford Unit – flat plain with medium textured deposits.
2. Swan Unit – alluvial terraces with red earths and duplex soils.
3. Serpentine River Unit – poorly drained plain with fine textured alluvial deposits.

Bassendean Dune System

1. Southern River Unit – sandplain with low dunes and many intervening swamps: iron and humus podzols, peats and clays.

The characteristics of the various landform units are linked directly to the underlying geology. The geology of the area has been described by Playford *et al* (1976), Baxter (1977) and Commander (1984) and is summarised here.

The area occurs within the Bunbury Trough, a deep graben defined by two north south striking faults: the Busselton Fault to the west; and the Darling Fault to the east. The Bunbury Trough contains at least 10,000m of Phanerozoic sediments, although only the near surface formations have been described here. In the study area, these formations range in age from Jurassic to Holocene, as indicated below:

- Yarragadee Formation - conformably overlies the Cockleshell Gully Formation (not described here) and was developed in the Middle to Late Jurassic in a high energy, fluviatile environment. The Yarragadee consists mainly of medium to very coarse grained quartz sand, with abundant fine pebbles, minor thin interbeds of clay and rare, thin coal seams and is at least 700m thick.

- Bunbury Basalt - this unit unconformably overlies the Yarragadee and represents early Cretaceous lava flows which can be up to 85m thick. In some areas the Basalt has been weathered from a fresh micro-porphyritic basalt into a green clay. The basalt represents at least two valley-filling flows, separated by several metres of alluvial sediment. The flow started offshore, south of Black Point, east of Augusta and extended to over 60km west of Bunbury. From the western margin of the study area the basalt dips sharply eastwards.

- Leederville Formation - deposited during the early Cretaceous in a nearshore non-marine environment and unconformably overlies the Bunbury Basalt or Yarragadee Formation. This formation consists mainly of medium to very coarse-grained feldspathic quartz sand and gravel with thin interbedded clay and rare carbonaceous clay and coal. The Leederville Formation fills a synform that has resulted from differential subsidence of the underlying formations. As a result the Formation wedges out to the west.

- Superficial Formations - four Quaternary units are evident in the Preston and unconformably overlie the underlying pre-Quaternary units or each other :

1. The Guildford Formation is a layer of lenticular interbeds of sand, silt, clay and conglomerate generally of a fluvial origin, but with estuarine and shallow marine incursions of variable thicknesses. Exposure of this formation corresponds with lower lying, more water logged areas. Over a large proportion of the study area the Guildford Formation is widely covered by a layer of washed or blown sand (eroded Bassendean Dunes) of variable thickness. These units make up the Pinjarra Plain physiographic unit.

2. The Bassendean Sand consists of a fine to medium grained sand - very light grey at the surface grading into yellow at depth with some localised coffee rock development. The unit forms a series of discontinuous weathered dunes with interdunal depressions; many characterised by swamps or fined grained humic sands with internal drainage. This unit forms the Bassendean Dune physiographic unit.

A sub unit of the Bassendean Sand, up to 5m thick, covers a large portion of the study area and reflects the subdued topography of the underlying Guildford Formation. It is considered to be an erosional remnant of a formerly more extensive dune cover and because of its subtle topography and apparent thinness is often mapped as part of the Guildford Formation and included in the Pinjarra Plain physiographic unit.

3. The Spearwood Sand/Tamala Limestone is largely an eolian calcarenite and typically forms elongate dunes making up the Spearwood Dune physiographic unit. It is present only in the extreme north west corner of the study area. The formation ranges from coarse grained unconsolidated quartz sand (Spearwood Sand) to lithified calcarenite (Tamala Limestone).

The surface geology is shown in **Figure 3**.

2.4 SOILS

Detailed soil mapping has been carried out over a large part of the south west of Western Australia by the Department of Agriculture (Department of Agriculture, Western Australia, 2003) **(Figure 4)**.

Within the study area 29 distinct soil units have been identified and these are described in **Appendix B**.

The area is characterised by relatively thin sandy soils (assigned to various Spearwood, Bassendean and Pinjarra phase units). The sandier phases are prevalent over a large proportion of the study area and are typically highly leached, have a high permeability and low nutrient retention ability.

Loam or clay rich phases of the Pinjarra soil units, generally exposed in low lying areas and also associated with river terraces, have a lower permeability and higher nutrient retention ability.

Near surface clay rich soil units have a profound affect on the surface and subsurface hydrology of the area. High superficial water tables, winter inundation and waterlogging are typical of the study area as a result.

2.4.1 Soil Profiles

Nine monitoring bores were installed around the study area (Section 2.5.2) and provided an opportunity to inspect the geology and soil profile during construction. Bore locations are shown in **Figure 5** and bore logs are held in **Appendix C**. The bores were installed to monitor the superficial water table and were drilled to a maximum of about 5m, or shallower if a confining layer was reached.

All sites that were drilled had an initial layer of grey or light brown fine to very coarse leached quartz sand which ranged in thickness from about 1 metre to at least 5m. In some locations this was underlain by clayish sand or a grey claystone. Thin bands of iron cemented sandstone were also found at some locations. A green grey clay layer of unknown thickness was intersected in most bores and underlying the sandier units. The clay unit is thought to be widespread across the study site and forms a confining layer, supporting the near surface superficial water table.

2.4.2 Acid Sulphate Soils

Wetlands and seasonally inundated areas, often contain acid sulphate soils. Acid sulphate soils are soils that contain iron sulphides that, when drained or disturbed, produce sulphuric acid and result in the release of soluble iron, aluminium and other toxic metals (DoE, 2004a). These soils commonly have a pH between 4 and 6, which corrodes concrete and metals placed in contact with the soils. The low pH also causes groundwater to become unusable and can kill downstream vegetation. Construction on such soils requires great care and often removal of the affected soil. Indications that acid sulphate soils may occur include:

- Land elevation less than 5m;

- Soil and sediment of recent geological age (Holocene);
- Marine or estuarine sediments and tidal lakes;
- Low-lying coastal wetlands or back swamp areas, waterlogged or scalded areas; stranded beach ridges and adjacent swales, inter-dune swales or coastal sand dunes;
- Coastal alluvial valleys; and
- Areas where the dominant vegetation is tolerant of salt, acid and/or waterlogging e.g. mangroves, paperbarks and swamp oak (*Casuarina spp.*) (DoE, 2004a).

Most of the site shows a medium risk of acid sulphate soils with a relatively small area in the northern section showing a high risk **(Figure 6)** (WAPC 2003). No acid sulphate testing was undertaken during this study.

2.5 GROUNDWATER

2.5.1 Background

Previous work undertaken by Feilman Planning (1997) indicates that a number of aquifers exist in the Bunbury Region. It also indicated that virtually all of the Pinjarra Plain area is affected by seasonal flooding due to the high, perched water table that exists in or above the clay layer (Feilman Planning, 1997). Flooding of up to 30 cm in normal rainfall years was considered common (Feilman Planning, 1997).

Two studies have been undertaken into the hydrogeology of the Bunbury area by Wharton (1981) and Commander (1984). Wharton (1981) found thin superficial aquifers with high salinity in the Picton area. Below the superficial aquifer lie the Leederville and Yarragadee formations, except where basalt was encountered west of the Preston River (Commander, 1984). There is some interaction between the Leederville and superficial aquifers (Commander, 1984). Water is thought to flow from the Leederville aquifer into the superficial aquifer in the east and from the superficial aquifer into the Leederville to the west of Preston River (Commander, 1984).

2.5.2 New Work

As part of this study, ENV undertook to place nine monitoring bores in the Preston area **(Figure 5)**. Bores were placed to investigate flow through the site and to monitor water levels and quality close to wetlands. The bores were drilled into the superficial aquifer to depths between three and five metres, depending on the location of the confining layer.

All of the bores except Bore D and Bore I had confining clay layers at depths less than 5m. Bore D and Bore I showed sand to a depth of 5m. The bores with the least depth to clay were Bore A and Bore C, close to the junction of the Preston and Ferguson Rivers. Bore stratigraphy and land form around the bores is given in **Appendix C.**

Water levels in the bores were monitored on 2 September, 16 September, 30 September and 18 October 2004. Two Department of Environment bores, Bunbury Shallow Project 4B and 12B and nine Water Corporation groundwater monitoring bores were included in the last survey. Results taken from the Department of Environment bores on 6 September were also used for calibration.

From these results, depths to groundwater were determined for the eight ENV bores. This information was integrated with historical records from the Bunbury Shallow Project to estimate Average Annual Maximum Groundwater Levels (AAMGL). The Department of Environment generally requires a minimum of 2m separation height between the AAMGL and any construction.

Water quality samples were also taken from the ENV bores on 2 September and 18 October.

2.5.3 Groundwater Height

The groundwater table runs parallel to the two rivers forming a mound between them (**Figure 7).** The groundwater height ranged from 6.33m AHD in the north-west to 18.63 m AHD in the south-east in early September to 6.10m AHD to 18.34m AHD in mid-October **(Figures 7 and 8).** The drop off in groundwater height was not the same at all bores, although all bores experienced a gradual decrease over the monitoring period. Groundwater flow directions vary from northerly in the southwest of the estate to a westerly in the northeast of the site **(Figures 7 and 8).** The directions roughly parallel the Preston and Ferguson Rivers.

The depth to groundwater on the site ranged from 0.25m to 1.2m on 2 September and 0.4m to 1.34m on 18 October. Groundwater heights decreased over the study period, with most bores recording a drop of 20cm to 30cm.

Average Annual Maximum Groundwater Levels

From the bore records, the Average Annual Maximum Groundwater Level (AAMGL) was determined for the two bores over periods of five years, ten years and the record length of the bore, 27 years. This data is summarised in **Table 2** below. In comparison, the maximum values observed during the period of study were 6.33m AHD for Bore 4B and 15.45m AHD for Bore 12B.

	5 years	10 years	Full Record
4B	6.24m	6.27m	6.38m
12B	15.41m	15.49m	15.58m

Table 2 Average annual maximum groundwater level over different periods in metres AHD.

Because of the decreases in rainfall in the last few years, it was decided to use the ten-year AAMGL rather than the full record. These levels are 6cm below the levels recorded for Bore 4B and 4cm above those recorded at Bore 12B during the study period. These values were recorded at the start of September. The AAMGLs were estimated to be within 1cm (average) of the first set of data.

It appears from the data that the peak groundwater levels are achieved even in drier years, as this period was. This is likely to be because the winter superficial groundwater levels in the local area are controlled by the river levels and reach approximately the same high point annual. The AAMGLs are therefore based on the highest recorded water levels measured across the site.

The estimated AAMGLs for the bores are shown in **Table 3** and mapped on **Figure 9.** It should be noted that these values are estimates only and may be refined and improved when more long-term data as been collected from the nine new bores across the site.

	Height (m AHD)	Depth to Groundwater (m)
A	9.6	0.2
B	11.9	0.5
C	11.0	0.9
D	15.8	1.2
E	14.1	0.6
F	13.5	0.4
G	18.6	0.5
H	13.0	1.0
I	10.6	0.3
12B	15.5	n/a
4B	6.3	n/a

Table 3 Estimated Average Annual Groundwater Levels.

2.5.4 Groundwater Quality

As part of the groundwater assessment, levels of phosphorus, nitrogen, pH and electrical conductivity (eC) were measured in the ENV bores on two occasions **(Tables 4 and 5)**.

The results were then compared to the ANZECC guidelines for water quality in slightly disturbed lowland rivers and wetlands in South Western Australia. While it is recognised that the site is more than slightly disturbed, no values are available for more compromised sites.

Groundwater generally showed elevated levels of phosphorus and nitrogen throughout the site. These values are consistent with the marginally eutrophic state of the Leschenault Inlet (WAPC, 1997). Bores E and F are located immediately up gradient of EPP wetlands. The two bores show elevated nitrogen levels but comparatively low phosphorus levels.

The groundwater pH was almost always below the range expected in slightly disturbed wetlands and rivers. This is common in highly coloured wetlands, where pH is typically 4.5 to 6.5 (ANZECC, 2000). Most of the groundwater samples have a pH in this range. The samples taken were generally coloured, probably due to high tannin levels from the local vegetation. The water was generally of a brackish quality.

The average values from the two sampling events are:

- Total Persulpate Phosphorus – 0.3 mg/L
- Total Nitrogen – 3.2 mg/L
- pH – 5.9
- Electrical Conductivity @ 25°C – 2,090 µS/cm

All average values are currently outside the guidelines for both river and wetland water quality.

These water quality criteria provide some guidance for targets for stormwater on industrial sites that are not affected by industrial process. These levels can be also used to set achievable nutrient attenuation targets for stormwater treatment systems. Water that is treated and then discharged would aim to improve water quality to guideline levels for rivers and wetlands, as discussed later.

2/09/2004		Rivers Guideline	Wetlands Guideline	A	B	C	D	E	F	G	H	I
Total Persulphate Phosphorus, P	mg/L	0.065	0.03	0.06	0.63	0.12	0.06	0.02	0.06	1.2	0.16	0.19
Ammoniacal Nitrogen, NH3-N	mg/L	0.08	0.04	0.13	1.6	0.083	0.55	0.6	0.017	0.011	0.018	0.029
Kjeldahl Nitrogen	mg/L	-	-	4.1	8.6	1.1	1.6	3	1.4	4.3	2.8	1.4
Nitrate, NO3	mg/L	-	-	<0.05	0.06	<0.05	<0.05	0.51	<0.05	<0.05	<0.05	0.15
Nitrite-Nitrogen, NO2-N	mg/L	-	-	<0.005	0.05	0.008	<0.005	0.011	<0.005	0.011	0.02	<0.005
Total Nitrogen	mg/L	1.2	1.5	4.16	8.71	1.16	1.66	3.52	1.46	4.36	2.87	1.56
pH	pH Units	6.5 - 8	7 – 8.5	7.3	6.2	6.6	6.4	5.8	5.2	6	4.8	5.8
Electrical Conductivity @ 25oC	µS/cm	-	-	1,500	2,000	190	850	1,600	1,500	8,700	1,200	1,400

Table 4 Water quality results from bores, 2/9/04.

19/10/2004		Rivers Guideline	Wetlands Guideline	A	B	C	D	E	F	G	H	I
Total Persulphate Phosphorus, P	mg/L	0.065	0.03	0.02	0.53	0.07	0.02	0.02	0.02	1.8	0.13	0.19
Ammoniacal Nitrogen, NH3-N	mg/L	0.08	0.04	0.21	2	0.96	0.78	2	0.088	1.2	0.062	0.13
Kjeldahl Nitrogen, N	mg/L	-	-	1.2	7.5	1.6	1.2	6.8	0.27	4.8	2.7	1
Nitrate-Nitrogen, NO3-N	mg/L	-	-	0.015	0.028	0.072	0.019	0.022	0.021	0.02	0.012	0.044
Nitrite-Nitrogen, NO2-N	mg/L	-	-	<0.005	0.082	0.048	0.011	0.028	0.012	0.02	0.019	0.006
Total Nitrogen	mg/L	1.2	1.5	1.22	7.61	1.72	1.23	6.85	0.30	4.84	2.73	1.05
pH	pH Units	6.5 - 8	7 – 8.5	6.9	5.9	6.5	5.9	6.1	5.6	6.1	4.1	5.6
Electrical Conductivity @ 25oC	µS/cm	-	-	980	1,900	660	1,000	1,200	1,500	6,800	2,000	2,700

Table 5 Water quality results from bores, 19/10/04.

2.6 WATERWAYS

The surface hydrology of the site is dominated by the Preston and Ferguson Rivers. The Preston River has a catchment in excess of 1000km^2, of which more than 60% is cleared (Feilman Planning, 1997). The Ferguson River is basically ephemeral and has a catchment of about 120km^2 (Feilman Planning, 1997). The rivers join in the north-west of the site and then flow into the Leschenault Estuary. Total nitrogen levels in the Preston and Ferguson are generally low (less than 1.2 mg/L), as are total phosphorus levels (less than 0.08 mg/L) (DoE website, 2004).

The groundwater quality from bores at the site appears to be poorer than the receiving river water, indicating that water quality in higher parts of the catchment is better than in this low lying area, again reinforcing the need for industry to improve the quality of water that it uses.

Flood mapping of the Preston River has been undertaken by Department of Environment (**Figure 10)**. This mapping shows both the floodway and flood fringe of the river. Floodways are areas that experience significant flow velocities during the 100-year flood. Flood fringes experience flooding during the 100-year flood but the flow is much slower. No equivalent mapping has been undertaken for the Ferguson River.

Development is not allowed in the floodway, but is allowed in the flood fringe subject to management responses discussed later.

A man-made drainage network also exists over parts of the Preston area (**Figure 11)**. The system drains farmland areas to assist with reducing winter flooding. The system is operated and maintained by Water Corporation. The aim of the drainage network is to reduce flooding in the agricultural areas but is only partially effective (Fielman, 1997).

2.7 VEGETATION

2.7.1 Introduction

Preston Industrial Park is in the Drummond Botanical Subdistrict of the Southwest Botanical Province (Beard, 1981). This subdistrict is mainly *Banksia* low woodland on leached sands with *Melaleuca* swamps where the area is poorly drained. Woodlands of *Eucalyptus gomphocaphala* (Tuart), *Eucalyptus marginata* (Jarrah) and *Corymbia calophylla* (Marri) occur on less leached soils.

Beard (1981) records the natural vegetation of the area as a mosaic of *Banksia attenuata* and *Banksia menziesii* Low Woodland/ *Eucalyptus marginata* and *Corymbia calophylla* Woodland/Teatree woodland (b1,2Li/e2,3Mi/mLi).

The pre-European extent of this vegetation type was 119 340ha, of which 29 396ha remains vegetated. This represents 24.6% of the original area. Currently 13% is protected in IUCN Class I-IV Reserves and 8.9 % in other reserves (Shepherd *et al.*, 2002).

Heddle *et al.* (1980) in their study of the Darling System mapped four vegetation complexes as occurring within the study area. These are Karrakatta Complex – Central and South; Southern River Complex, Swan Complex and Guildford Complex.

The Swan Complex was confined to the Preston River, which traverses the study area. The Southern River Complex occurred to the east and west of the Swan Complex. The Karrakatta Complex – Central and South – was mainly confined to the northern western area and the Guildford Complex occurred on the eastern side of the study area.

The natural areas in the Greater Bunbury Region (GBR) have been significantly reduced and/or altered. The total remnant vegetation of the above vegetation complexes is provided in EPA (2002) and tabulated below in **Table 6.**

VEGETATION COMPLEX	ORIGINAL GBR ha	REMAINING GBR ha	REMAINING % GBR	REMAINING % SCP	%SECURE TENURE GBR
Spearwood Dune System					
Karrakatta – Central and South	11686	6091	52	29.5	16
Pinjarra Plain					
Southern River	16070	3320	21	20	6
Swan	5646	906	16	16	0
Bassendean Dune System					
Guildford	33294	1470	4	5	1

Table 6 Total remnant vegetation remaining in the Greater Bunbury Region (GBR) and southern Swan Coastal Plain (SCP) as recorded by EPA (2002).

For the Greater Bunbury Region the objective of the EPA (2002) and Commonwealth of Australia (2001) is to retain 30% or more of the pre-clearing extent of each ecological community if the biodiversity is to be protected. Referring to Table 1, Karakatta Central and South has 52% or more remaining within the Greater Bunbury Region and the other three vegetation complexes have less than 30% remaining. Remnants of the Karakatta Central and South complexes occur on areas of higher ground. Low lying areas have been preferentially cleared for grazing as the higher water table and clay rich soils provide better quality pastures over a longer period. When these assessments are made for the Swan Coastal Plain all four complexes have less than 30% of their original coverage remaining putting conservation pressure on all complexes including Karakatta Central and South.

The overall extent of clearing on the Swan Coastal Plain and within the GBR shows that all the remnant vegetation within the study area is of environmental importance.

The full botanical report is given in **Appendix A.**

2.7.2 Previous Surveys

Previous field work in the study area was undertaken for Main Roads Bunbury and the Western Australian Planning Commission. The vegetation units from these surveys are described in **Appendix B.**

2.7.3 2004 Survey

Field work was undertaken between 24 and 27 March 2004 with a follow up in spring between 20 and 23 October 2004. Field assistance was provided in March by Ms R. Ryan from the Bush Forever Office at the Department of Planning and Infrastructure and during October by Mr. J. Bennett.

Quadrats

A total of 18, 10m x 10m quadrats and 3 relevees were established in representative areas of the various vegetation units observed in the field (**Figure 12**). Attempts were made to place the quadrats where the condition was good or better, but this was not always possible.

The field data gathered during this survey is provided in **Appendix A**.

Vegetation

The vegetation units recorded during the survey were described using the vegetation layers as given in **Appendix A**.

Due to a large amount of the Preston area being developed, the remnant vegetation remaining is small in size and often isolated from other areas of vegetation.

As much of the study area has been cleared there are only small pockets of the original remnant vegetation remaining. Most of the remnant vegetation occurs in the Southern River Vegetation Complex, the largest complex of the survey area, and the Swan Vegetation Complex, which is restricted to the Preston and Ferguson Rivers in the study area. The other two vegetation complexes do not have distinct vegetation units associated with them, mainly due to the lack of original vegetation structure remaining. The vegetation of the study area was therefore considered under vegetation layers and not under the vegetation complexes **(Figure 13).**

Vegetation Condition

As most of the Preston area has been developed, especially the lower lying land, its vegetation condition is completely degraded (Condition 6 in **Table 7**). In other areas the upper storey was in reasonable condition but the understorey had been completely or nearly completed replaced with pasture species – parkland cleared. This parkland cleared condition was recorded as degraded (Condition 5 in **Table 7**) **(Figure 14).**

Rating	Description	Explanation
1	Pristine	Pristine or nearly so, no obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered, obvious signs of disturbance.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

Table 7 Explanation of Vegetation Condition Rating (Department of Environmental Protection,2000).

Most of the remnant vegetation had been grazed previously so the best vegetation condition that could be applied to any of the quadrats and vegetation units described was excellent, Condition 2 in **Table 7.**

The vegetation in better condition occurred scattered throughout the area. Refer to appendixes of the vegetation report where the vegetation condition is recorded for each quadrat and to **Figure 14** where the vegetation condition is presented.

2.7.4 Vegetation Units

This section will combine all the vegetation units identified during all surveys conducted in the area.

The description of the vegetation unit is provided followed by the abbreviation used in Table 8 and **Figure 13**. These are organised under vegetation structure rather then vegetation complex. The remnant vegetation at the Bunbury Pistol Club could not be accessed. Several attempts were made but each time the red flag was flying indicating that access was not permitted (pers. com., Staff at City of Bunbury).

A total of 13 lower ground and 8 higher ground vegetation units were described from the vegetation surveys undertaken of the Preston Industrial Park.

Floristic Community Type (FCT)

The FCT of each structural unit was inferred from a desktop comparison of the survey data to Gibson *et al.* (1994), in particular Table 12 in this publication. This is a 2-way table where the species that occur with a frequency of at least 50% are recorded for each FCT.

A large number of the drier wetlands or the fringes of deeper wetlands were representative of FCT4 – *Melaleuca preissiana* damplands. The typical species associated with this FCT are:

- trees *Melaleuca preissiana*;
- shrubs *Hypocalymma angustifolium, Pericalymma ellipticum, Xanthorrhoea preissii, Adenanthos obovatus, Astartea* affin. *fascicularis*; and
- herbs **Briza maxima, Dampiera linearis, Dasypogon bromeliifolius, *Hypochaeris glabra, Hypolaena exsulca, Lyginia barbata, Phlebocarya ciliata, Schoenus rodwayanus, Stylidium brunonianum, Stylidium repens, Xanthosia huegelii.*

FCT11 – Wet forests and woodlands was also recorded during the survey. The typical species associated with this FCT are:

- trees *Eucalyptus rudis*;

- shrubs *Astartea* affin. *fascicularis*; and
- herbs **Briza maxima, *Hypochaeris glabra, Lepidosperma longitudinale.*

FCT13 – Deeper wetlands on heavy soils recorded along some sections of the Preston River were. The typical species associated with this FCT are:

- shrubs *Hakea varia, Melaleuca lateritia, Melaleuca rhaphiophylla*; and
- herbs *Cassytha racemosa, Triglochin huegelii.*

FCT17 – *Melaleuca rhaphiophylla – Gahnia trifida* wetlands. The typical species associated with this FCT are:

- tree *Melaleuca rhaphiophylla;* and
- herbs *Gahnia trifida, Lobelia alata, Baumea juncea, Lepidosperma longitudinale, *Sonchus oleraceus.*

The higher ground vegetation was representative of

FCT21a – Central *Banksia attenuata – Eucalyptus marginata* woodlands. The number of characteristic species is relatively high compared to other FCT's. The typical species associated with this FCT are:

- trees *Banksia attenuata, Eucalyptus marginata;*
- shrubs *Bossiaea eriocarpa, Conostephium pendulum, Gompholobium tomentosum, Hibbertia hypericoides, Macrozamia riedlei, Petrophile linearis, Philotheca spicatus*; and
- herbs *Austrodanthonia occidentalis, *Briza maxima, Burchardia umbellata, Caladenia flava, Chamaescilla corymbosa, Conostylis aculeata, Conostylis juncea, Dasypogon bromeliifolius, Drosera erythrorhiza, Drosera stolonifera, *Hypochaeris glabra, Lagenophora huegelii, Lepidosperma angustatum, Lomandra caespitosa, Lomandra hermaphrodita, Lomandra sericea, Loxocarya flexuosa, Lyginia barbata, Patersonia occidentalis, Phlebocarya ciliata, Trachymene pilosa, *Ursinia anthemoides, Xanthosia huegelii, Lomandra caespitosa, Microlaena stipoides, *Orobanche minor, *Oxalis perennans, *Petrorhagia velutina, *Sonchus oleraceus, Sowerbaea laxiflora, Trachymene pilosa, *Trifolium campestre.*

FCT 21c – Low Lying *Banksia attenuata* woodlands of shrublands. The typical species associated with this FCT are:

- trees *Banksia attenuata, Banksia menziesii*
- shrubs *Gompholobium knightianum, Kunzea glabrescens, Leucopogon conostephioides, Petrophile linearis, Scholtzia involucrata*
- herbs **Briza maxima, *Hypochaeris glabra, Lomandra caespitosa, Lyginia barbata, Thysanotus manglesianus, Trachymene pilosa, Burchardia umbellata, Caladenia flava, Dasypogon bromeliifolius, Drosera erythrorhiza, Hypolaena exsulca, Lomandra hermaphrodita, Patersonia occidentalis, Stylidium brunonianum, Stylidium repens, *Ursinia anthemoides*

FCT	Vegetation Unit
4	Af , MpMtLl, BlMp, MpKg, MpKgLl, Pe, Herb, MpAs, MpAf, MpPe
11	MrEr, ErAf
13	MrMl, Mr
17	CcAf, MpMrLl,
21a	BaEmXo
21c	BaBiKg, BiKg, CcEm, CcXb

Table 8 Vegetation Units recorded for each Floristic Community Type (FCT)

2.8 THREATENED ECOLOGICAL COMMUNITIES

Ecological communities are defined as naturally occurring biological assemblages that occur in a particular type of habitat (Department of Environmental Protection, 2000), some of which are under threat. A search of the CALM database recorded no Threatened Ecological Communities (TEC) for the Preston area. Potential Threatened Ecological Communities (TEC) that may occur within the Preston area were identified as FCT2 – Southern wet shrublands; FCT10a – Shrubland on dry clay flats and FCT 15 – Forests and woodlands on deep seasonal wetlands (V. English pers. comm.).

None of the other FCT's listed for the site are considered to be Threatened Ecological Communities by CALM or the EPBC Act (1999).

2.9 SIGNIFICANT FLORA

Species of flora are defined as rare or priority conservation status where their populations are restricted geographically or threatened by local processes. The Department of Conservation and Land Management recognises these threats of extinction and consequently applies regulations towards population and species protection.

Rare Flora are gazetted under Sub-section 2 of Section 23F of the Wildlife Conservation Act (1950) and therefore it is an offence to "take" or damage rare flora without approval from the Minister for the Environment.

The search of the Department of Conservation and Land Management (DCLM) rare flora resulted in a list of nine Priority flora from within or in close proximit to the study area. One, *Acacia semitrullata*, was a Priority 3 flora and the remaining 8, *Acacia flagelliformis, Aponogeton hexatepalus, Caladenia longicauda* subsp. *clivicola, Caladenia speciosa, Drosera marchantii* subsp. *marchantii, Franklandia triaristata, Pultenaea skinneri* and *Villarsia submersa* were Priority 4 flora.

GHD (2002) recorded four priority flora in the survey of the wetlands and threatened ecological communities in the proposed Bunbury outer ring and port access roads. *Acacia flagelliformis* and *Caladenia speciosa*, both Priority 4 flora, were recorded within the current survey area. *Aponogeton hexatepalus* and *Villarsia submersa* were recorded from the Hynes Road wetland, which is excluded from but on the boundary of the current survey area.

Bennett Environmental Consulting Pty Ltd (2003) recorded *Verticordia attenuata* a Priority 3 Flora and *Eucalyptus rudis* subsp. *cratyantha, Jacksonia sparsa* and *Acacia flagelliformis* all Priority 4 Flora during the survey of the propose Bunbury ring and port access roads **(Table 9 and Figure 15).**

Priority Flora	**GPS (WGS84)**		
Priority 3			
Verticordia attenuata	380410E 381689E 379985E 379558E	6311809N 6312144N 6311512N 6311621N	5 >100 10 10
Priority 4			
Acacia flagelliformis	380307E 380293E 381689E	6310431N 6311669N 6312144N	>50 2 >100

Priority Flora	GPS (WGS84)		
Eucalyptus rudis subsp. *cratyantha*	379240E 377857E 377475E 378515E: 378626E 378396E	6308742N 6308568N 6308491N 6305974N 6305312N 6306328N	>20
Jacksonia sparsa	379988E	6311621N	10

Table 9 Location of Priority Flora recorded during survey

A description of all priority flora recorded during surveys of the study area has been extracted from FloraBase (Western Australian Herbarium, 2004) and provided in the botanical appendix.

2.10 WETLANDS

2.10.1 Methodology

Wetland assessment was undertaken by reviewing the mapping available from the Department of Environment and Department of Land Information. Once this had been undertaken, ground surveys were undertaken to properly assess the condition and classification of the wetland. Wetlands are classified by the Department of Environment according to their conservation value, which includes both environmental and social factors. The wetlands were described using the classification system developed by Semenuik (1987) an overview of which is provided in **Table 10.**

Wetland Type	General Description
Basin Wetlands	Dampland - seasonally waterlogged basin. Sumpland - seasonally inundated basin. Lake - permanently inundated basin. Artificial basins (e.g. dams, reservoirs).
Flat Wetlands	Floodplain - seasonally inundated flat. Palusplain - seasonally waterlogged flat.

Table 10 Wetland types within the Swan Coastal Plain

All wetlands were considered in the botanical survey, but only those where remnant native vegetation present were surveyed. Depending upon the size, 10m x 10m quadrats or relevees recorded the vegetation units present. Where the vegetation was of a large enough dimension, a 10m x 10m quadrat was established and the results are included in the quadrat data. The dominant species of each stratum within the different vegetation units was recorded, together with the presence of standing water.

A requirement of this survey was that the wetlands were to be evaluated and a level of significance and therefore the appropriate management category are assigned using the Management Categories of the Water and Rivers Commission (2001).

If Declared Rare Flora is recorded, the wetland is automatically considered to be Category H, high conservation.

The Water and Rivers Commission (2004) and the Environmental Protection Authority (2004b) have classified most of the Preston Industrial Park as a Multiple Use wetland (a category that permits development with some conditions). There are Conservation and Resource Enhancement wetlands listed for the study area **(Figure 16)**, which are more restrictive for development. The whole extent of the Preston River (coloured green) is listed as a Conservation Category wetland, but the Ferguson River (coloured pale blue) is listed as Multiple Use wetland. There are two additional areas of Conservation Category wetlands (green or red), four Resource Enhancement wetlands (blue) and four that have not been assessed (grey).

Management objectives for different wetland categories are presented in **Table 11.**

Category (Department of Environmental Protection, 1993).	Management Category (Water and Rivers Commission, 2001)	General Description	Management Objectives
H – High conservation C - Conservation	C – Conservation (incorporates EPA Bulletin 686 categories H and C)	Wetlands support a high level of ecological attributes and functions.	Highest priority wetlands. Objective is preservation of wetland attributes and functions through various mechanisms including: • reservation in national parks, crown reserves and State owned land, • protection under Environmental Protection Policies, and • wetland covenanting by landowners. • These are the most valuable wetlands and the Commission will oppose any activity that may lead to further loss or degradation. • No development.
O – Conservation and recreation R – Resource enhancement	R - Resource enhancement (incorporates EPA Bulletin 686 categories O and R)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is for management, restoration and protection towards improving their conservation value. These wetlands have the potential to be restored to conservation category. This can be achieved by restoring wetland structure, function and biodiversity. Protection is recommended through a number of mechanisms.
M – Multiple Use	M - Multiple use (aligned with EPA Bulletin 686 category M)	Wetlands with few important ecological attributes and functions remaining.	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. Should be considered in strategic planning (e.g. drainage, town/land use planning).

Table 11 Categories assigned to wetlands (Department of Environmental Protection, 1993 and Water and Rivers Commission, 1991)

With the new environmental protection regulations for Swan Coastal Plain wetlands (Environmental Protection Authority, 2004b), if the wetland has one or more of the listed significant natural attributes it is considered a significant wetland. These attributes are summarised below:

1. Supports flora being declared to be protected flora for the purposes of the Wildlife Conservation Act 1950;

2. Supports fauna specified in a notice in operation under Section 14(2)(ba) of the Wildlife Conservation Act 1950 as fauna likely to become extinct, or is rare, or otherwise in need of special protection;

3. Supports vegetation in good, very good, excellent or pristine condition B.J. Keighery in *Bushland Plant Survey. A Guide to Plant Community Survey for the Community*, Wildflower Society of WA (Inc.), Nedlands Western Australia, 1994;

4. Supports an ecological community listed as 'threatened' in Category 1, 2, 3, or 4, as described by V.J. English and J. Blyth;

5. Is a wetland that is part of a natural wetland group of which fewer than 30% of wetlands of that type in that group are represented in the conservation estate on the Swan Coastal Plain, according to the wetland type and geomorphic classification system in Hill, A.L., Semeniuk, C.A., Semeniuk V and Del Marco, A. (1996); and

6. It is a significant habitat or refuge for native or migratory fauna.

2.10.2 Results

Two areas of palusplain were recorded during the survey but most of the wetlands found were sumplands or floodplains **(Table 12, Figure 16).**

Wetland type	Wetland Identifier
Palusplain	PCRA, Reserve 40552; 4.5i&ii
Floodplain	PC09; PC13; PC18; PCRC; HGM – 4.5; Moore Road – 3.2, 3.2, 3.3, 5.1, 6.1
Sumpland	PC05, PC06
River	PC11; PC14; PC16; HGM –4; Harris Road 9.3;

Table 12 Wetland types recorded during the survey

There were no EPP wetlands with standing water in them. This need not be permanent but temporary during the winter months. They are protected from unauthorised filling, mining, effluent disposal and drainage.

Some wetland areas were identified and quadrats established. Using Environmental Protection Authority (2004b) a wetland has a significant natural attribute if fulfils at least one of six defined conditions. Four of the wetlands include one of these attributes, namely "they supports vegetation in 'good, very good, excellent or pristine condition' as described by B.J. Keighery in *Bushland Plant Survey. A Guide to Plant Community Survey for the Community*, Wildflower Society of WA (Inc.), Nedlands, Western Australia, 1994". A total of 11 wetlands are considered to support vegetation worthy of significance. These are mapped in **Figure 16.**

Several of the wetlands identified during the survey correspond with the wetlands identified by the Water and Rivers Commission (2004) and with the wetlands identified by the Environmental Protection Authority (2004b). Wetlands identified on the map as Numbers 5, 7 and 8 also included priority flora an additional attribute listed by the Environmental Protection Authority (2004b). GHD (2002) also identified the Priority 4 species, *Caladenia speciosa*, from Wetland 5.

All of these wetlands are small in area with open areas scattered through and typically surrounded by degraded or cleared land. The Hynes Road wetland, which is just outside of the study area in the north east, also included the priority flora, *Aponogeton hexatepalus*.

All the other wetlands observed during the study had cattle grazing through them or were weed infested. With the exception of the Preston River, there were none that were considered still to warrant Resource Enhancement category due either to their very small size or to the weed cover.

2.11 LIQUID WASTE MANAGEMENT

The Preston area is not currently sewered and no plans for large scale sewerage in the area exist. Preston Industrial Park is more likely to connect to the large Bunbury wastewater system rather than the smaller Eaton-Australind system (G. Davis, Water Corporation). Because of this, potential points of connection will occur along the Western boundary of the site, including Glen Iris, Davenport and the Bunbury Airport area.

There are currently no plans for a centralised industrial liquid water treatment facility to our knowledge. Industries would therefore be required to treat their own liquid waste on site as set out in the management section of this document.

Nutrient, pH and salinity (conductivity) 'contamination' of liquid waste is treated differently in the management responses because of the pre-existing elevated levels. There are therefore different management responses proposed for stormwater that is not affected by industrial processes.

3. OPPORTUNITIES AND CONSTRAINTS

3.1 INTRODUCTION

The complex hydrology and remnant vegetation of Preston Industrial Estate provides a number of opportunities and constraints for industrial development in the area. These constraints can be mitigated by good management and appropriate placing of industrial facilities. The main constraints for the estate are the shallow groundwater table and the need to protect the wetlands, Preston River and Ferguson River.

The provision of suitable fill is a constraint and discussed in detail in the section below. Sourcing fill is also a constraint in itself as it is important that fill not be sourced from high areas of this site because this is the location of much of the best vegetation.

The location close to Bunbury and the buffering between urban areas to the west by the Preston River presents a great opportunity to develop light industry close to Bunbury. The location gives businesses a chance of financial success because of the good service that they an provide to the sizeable population of Bunbury.

Although wetlands are present in the area in abundance and cover a substantial portion of the area, most of the high conservation value wetlands are within the flood areas of the rivers or in the high quality vegetation zones, which are areas already set aside for protection. In addition, many of the wetlands no longer support wetland vegetation because of grazing and can be developed, as the Multiple Use Category recognises.

3.2 FILL REQUIREMENTS

Department of Environment generally requires a 2m vertical separation between industrial use and the Annual Average Maximum Groundwater Level (AAMGL) (DoE, 2004). This ensures that soils are free-draining, waterlogging is avoided and microbial action can attenuate any contaminants before they reach the groundwater table. Department of Environment also recommends that development should not occur on seasonally inundated land (DoE, 2004).

The amount of fill required to maintain a 2m separation distance between the surface and the estimated AAMGL varies between 0.8m and 1.8m (**Table 13**). The fill requirements over the site (in terms of built levels AHD) are shown in **Figure 17.**

	Height (m AHD)	Depth to Groundwater (m)	Fill Required (m)
A	9.6	0.2	1.8
B	11.9	0.5	1.5
C	11.0	0.9	1.1
D	15.8	1.2	0.8
E	14.1	0.6	1.4
F	13.5	0.4	1.6
G	18.6	0.5	1.5
H	13.0	1.0	1.0
I	10.6	0.3	1.8

Table 13 Depth to groundwater and fill requirements at monitoring bores.

The extent of seasonal inundation or waterlogging can be difficult to determine without detailed studies, although the bore installation program and data collected as part of this study provides more definitive information than was previously available. The figure **(Figure 19)** given in this report should be considered as a guide. ENV recommends that information be confirmed on a lot by lot basis because this may affect the fill volumes that are required. There may some local high points on a site that reduce fill requirements and associated costs.

ENV also considers the lower areas as good sites for industries that have small building footprints relative to their other activities. Fill can then be applied just to the building envelope, minimising the fill requirement.

3.3 FLOODPLAINS

The management of river floodplains needs to take into account the differing requirements of the floodway and flood fringe. In Western Australia, construction in floodways is not permitted (WRC, 2000).

Construction is permitted within the flood fringes but only if the site is at least 10m from the edge of the floodway and is raised a minimum of 0.5m above the level of the flood (WRC, 2000). The increase in flood height due to the construction must be less than 0.15m (WRC, 2000), which is generally not an issue for small development in the fringe of a large river such as the Preston River.

Department of Environment recommends that extensive filling of flood fringes for industrial developments should be avoided as this increases the chance of upstream flooding and the chances of soil erosion (DoE, 2004 b). Industries within the flood fringes should also be limited to those that will not cause surface water or groundwater pollution.

The fill of flood fringe areas should be assessed on a case-by-case basis and the type of development would need to be suited to its location on the flood fringe, i.e. non-polluting, small proportion of building therefore limited fill and outside activities that can tolerate occasional inundation.

The constraint area associated with floodplains is shown by the blue regions in **Figure 19.**

3.4 DRAINAGE

Infiltration of stormwater at Preston is not considered generally feasible due to the high water tables and confining clay layers, both of which severely limit the infiltration rate. Because of this, a drainage system will be required to remove excess stormwater from the site. Where use of the existing drainage system is not feasible, new drains may be required. New drains should be built above the AAMGL to avoid draining groundwater from the site (WAPC, 2000).

3.5 VEGETATION

3.5.1 Clearing Constraints

Four vegetation complexes were identified as occurring in the Preston Industrial Park study area. Within the Greater Bunbury Region the EPA (2002) lists the Karrakatta – Central and South vegetation complex as having greater than the recommended 30% remaining and the other complexes, (Southern River, Swan and Guildford) as having 20% or less remaining. However within the entire Swan Coastal Plain less than 30% remains of all the complexes that are on this site – the Karrakatta Central and South, Bassendean Central and South, Southern River, Serpentine River, Swan and Guildford Complexes. The objective of the Commonwealth of Australia (2001) and the EPA is to retain 30% or more of the pre-clearing extent of each ecological community if the biodiversity is to be protected. Therefore all the remnant vegetation within the Preston Industrial area should be retained.

Some of the area has been cleared and widely grazed and can be considered to be in a degraded or completely degraded state. This means that the area is challenging for rehabilitating to a good vegetation state. This area should be suitable for further clearing for industrial or other land uses. However, a flora survey should still be conducted prior to clearing to determine the presence of rare and priority flora on a particular lot.

In addition, the wetlands of the area should be preserved in line with legislation and guidelines provided by the Department of Environment. This is discussed in Section 3.6 below.

3.5.2 Maintaining Ecological Processes or Natural Systems

The lowest size limit given for maintaining ecological processes is 20ha (EPA, 2002). Very few sections of remnant bushland in good or better condition are of this size. Moore Road - Lots 1, 5 and 7 has a reasonably sized remnant bushland, mostly on higher ground. Some of this land has already been proposed for the Bunbury Bypass Road and some for a motor sports facility. Lot 4 owned by the Southwest Development Commission also includes vegetation in good or better location, although its continuity is broken by a powerline and the presence of dieback is apparent at some locations.

It is strongly recommended that the South West Development Commission retain Lot 4 on the Australind Bypass as natural bushland. This area forms an aesthetic entrance to the City of Bunbury and a pleasant outlook for the entrance to Eaton, which is on the northern side of the bypass. In addition thi bushland is in very good condition, with a variety of different trees and species, including the priority flora *Acacia flagelliformis* and *Verticordia attenuata*. It hides the power lines which traverse the countryside to the south of the Australind Bypass Road. Small areas of significant wetlands would also be included as a result.

The other bushland area of reasonable size is that adjoining the old railway line and Moore Road, Lot 1. This includes the Closed Heath of *Pericalymma ellipticum* and *Hakea varia* over a Sedgeland of *Lepidosperma longitudinale* with emergent *Melaleuca preissiana,* an area of palusplain. In addition plants of the priority flora *Acacia flagelliformis, Verticordia attenuata* and *Jacksonia sparsa* would be protected if this area was conserved.

The area includes representation of uplands and wetlands. Areas which contain both ecological community groups, support the highest biodiversity and are a focus for protection.

3.6 WETLANDS

Much of the Preston Industrial Park site can be considered to be wetland of one type or another, even if it is only seasonally waterlogged. Most of this wetland area has been cleared for grazing area but eleven wetland areas with significant natural attributes remain, mainly because they had a vegetation condition of good or better (EPA, 2004 b). All the significant wetlands were small in size, and most, even if higher ground vegetation was included, were of a size smaller than 20ha, which is the minimum area considered adequate to maintain ecological processes and natural systems (EPA, 2002).

Three of the eleven wetlands, Numbers 5, 7 and 8, also included the priority flora *Acacia flagelliformis* and *Verticordia attenuata*. GHD (2002) also listed *Caladenia speciosa* from Wetland 5. None of these wetlands were considered to be of Conservation Category standard.

All wetlands observed during the surveys were small in size and most were surrounded by bushland in degraded condition or pasture. The Preston and Ferguson Rivers, although degraded in many sections are important river corridors (EPA, 2002). These wetlands and the river corridors of the Preston and Ferguson Rivers should be retained and conserved with a goal of improving the quality of surface inflows, adjacent wetland areas and riparian vegetation.

Swan Coastal Plain wetlands with significant natural attributes are protected from unauthorised filling, mining, effluent disposal, discharging water into or taking water from, taking groundwater from below the wetland, removing, killing, burning or destroying native vegetation, severing or ring barking trees or shrubs, bringing other than indigenous flora into the wetland and taking of fauna.

Because of land practices in the area, the nutrient concentrations in the groundwater are quite high. This can cause algal blooms in wetlands and contribute to algal problems in the Leschenault Estuary. Although this is outside the scope of this document, consideration should be given to how these issues can be better managed in future.

3.7 RIPARIAN ZONES

Riparian zones of rivers and sometimes drains require protection to avoid pollution and to aid in the maintenance of water quality. Vegetation in this area should be retained or rehabilitated where degradation has occurred. Because of the sensitivity of these areas, industry should not be developed in these zones. The main riparian zones along the Preston and much of the Ferguson rivers are already protected by designated Conservation Category areas.

A nominal buffer distance of 30m is generally required between a waterway and construction, but determining the biophysical extent of the riparian zone and associated wetlands allows for a better assessment of riparian zones (WRC, 2002). The banks of the Preston and Ferguson Rivers are degraded, often due to stock accessing the river, with only small sections in a better than degraded condition. However, rivers are important and rehabilitation with endemic species should be undertaken. Private properties do not include the riverbanks but permission is currently provided for owners to water their stock during the summer months.

Consideration should be given to restricting stock access to the rivers and vesting the riverbanks in an appropriate body who can assist in maintaining and improving the rivers.

The constraints associated with the riparian zone are shown in **Figure 18.**

3.8 LIQUID WASTE

The thin nature of the water table and poor groundwater quality indicate that land discharge of industrial wastewater by infiltration is generally unsuitable in the Preston area. Western Australian Planning Commission will only approve development of industrial areas without reticulated sewerage where 'dry' industry is proposed and soil conditions allow for safe land disposal of effluent on a long-term basis (WAPC, 1988). The Environmental assessment of the Greater Bunbury Region Scheme indicated that approval of industrial development in the Preston area was unlikely without the provision of deep sewerage (WAPC, 1997). All future industrial development in the Preston area should therefore have deep sewerage.

While the provision of sewerage and the construction of water treatment facilities to meet stringent discharge criteria are an added financial cost, th[i]s issue is likely to become less of a constraint in the long-term as the land values rise.

4. MANAGEMENT OF ENVIRONMENTAL IMPACTS

4.1 INTRODUCTION

The aim of this section is to provide guidelines for management of environmental impacts and special management areas at Preston Industrial Estate.

4.2 FILL REQUIREMENTS

The estimated amount of fill required for industry is extensive – between 0.81m and 1.76m at the test bore locations and may be more or less at surrounding locations depending on the local undulations.

The groundwater table is likely to be dominated by local features such as wetlands, drains and the local thickness of the aquifer. Because the aquifer is thin, local features may have a significant influence on water table height and water quality. Rainfall events may also lead to rapid increases in groundwater level on a localised basis. A local groundwater survey on a finer grid that the one conducted for this project may be able to reduce the amount of fill by finding suitable local areas within the site that are already elevated above the water table or highlighting perched water tables that should be avoided on the site.

It is advisable that a geotechnical/environment investigation is undertaken for all sites prior to development to determine whether fill can be laid directly on the surface or whether some material must first be moved, particularly in areas where wetlands are being re-developed and peat might be present. In such cases, quantities of fill may increase considerably. If acid sulphate soils are present then an environmental management plan would be required for the earthworks to prevent environmental impact during works. Again this reinforces the importance of judiciously locating buildings on a site.

One alternative to using extensive amounts of fill is to build on higher ground. The higher areas tend to be the scattered Bassendean Sand Dunes in the east. However, the sand dunes were often not cleared by farmers as the soil is poor and prone to wind erosion. Hence, much of the good vegetation that remains in the area is on the high areas. However, construction of industry on higher areas outside the areas of preserved vegetation should be considered where this does not interfere with remnant vegetation.

Management Response:

- A local groundwater survey is recommended to locate perched water tables and refine the amounts of fill.
- All industries should undertake a geotechnical study prior to development to optimise fill requirements by carefully selecting the building location that gives the minimum fill and also ensures stability beneath buildings.
- Soil should be tested for the presence of acid sulphate soils prior to any construction works that involve soil disturbance and a management plan will be required if acid sulphate soils are present to prevent environmental impact during works.
- A minimum of 2 m separation distance is required between the AAMGL and industrial development.
- Encourage the siting industry on higher ground where possible, while minimising the clearing of areas of good vegetation (giving vegetation preservation a preference)

4.3 FLOODWAYS AND FLOOD FRINGES

The flood ways of the Preston and Ferguson Rivers must not be developed fo industry. However, any development in areas subject to fast flowing water would not be practical and would unlikely to be considered, except for road crossings and other essential infrastructure.

Development of the flood fringe is possible but development should be limited to industries that use few chemicals and do not have the potential to pollute ground or surface water since these areas will be occasionally inundated. Examples of possibly suitable industries include food processing, concrete manufacturing, timber milling and general light industries. Development of industries in the flood fringe should also be limited to minimise the impact on the extent of the flood upstream. This is likely to mean smaller industries rather than intensive development with large floor areas of factory.

As floodplain mapping has not been conducted for the Ferguson River, it is difficult to determine the extent of the 100-year flood on this river. The floodplain of the Ferguson River is assumed to lie within the 30 m buffer zone provided. Installation of data loggers, data collection for at least a year and a survey of representative cross-sections along the Ferguson River are required before calibrated flood modelling can be conducted.

Management Response:

- Limit development of the flood fringe to industries that have minimal potential to pollute ground or surface water and have a relatively small building footprint.
- Retain the floodway of the Preston and Ferguson Rivers as a reserve.
- Develop floodplain mapping of the Ferguson River prior to development of the flood fringe, including installation of data loggers, data collection and survey of representative cross-sections.

4.4 DRAINAGE

Department of Environment regulations recommend that 'clean' and 'dirty' stormwater from industrial sites are separated so that clean stormwater remains clean (DoE, 2004 b) and the pre-development water balance can be maintained. Stormwater discharge volumes should also be limited to the pre-development volume (WRC, 2002 b).

Swale-like drains are strongly recommended as they are shallow and can be vegetated to encourage nutrient removal from stormwater. This a key aspect of water sensitive design.

Dirty stormwater discharges from industrial estates should be treated to remove sediments, grease and oil prior to discharge to watercourses (DoE, 2004 b). A settling basin with a minimum capacity of the 2-year return frequency, 72-hour storm is usually required (DoE, 2004 b). This also helps to moderate the stormwater flow so that the peak discharge is no greater than the peak discharge pre-development.

Due to the high groundwater tables and underlying clay over much of the area, retaining stormwater on site may not always be possible. In these cases industry should be encouraged to connect to the existing drainage network. New drainage systems should be kept out of existing wetlands and where possible, above the groundwater table.

Currently there is no comprehensive stormwater management system for the Structure Plan area as it has not previously been the subject of forward service planning. The proposed management system includes two key aspects:

1. Individual developers treat the stormwater from developed parts of their land within their landholding prior to discharge to maintain quality and preserve the pre-development water balance; and

2. Control of stormwater quality over the entire Preston River Industrial Park by trapping and settlement of suspended matter, treatment for oil and grease and catchment maintenance at strategic points before flow discharges into wetlands or the Preston or Ferguson River systems.

The Water and Nutrient Management Plan **(WNMP)** for each development within should contain the following elements to maintain water quality and the water balance in the estate:

- Collect clean stormwater from rooves and hard stand areas and low permeability soils;

- Reuse, recycle and reduce the use of water from external sources in accordance with DPI's sustainability principles. The development plans should estimate the annual water requirements for the industry and present a water balance with items showing the sources and estimated off-site discharges from the process stream.

- Treat and discharge potentially contaminated stormwater. Industries are encouraged to reuse potentially contaminated stormwater and show in the water balance of the stormwater systems (as opposed to the industrial water system, although it is desirable that the two are connected) that there is sufficient on-site capacity to ensure that any increase in runoff associated with clearing roof / hard stand development is attenuated on site in some manner;

- Discharge treated water at a quality that meets all relevant licence conditions and guidelines, including the contaminated sites criteria, and a quality that improves the nutrient levels and pH.

- Target levels are the wetland guidelines, which are more stringent that the river guidelines:

  Total Persulpate Phosphorus – 0.03 mg/L

  Total Nitrogen – 1.5 mg/L

  pH – 7 to 8.5

- Construct stormwater systems in accordance with the Rational Method, as developed in Australian Rainfall and Runoff, and the current Department of Environment water guidelines.

- Aim to divert surface runoff past the industry without contamination where possible but discharge through a treatment system, such as vegetated swale, to reduced the nutrient levels by at least 40% in line with some of the targets being recently proposed elsewhere for integrated water management systems. The 40% target will be based on the annual average nutrient levels from the nine bores on the site. At this stages the targets are:

  Total Persulpate Phosphorus – 0.18 mg/L (40% reduction from 0.3 mg/L)

  Total Nitrogen – 1.9 mg/L (40% reduction from 3.2 mg/L)

- Design storage basins (integrated with swales systems where possible) to contain a minimum 1 in 10-year, 72-hour storm duration event, unless stormwater is being reused. In this case, sizing should be determined on a water balance approach;

- Use best practice storage procedures for chemical storage and stockpiles. This includes providing suitable bunding for tanks and diverting stormwater around stockpiles; and;

- Provide education and signage to inform employees of appropriate disposal of chemicals and that chemicals and contaminated waters should not be discharged to the stormwater system.

Management Response:

- Industrial developers are required to develop an annual water balance model as part of their development plan and show that the design incorporated the principles of reuse, recycling and reduction.
- It is advisable to evaluate the water sources available in Preston Park now and into the future on a district basis. This would include scheme water quantities, groundwater allocations, available waste water from nearby industry or sewerage treatment facilities and other possible sources.
- Industry developers must design methods to attenuate stormwater flow on-site to pre-development levels.
- Any discharge of industrial water from the site into the river or wetlands must be regularly tested and shown to be of a very high quality, meeting all relevant criteria and achieving the stringent wetland criteria for nutrients and pH.
- Industry must treat the stormwater from developed parts of their land prior to discharge and achieve 40% improvement in nutrient levels; and
- Control of stormwater quality by trapping and settlement of suspended matter, treatment for oil and grease and catchment maintenance will be done for the industrial park as a whole at strategic points, as required as development progresses.

4.5 VEGETATION

Four vegetation complexes were identified as occurring in the Preston Industrial Park study area. Within the Greater Bunbury Region the EPA (2002) lists the Karakatta – Central and South vegetation complex as having greater than the recommended 30% remaining and the other complexes, (Southern River, Swan and Guildford) as having 20% or less remaining. However within the entire Swan Coastal Plain less than 30% remains of the original areas of Karakatta – Central and South, Bassendean Central and South, Southern River, Serpentine River, Swan and Guildford Complexes. The objective of the Commonwealth of Australia (2001) and the EPA is to retain 30% or more of the pre-clearing extent of each ecological community if the biodiversity is to be protected.

Therefore all the remnant vegetation within the Preston Industrial area of a good or better condition should be retained.

The lowest size limit given for maintaining ecological processes is 20ha (EPA, 2002). Very few sections of remnant bushland in good or better condition are of this size.

It is strongly recommended that the South West Development Commission retain Lot 4 on the Australind Bypass as natural bushland. This area forms an aesthetic entrance to the City of Bunbury and forms a pleasant outlook for the entrance to Eaton, which is on the northern side of the bypass. In addition this bushland is in very good condition, with a variety of different trees and species, including the priority flora *Acacia flagelliformis* and *Verticordia attenuata*. It also hides the power lines, which traverse the countryside to the south of the Australind Bypass Road. Small areas of significant wetland would also be included as a result. The cadastral lot has been set aside in this case because it closely matches the vegetated area and it is identified on **Figure 19** as "Vegetation Reserve".

The "Vegetation Reserve" area should not be developed and the shire should invest in maintaining the bushland for the visual amenity of the area.

Moore Road (Lots 1, 5 and 7) has a reasonable sized remnant bushland, mostly on higher ground. Some of this land has already been proposed for the Bunbury Bypass Road and some for a motorcross track. Lot 4 owned by the Southwest Development Commission also includes vegetation in good or better location, but the powerline crosses this area and there are old tanks adjoining the area where dieback of the Banksia trees is obvious. These areas have been identified on **Figure 19** as an area for "Vegetation Reserve with Easements." A small area of lower vegetation quality between two lots has been included to provide one continuous area.

The other bushland area of reasonable size is that adjoining the old railway line and Moore Road, Lot 1. This includes the Closed Heath of *Pericalymma ellipticum* and *Hakea varia* over a Sedgeland of *Lepidosperma longitudinale* with emergent *Melaleuca preissiana,* an area of palusplain. In addition plants of the priority flora *Acacia flagelliformis, Verticordia attenuata* and *Jacksonia sparsa* would be protected if this area was conserved. The area includes representation of uplands and wetlands. Areas which contain both ecological community groups, support the highest biodiversity and are a focus for protection. This is included in the area "Vegetation Reserve with Easements".

The area of high quality vegetation, "Vegetation Reserve with Easements", is already is earmarked for some development. Any further development should avoided in the short-term and this area should be developed last within the industrial park, if at all. By that time, some of the other developments will have

enhanced the lower quality vegetation areas as part of the condition of development in those areas.

The areas with some vegetation of at least good quality are shown on **Figure 18**. These are areas that should be developed in preference to the vegetation areas of higher quality shown on **Figure 19**. However, they still contain vegetation complexes that are below target levels across the state. We therefore recommend that a botanist advises developers of the best part of the vegetation on their site and these parts are preserved. In addition, any clearing of vegetation will be accompanied by a commitment to a long-term program to enhance the quality of vegetation in an area of at least equivalent area within the site.

Management Response:

- The vegetation on Lot 4 on the Australind Bypass, labelled "Vegetation Reserve", represents the best large area of vegetation and should be preserved for its quality and visual amenity. It should possibly be vested in a government body and maintained by the local shire.
- The largest area of remnant vegetation along Moore Road, labelled "Vegetation Reserve with Easements", should have any further development delayed until all other possibly areas of the industrial park are developed.
- The other vegetation areas highlighted in Figure 18, but not in Figure 19, should be preferentially developed with the best vegetation areas on the site preserved and any clearing conditional on a commitment to a long-term program to enhance vegetation across at least an equal area of the site.

4.6 WETLANDS AND RIPARIAN ZONES

The eleven wetlands with significant natural attributes and the riparian zones of the Preston and Ferguson Rivers should be conserved and consideration given to vest in a government body. Some of these are in areas already set aside for preservation of vegetation, however the wetland restrictions are more formal and stringent. They will encompass the vegetation requirements and add more constraint. The wetlands areas are therefore plotted over the vegetation areas in **Figure 19.**

To avoid potential impact from industry, riparian buffer zones should be created around the wetlands and sections of the Preston and Ferguson Rivers identified as having significant natural attributes.

The buffers between these areas and development generally should be 200m, unless it can be shown that the industry is unlikely to have impact on the wetland.

A minimum buffer of 50m is required between wetlands and industry (Government of Western Australia, 2000).

There is one Conservation Category wetland, also an EPP wetland, amongst the 11 to be presented and it is north of the South Western Highway. This wetland is labelled "Conservation and EPP Wetlands" and it is unlikely that development can occur in the buffer of this wetland. The EPP wetland in the Reserved area on the Australind Bypass should also be retained and the vegetation enhanced.

There is another small wetland close to the Ferguson River that is an EPP wetland that warrants retention and this is labelled as "EPP Wetlands – Preservation". An EPP classification is a federal classification and usually indicates a high quality wetland. There is also a nearby Resource Enhancement wetland labelled "Resource Enhancement – Preservation". The aim for a Resource Enhancement wetland is to restore the wetland to a Conservation Category. Both EPP and Resource Enhancement wetlands will have similar, but a little different restrictions to the Conservation Category wetland.

Of the remaining well-vegetated wetland areas, the rest are classified as Multiple Use Category wetlands, which permits some development within the buffer while still recognising the value of the wetland. There are seven of these and they are labelled "Multiple Use Wetland – Preservation". The condition associated with this category of wetland is,

> *"Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. Should be considered in strategic planning (e.g. drainage, town/land use planning)."* (Department of Environmental Protection, 1993 and Water and Rivers Commission, 1991)

There are a number of wetlands on this site that have Conservation, Resource Enhancement or EPP status, but there is not currently a wetland vegetation community. These wetlands have all been labelled as "Re-evaluation" on **Figure 19**. We would recommend applying to the Department of Environment have these wetlands evaluated, using the botanical work already done as part of the supporting documentation and photos of each specific wetland. It is likely that they would be reclassified to Multiple Use category or the classification removed.

Other riparian buffer zones should be a minimum of 30 m wide or the width of the flood way, whichever is greatest. The riparian zone should include wetlands associated with the river. Development should not isolate floodplain wetlands from the river but aim to reconnect them through revegetation and rehabilitation.

As the riparian zones of both rivers are degraded, revegetation programs should be undertaken to assist with the management of nutrient and erosion issues. Revegetation of riparian zones will also provide a visual buffer for the area.

It appears that responsibility for maintenance of the riparian vegetation is not well defined. One option is to vest wetland riparian buffer areas with the council or another suitable government body as a park. This allows for consistent, well-planned conservation measures to be put in place for these areas. This would ideally include revegetation and restricting stock access to rivers and wetlands. In addition, vesting the area as a park allows space for public access and recreation. Alternatively, conservation covenants with willing landowners may be considered.

Management Response:

- No development will be likely to allowed in the buffers of EPP, Conservation Category or Resource Enhancement wetlands earmarked for preservation (three in total).
- Significant wetlands require a minimum 50m buffer and may require 200m.
- 200m wide buffers should be provided for the wetlands and rivers with significant natural vegetation, unless it can be shown that a particular industry will not affect the wetland.
- A rehabilitation plan should be included by developers who have a Resource Enhancement wetland on the site, or if they fringe the Ferguson or Preston Rivers.
- Developers with a wetland of conservation status should include a maintenance program in their development plan.
- Only the well-vegetated Multiple Use wetlands should be retains in the development plan (eight in total).
- Development is allowed in the buffers of Multiple Use wetlands.
- A buffer of 30 m or the width of the floodway should be provided for areas of the Preston and Ferguson Rivers not requiring a 200m buffer (i.e. those where there is no adjacent wetland on the flood fringe).
- The potential to vest riparian and wetland zones in a government body should be investigated.
- There are a number of Conservation Category, EPP and Resources Enhancement wetlands that warrant re-evaluation. Applications should be made to the Department of Environment using the botanical report (while still current) and photographs of each wetland as supporting documents. It is likely that these areas can be reclassified and developed.

4.7 LIQUID WASTE

Further industrial development of the Industrial Estate should not occur without deep sewerage.

There are already a number of industries, farms and houses in the area that do not have access to sewerage. Deep sewerage is generally considered cost prohibitive in rural areas but will become more cost-effective as Bunbury develops and land prices rise. As sewerage is developed for new industries, other industries and land users should be required to connect to the scheme.

Individual developers should treat their liquid waste on site prior to discharge. Stringent water quality criteria will apply. Industry should only be permitted to discharge treated water at a quality that meets all relevant licence conditions and guidelines, including the contaminated sites criteria, and a quality that improves the nutrient levels and pH. Target levels are the wetland guidelines, which are more stringent that the river guidelines:

- Total Persulpate Phosphorus – 0.03 mg/L
- Total Nitrogen – 1.5 mg/L
- pH – 7 to 8.5

Management Response:

- Industrial development shall not occur without deep sewerage.
- A very high standard of industrial water treatment is set for the industrial park, requiring individual industries to regularly monitor (at least three monthly) and meet all relevant guidelines and improve the nutrient levels and pH to stringent wetland standards.

5. MANAGEMENT ZONES

Preston Industrial Estate can proceed without significant environmental impact if the issues can be managed properly. The major issues for the site are the high groundwater table, management of conservation areas and liquid waste disposal. However, other water and vegetation issues also require careful attention. To manage the site, a number of zones have been developed **(Figures 18 and 19).** These include:

- **Vegetation and Wetland Preservation zones** including high conservation value wetlands and high quality bushland. These zones will be conserved and not developed. Consideration should be given to vesting these areas with suitable government bodies. These areas have a range of slightly different management requirements depending on the category and are shown on **Figure 19.**

- **Flood fringe zones** where limited, non-groundwater polluting industries may be allowed. These areas are coloured blue on **Figure 19.**

- **Seasonally inundated or waterlogged zones** that do not have conservation status are areas that are generally only suitable for development if areas of building are elevated by imported fill. These areas are coloured pale green / yellow on **Figure 19.**

  The extent of seasonal inundation or waterlogging can be difficult to determine without detailed studies. If an area is seasonally waterlogged but the DoE is satisfied, then development can be undertaken without negative impacts on the environment and it would likely be permitted.

- **Wetland and riparian buffer zones.** A 200m buffer has been placed around all Conservation/EPP/Resource Enhancement wetlands and th better quality stretches of river. A 30m buffer has been used on riparian areas in poor condition. However, these buffers may be negotiable depending on the land use involved. A minimum 50m buffer is required for wetlands, including sections of the Preston and Ferguson Rivers in good condition. The 200m zones areas have been hatched on **Figure 19.**

  Wetland and riparian buffer zones may also be constrained by other issues (e.g. seasonal inundation). All these factors need to be taken into account when determining the land use.

- The rest of the site will be considered an **unconstrained zone** where development is allowed on the conditions that issues of stormwater, wastewater and depth to groundwater are managed appropriately. Development should take place preferentially where depth to

groundwater is greater and access to sewers is more readily available. The unconstrained area is coloured pink/mauve on **Figure 19.**

To ensure that water resource issues are properly addressed, conditions for all industries include:

- All industries must undertake a site-specific hydrogeological /geotechnical study and test for acid sulphate soils prior to development to resolve potential issues of acid sulphate soils, depth to groundwater and refine fill requirements;
- All industries must do a site-specific Water and Nutrient Management Plan (WNMP), as set out in this document;
- A minimum of 2 m separation distance is required between the AAMGL and industrial development;
- Land should be progressively released with the poorer vegetation areas first and proposals by industries for vegetation clearing should be accompanied with a long-term commitment to rehabilitate at least an equal area on the same site.
- Stormwater quality should be controlled by trapping and settlement of suspended matter, treatment for oil and grease and catchment maintenance if required; and
- New development must be connected to deep sewerage.

Prior to industrial development of the area, a number of issues should be resolved:

- The floodplain of the Ferguson River should be mapped by going through a process of data collection and modelling;
- Consideration should be given to vesting conservation areas in an appropriate government body;
- Available water sources should be determined for the industrial park;
- DPI should apply to the Department of Environment to have a number of wetlands re-evaluated; and
- Planning should be undertaken for deep sewerage in the areas to be developed.

	Industrial Development Allowed?	Fill required for industry?	Deep sewerage and stormwater protection required?	Rehabiliation or Maintenance Plan required?
Vegetation Reserve	Not until other vegetation restored	N/A	N/A	N/A
Vegetation – Poorer Condition	Yes	Yes, to 2 m above AAMGL	Yes	Yes
Conservation Categories, EPP and Resource Enhance Wetlands – Preservation	No	N/A	Possibly, if part of a larger area that can be developed	Possibly, if part of a larger area that can be developed
Multiple Use Wetlands – Preservation	Yes	Yes, to 2 m above AAMGL	Yes	No
Flood fringe zones	Conditional	Yes, to 0.5 m above 100 year flood level and 2 m above AAMGL	Yes	Yes
Wetland and riparian buffer zones	Negotiable, depending on nature of wetland and industry. A minimum 50 m.	Yes, to 2 m above AAMGL	Yes	Yes
Seasonally inundated and waterlogged zones	Yes	Yes, to 2 m above AAMGL	Yes	No
Unconstrained zones	Yes	No	Yes	No

Table 14: Constraints for different parts of the Preston Industrial Estate.

6. CONCLUSIONS

The main drivers in the Preston area are the perched water table, the river system and the valuable wetland and remnant vegetation areas. The high perched water table supports the wetland systems for the area. While the water may appear to be of low quality, care should be taken to ensure that the quality and quantity of groundwater is maintained and not compromised by drainage or waste discharge. The following issues are key to maintaining this environmental resource.

- Providing adequate buffers for wetlands, drains and rivers;
- Avoiding unsuitable construction in floodplain areas;
- Ensuring that adequate fill is used in areas with high water tables;
- Providing wastewater treatment of both stormwater and industrial water; and
- Preserving native vegetation.

While most of the Preston area has been cleared, pockets of good vegetation and wetlands with conservation value remain. Despite the degradation of the rivers, these are still an environmental resource. Areas of good vegetation, wetlands and riparian zones should be preserved, enhanced where possible and protected by either vesting in an appropriate body or conservation covenants.

The main constraint on the Preston Industrial Park is the high water table over much of the site, although as land prices rise, the cost of fill will be less of a constraint. Fill can be minimised in a number of ways, as discussed in this document.

A large portion of the site is seasonally waterlogged or inundated. A number of wetlands also occur on the area. The best spots for industry are on the higher land in the south-east and north-west of the site. However, the higher areas often have the best vegetation and lower areas should be developed preferentially looking for locally developed areas.

By proposing a reasonably complicated approach to managing constraints on the Preston Park site and incorporating many best practice strategies, a large portion of the land can be released for development while still respecting the environmental values.

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FIGURES

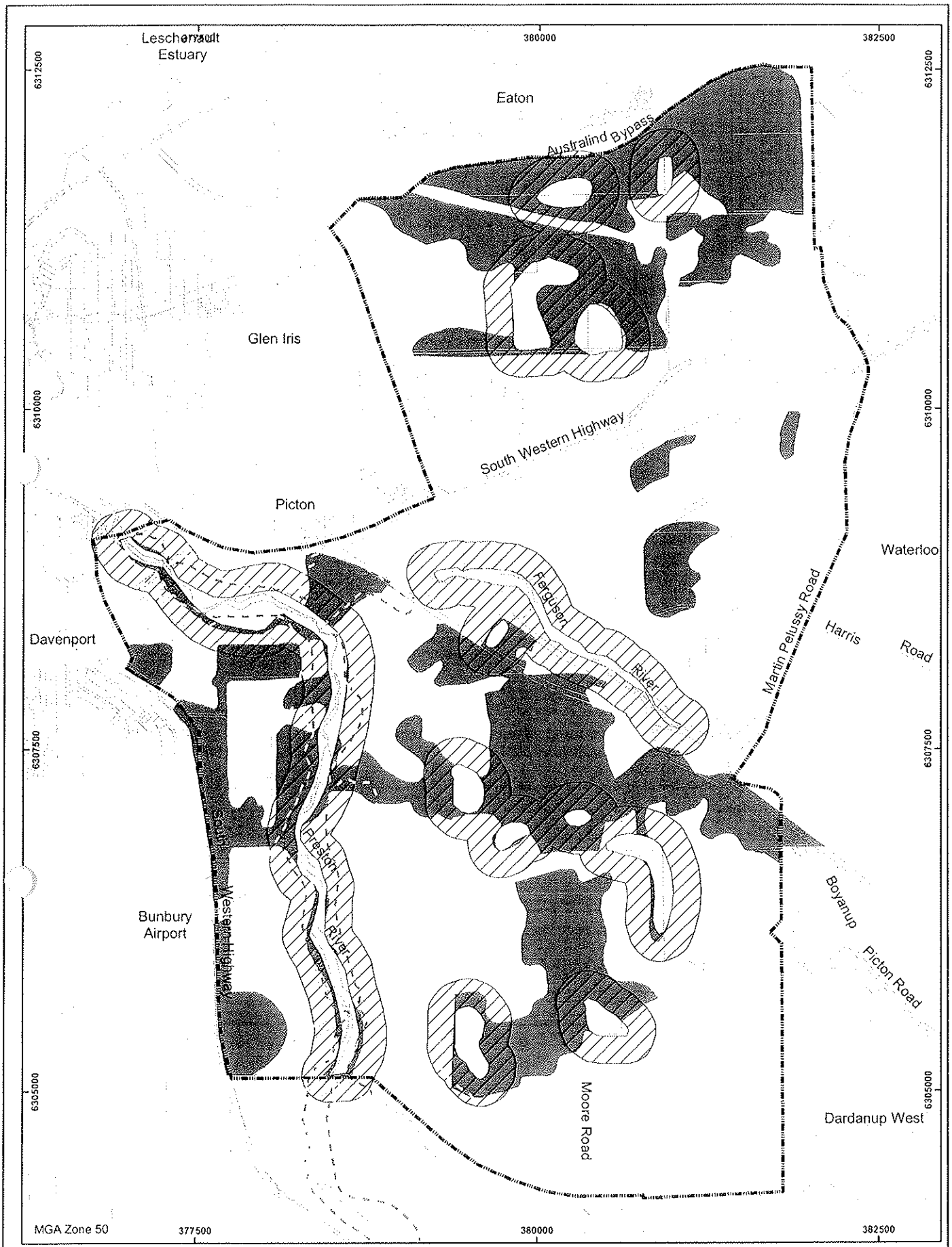
APPENDIX A

APPENDIX B

Soil Map Unit Name	Soil Description
Bassendean B1 phase	Deep bleached grey sands with an intensely coloured yellow B horizon occurring within 1 m of the surface.
Bassendean B1a phase	Deep or very deep grey siliceous sands.
Bassendean B1b phase	Variable acidic mottled yellow and grey duplex soils becoming alkaline with depth.
Bassendean B2 phase	Deep acidic mottled yellow duplex soils. Moderately deep pale sand to loamy sand over clay
Bassendean B3 phase	Moderately deep to deep sands over mottled clays. These may be acidic or less commonly alkaline grey and yellow duplex soils
Bassendean B4 phase	Uniform friable brown loams, or well structured gradational brown earths.
Bassendean B5 phase	Deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay
Bassendean B6 phase	Deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay
Bassendean wet, swamp phase	Moderately deep to deep sands over mottled clays. These may be acidic or less commonly alkaline grey and yellow duplex soils
Pinjarra P10 phase	Variable acidic mottled yellow and grey duplex soils.
Pinjarra P1a phase	Deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay
Pinjarra P1b phase	Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
Pinjarra P2 phase	Wet soils (Pale deep sands and peaty sands)
Pinjarra P3 phase	Uniform friable brown loams, or well structured gradational brown earths.
Pinjarra P5a phase	Deep alkaline mottled yellow duplex soils which generally consist of shallow pale sand to sandy loam over clay.

Pinjarra P6a phase	Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
Pinjarra P6b phase	Deep bleached grey sands with an intensely coloured yellow B horizon occurring within 1 m of the surface.
Pinjarra P6c phase	Deep or very deep grey siliceous sands.
Pinjarra P7 phase	Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at generally > 2m
Pinjarra P7a phase	Deep bleached grey sands with an intensely coloured yellow B horizon occurring within 1 m of the surface.
Pinjarra P8 phase	Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at generally > 2m
Pinjarra P9 phase	Deep acidic mottled yellow duplex soils. Moderately deep pale sand to loamy sand over clay
Pinjarra, B1 phase	Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
Pinjarra, B1a phase	Deep or very deep grey siliceous sands.
Pinjarra, B1b phase	Deep acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface
Pinjarra, B2 phase	Bleached or pale sands with a yellow-brown or pale brown subsoil (like S1c).
Pinjarra, B6 phase	Deep acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface
Spearwood S1c phase	Deep acidic mottled yellow duplex soils. Moderately deep pale sand to loamy sand over clay
Spearwood S2c phase	Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths

APPENDIX C



Legend

- Study Area Boundary
- Cadastral Boundaries
- Preston River Floodway
- Preston River Flood Fringe
- Wetlands & Riparian Zones
- 200m Buffer - Wetlands & Riparian Zones
- Condition 1-4 Vegetation (inc 3-4)
- Areas Subject to Inundation/Waterlogging

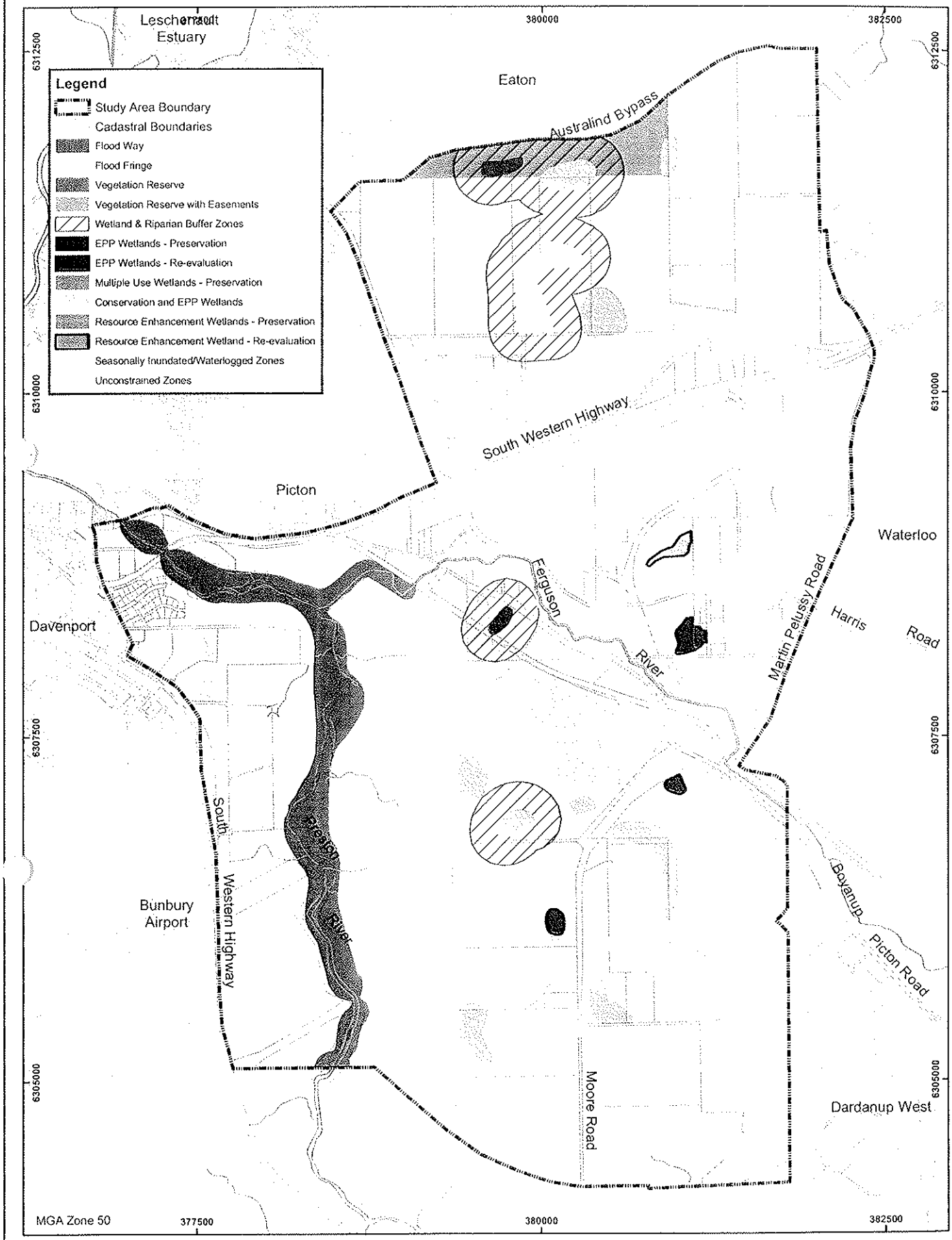
env

DRAWN G Harewood
DATE Feb 2005
SCALE 1:25,000
REF

Department of Planning and Infrastructure
Preston Industrial Park Structure Plan
Water Resources and Vegetation Management Strategy

Figure 18:
Vegetation, Riparian & Wetland Constraints

Figure 18



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Preston Industrial Park Structure Plan
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Figure 19: Development Constraints

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DATE	Feb 2005
SCALE	1:25 000
REF	Figure. 19