Town Planning Management Engineering

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Serpentine Jarrahdale Shire

West Mundijong

District Water Management Strategy

February 2013

Project Management Planning Environmental Engineering

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EXECUTIVE SUMMARY

The West Mundijong Industrial Area District Water Management Strategy (DWMS) has been prepared to support the industrial rezoning of the subject land. The subject land is bounded by Mundijong Road (south), Tonkin Highway Road reserve (east), Bishop Road (north) and Kargotich Road (west). It is approximately 474 hectares in area. The land is approximately 1.5km west of the existing Mundijong town site (see Figure 1).

The subject land has a number of minor water courses that either traverse or begin on the site. This includes waterways that begin on the scarp to the east. All water leaving the site via the surface, flows under Kargotich Road and into Oakland's drain, which flows southward. A small section of one of the waterways (Manjedal Brook) is considered a Conservation Category wetland. Around 80% of the remainder of the site is also considered Multiple Use wetland.

The majority of the site has been cleared and is composed of pastures. The remaining native vegetation on the site is degraded. It is usually composed of native overstorey species with none or limited native understorey.

Historically the land has been used for broad acre agricultural purposes, and currently is used for livestock grazing purposes. There are a number of dwellings on the subject land, especially in the rural residential section in the south east corner.

The future Tonkin Highway and rail line are located along the eastern boundary. This area may also include an intermodal area.

The DWMS has been prepared to satisfy the Better Urban Water Management guidelines that require a DWMS to support the rezoning of part of the subject land from 'Rural' to 'Industrial'.

The objective of the DWMS is to demonstrate how a best management practices approach will achieve the principles, objectives and requirements of total water cycle management. The constraints of the site, proposed land use and surrounding environment have all been investigated to determine potential issues and outline potential strategies to manage, protect and conserve the total water cycle of the local environment and the greater catchment. The strategies include:

- Integrate water sensitive urban designs (WSUD) into the development and surrounding landscape;
- Achieve water quality targets entering surrounding waterways and the groundwater resource;
- Manage water quantity and flooding for the industrial development and hydrological regimes;
- Manage the groundwater resource with close to source treatment trains and to minimise the required fill;
- Investigate opportunities for stormwater, superficial groundwater and greywater harvesting and reuse;
- Investigate innovative schemes for Industrial wastewater management;
- Protect associated ecosystems dependent on water resources from the development; and
- Investigate practical methods to reduce potable water demand.

The effectiveness, efficiency and benefits provided by the best management practices will require a collaborative effort between local governments, developers and relevant regulatory authorities.

Cleared rural land with isolated trees typical of the subject land

SUPPORTING DOCUMENTATION

The DWMS was compiled using information contained within the detailed assessments and reports undertaken for the subject land. These reports listed below have been included on the enclosed CD accompanying the DWMS.

- TME. 2012. *West Mundijong Industrial Area Fill Analysis.*
- TME. 2012. *West Mundijong Industrial Area Feasibility Study.*
- PGV Environmental. 2012. *West Mundijong Industrial Area Environmental Assessment.*
- TME. 2012. *Drainage modelling - HECRAS and DRAINS*

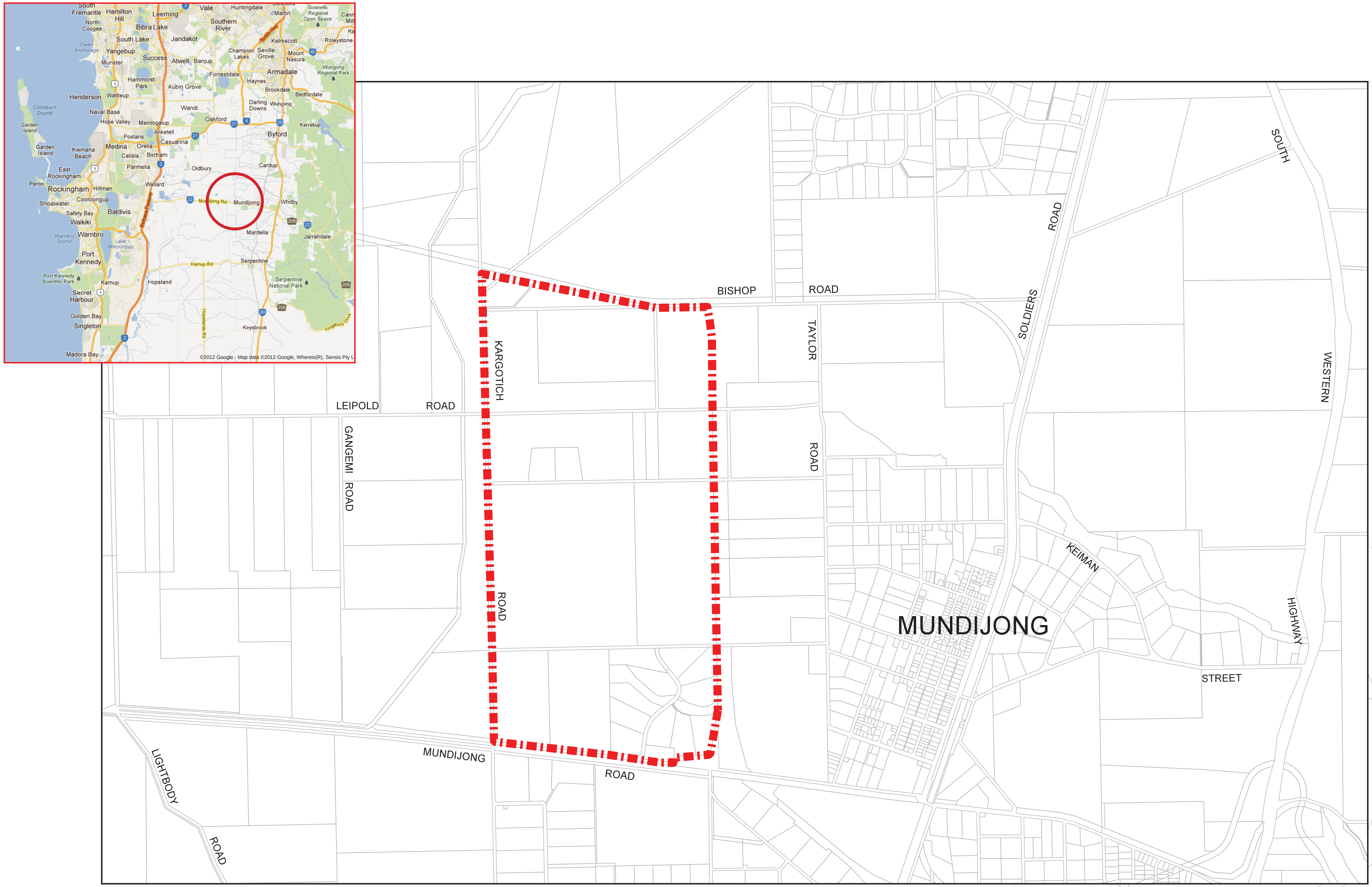


Figure 1 - Location Map

1 - PLANNING SUMMARY

PLANNING FRAMEWORK

Zoning and reservations

The land is currently zoned 'Rural' in the Metropolitan Region Scheme. With respect to adjoining and nearby land the following should be noted:

a) Mundijong Road, adjoining the southern boundary, is a designated 'other regional road'

b) The portion of Mundijong Road is also designated 'bush forever area'

c) Land adjoining the eastern boundary is designated 'primary regional road' in lieu of the southern extension of the Tonkin Highway; and

d) The primary regional road reserve allows for future intersection treatment to Mundijong Road and grade separation of the freight rail line

Refer *Figure 2*

In terms of the Serpentine Jarrahdale Shire's (the Shire) Town Planning Scheme No. 2, the land is included within the following zones:

a) 'Farmlet' zone; and
b) 'Rural' zone.

There are two main areas zoned 'Farmlet' within the structure plan area. One is located in the south east and associated with Pure Steel Lane. The area has been subdivided into 4 hectare allotments and accordingly developed for a range of rural lifestyle pursuits.

The other area adjoins Kargotich Road. Currently no subdivision approval has been issued for this area, although a subdivision guideline plan did accompany the relevant amendment to include the land within the 'Farmlet' zone.

In addition the Scheme identifies an 'area of natural beauty' (No. 33) which bisects the land east west. The following description is provided in Appendix 13:

33. MANJEDAL BROOK
From its source East of Nettleton Road along its length to Kargotich Road.

In relation to areas of natural beauty Clause 7.12.2 of the Scheme states:

A person shall not without the approval of Council at or on a place described in Appendix 13 carry out any development including, but without limiting the generality of the foregoing:

(a) the erection, demolition or alteration of any building or structure (not including farm fencing, wells, bore or troughs and minor drainage works ancillary to the general rural pursuits in the locality);

(b) the clearing of land or removal of trees; or

(c) the erection of advertising signs.

The status of Manjedal Brook is discussed in further detail below.

Key Findings

a) The Metropolitan Region Scheme (MRS) facilitates significant future infrastructure upgrades of critical importance to future industry, including the extension of the Tonkin Highway and the upgrading of Mundijong Road;

b) In order to facilitate industrial development, the MRS will require an amendment to include the land in the 'Industry' zone; and

c) The opportunity, via subsequent structure planning, to incorporate Manjedal Brook as an 'ecological corridor' that also continues to provide a valuable drainage function for the district and future industrial development.

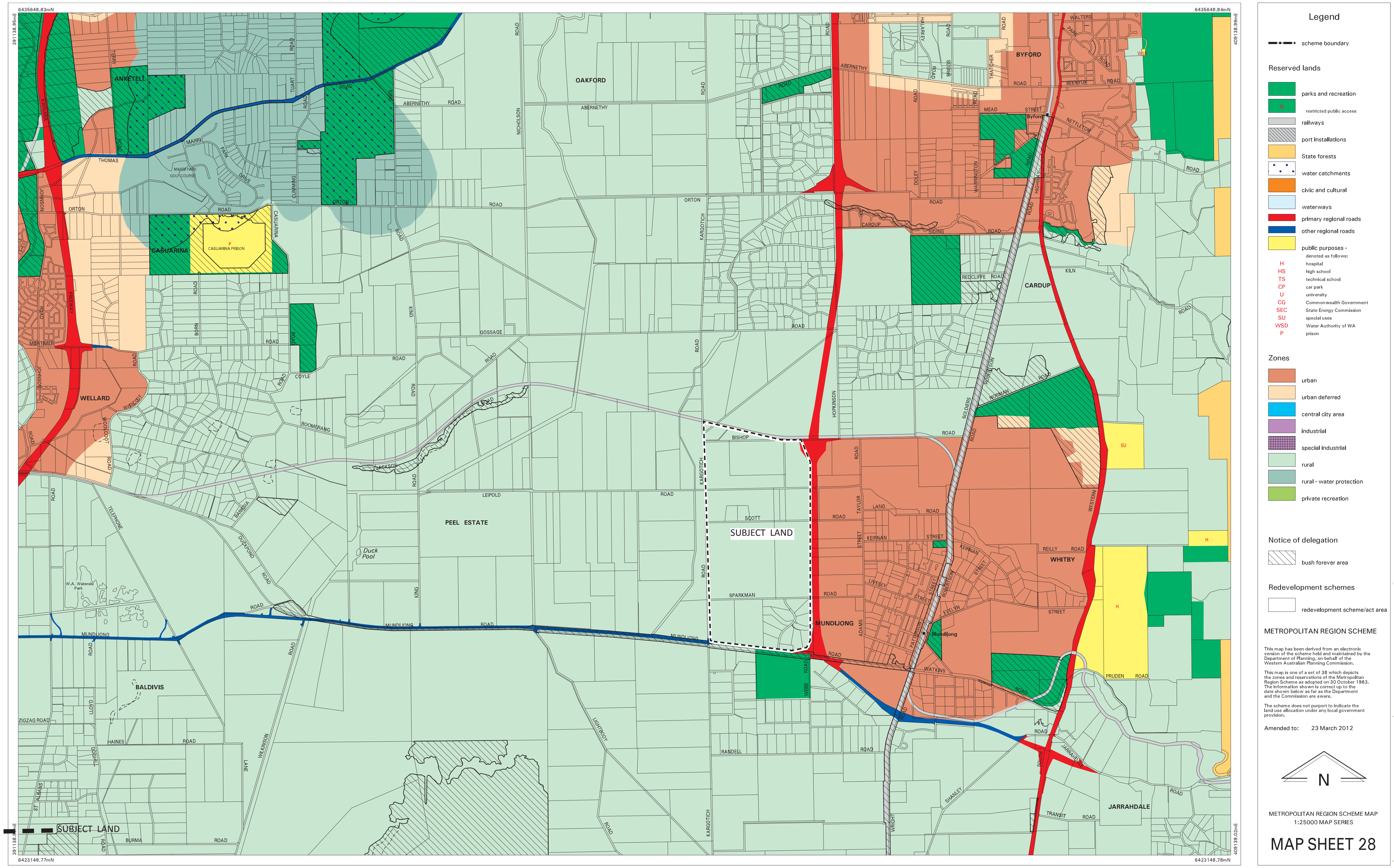
PURPOSE OF DISTRICT WATER MANAGEMENT STRATEGY

The DWMS will support the development of a District Structure Plan (DSP) for West Mundijong. The DSP will be a strategic document which justifies rezoning of the land in 'Industry' in the Metropolitan Region Scheme.

On Page 5 *Figure 2's* inset shows the current zoning of the land under the MRS.

It is proposed that the development will predominantly support general and light industry. Any heavy industry sites will be limited and need to satisfy planning, site and environmental conditions for their consideration.

Typical Flat Plain on Subject Land



METROPOLITAN REGION SCHEME MAP

SCALE 1:25000

Figure 2 - Existing M.R.S Zoning

2 - KEY ELEMENTS

Water management strategies for the subject land are based on best practice water sensitive designs that suit the site's constraints. They also provide recognition of the importance of water as a resource across the entire development and surrounding environment. Specific constraints and threats identified for the subject land are discussed in Section 9, and listed below:

CONSTRAINTS AND THREATS

- Wetlands (and associated buffers).
- Waterways/drainage lines and associated flooding.
- High groundwater levels and potential quality issues.
- Acid sulphate soils (ASS) risk.
- Stormwater runoff contaminants from on site and upstream land uses.
- Cost to deliver suitable wastewater disposal and greywater reuse schemes.
- Cost to deliver potable water supply.

OPPORTUNITIES AND MANAGEMENT OPTIONS

The recommended strategies provide an integrated approach through the synthesis of industrial planning and designs to manage, protect and conserve the total water cycle. The plans and designs for the development are appropriate for the subject land's development constraints and unique surrounding environment and providing a sustainable industrial estate.

A summary of the key best water management practice elements that are recommended for implementation within the development to achieve best management practices are outlined below, and visually represented in *Figure 3 page 7*:

WATER QUALITY AND ENVIRONMENTAL PROTECTION

- Establishment of appropriate management practices for foreshore reserves and wetlands along Manjedal Brook.
- Utilisation of water sensitive designs, including bioretention gardens, basins, swales, and flow spreader devices to capture, detain, treat and convey all development runoff.
- Investigation of building design guidelines that encourage structural separation of potentially polluted runoff in work areas from the stormwater runoff pathways.
- Providing lot owners with information relating to the establishment and maintenance of water wise and nutrient wise gardens in their required landscape areas on each development.
- Encourage non-structural best management practices.
- The pre development monitoring of groundwater and surface water quality to establish benchmarks and identify any potential issues.
- The monitoring of storm water outflow rates and quality post-development.

STORMWATER MANAGEMENT AND FLOOD PROTECTION

- Utilisation of best practice to treat, store, convey, control and discharge stormwater runoff;
- Lot storage and treatment of all runoff from the 1 year 1 hour event on the lot.
- Storage and treatment of the 1 year 1 hour event in road reserves; and
- Post development monitoring of water quality.
- No development to be within the 100 year flood ways of the subject land waterways.
- All finished floor levels on lots to be designed to maintain a minimum separation clearance of 500mm to the 1:100 year flood levels of the Manjedal Brook, Oaklands Drain and all flood storage areas.
- All habitable floor levels on lots to be designed to maintain a minimum separation clearance of 300mm to the internal 1:100 year average recurrence interval (ARI) flood levels.
- Protection of buildings and infrastructure with conveyance and storage of flood waters via the open and piped drainage network and road reserves.
- Discharge of 1:10 year flow rates from the site is not to exceed pre development flow rates.
- Discharge of 1:100 year flood flow rates from the site is not to exceed pre development flow rates.
- Storage of predevelopment flood volumes as well as the extra post development runoff, to control downstream flooding.

GROUNDWATER MANAGEMENT

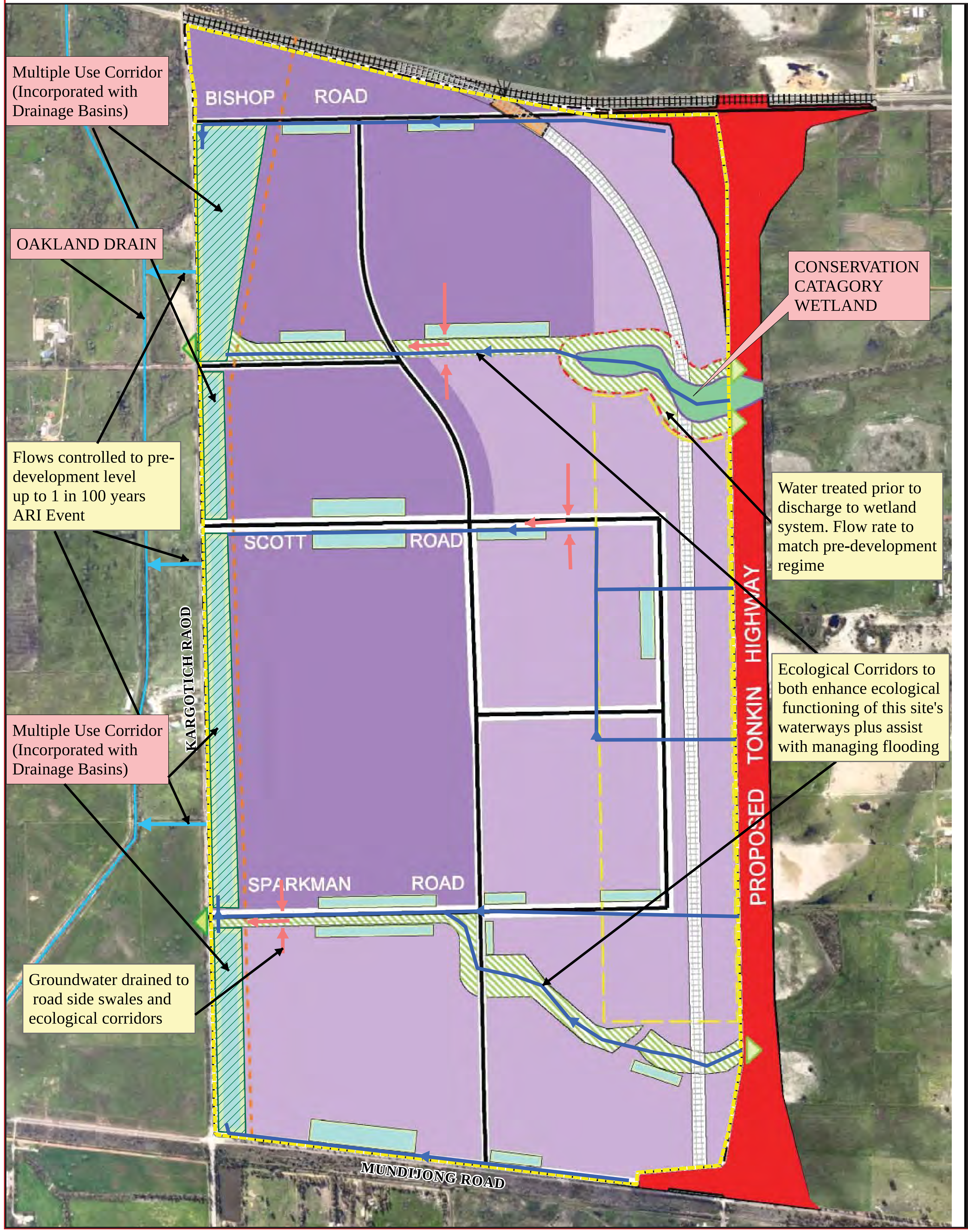
- Ensure development has no negative impact on the groundwater resource, or ecosystems dependent on the resource.
- Filling building and infrastructure sites where necessary so that there is an appropriate clearance to the controlled groundwater level (CGL).
- The installation of a sub-soil drainage pipe network and swale systems at the proposed CGL to control groundwater from rising above this level.
- Treatment of controlled groundwater and the stormwater runoff infiltration via planted swales and basins.
- The monitoring of the groundwater quality and levels across the subject land post development to identify any future detrimental impacts on the groundwater resource.
- There is potential to harvest excess superficial groundwater for use on site or nearby.

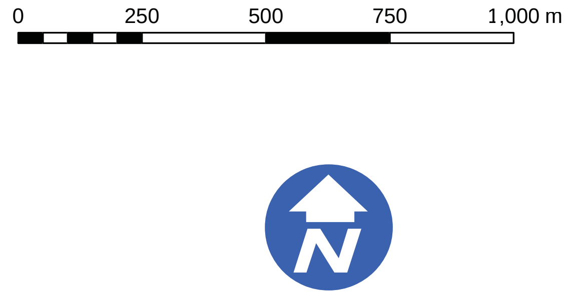
WATER CONSERVATION AND SERVICING

- Development to be connected to a reticulated water supply (most likely Water Corporation);
- Encourage water efficient fixtures and fittings for all buildings constructed.
- Encourage lot owners to install a suitable rainwater tank. The tank size will be dependent on the roof area and water usage patterns of the business.
- Encourage greywater reuse schemes for landscape irrigation and business related purposes.
- Public areas, bioretention units and street landscaping will have a strong focus on using locally suitable native water wise species and use of soil amendments to reduce irrigation requirements.
- A reticulated wastewater service is to be supplied, with the potential for some wastewater types to be reused on site or nearby following appropriate treatment.

OTHER ASPECTS

- Future investigations and liaison are to take place with the Department of Indigenous Affairs (DIA) prior to construction, if required, for sites of significance.





Legend

- Oakland Drain
- Major Surface Flow Outlet Points
- Indicative major post-development drainage lines
- Localised Ground Flow Direction
- Multiple Use Corridor
- Subject Land
- Indicative Post-Development Drainage and Flood Storage Area(10 Years ARI)
- Indicative Post-Development Drainage and Flood Storage Basin to maintain 1 in 100 Years ARI Pre-development flow
- General Industry
- Light Industry
- Indicative Ecological Linkage
- Possible Intermodel Facility
- 330 V Power Lines
- Buffers
- Major Roads

Figure 3 - Key Elements Plan

3 – LANDFORM & SOILS

The subject land is located on the Swan Coastal Plain and the landforms are typical of this area. The land is composed of three (3) main landforms, which are shown in *Figure 4 Page 9* and described below.

Figure 4 Page 9 displays contour information derived for the subject land from LiDAR (Light Detection and Ranging data) modelling.

1. **Wet Flats** – The majority of the site is a mildly sloping wet plain. This landform slopes downwards from east to west with a fall from 25-26mAHD to 16mAHD. The slopes vary between 0.2 and 1% with the slope generally flattening towards the west. These flats are generally sands over loams and clays. The low slopes and predominately sandy surface of this landform produces a low runoff rate until the land becomes waterlogged. These areas are classified as wetlands.
2. **Sand Rises/Ridges** – Low Bassendean sand ridges are located sporadically across the subject land. These are low relief dunes with deep bleached grey sands. The sand ridges rise between 2m and 6m above the surrounding plain with the peaks being up to 27mAHD. The slopes vary from 1 to 5% on the sides of the ridges. The sandy nature of this landform produces a low runoff rate, with most water infiltrating into the soil profile.
3. **Waterways** - There are also a number of minor waterways that traverse or begin on the subject land. Many of these have been modified through drainage works. The largest of these waterways is known as Manjedal Brook. The waterways/drains tend to be incised within the wet flats landform. It is likely that historically these waterways were considerably more braided and less defined.

Shallow Drainage Line

4 – GEOTECHNICAL

GEOLOGY

The superficial formations over the land consist predominately of Pinjarra System alluvial soils overlaid with aeolian Bassendean System sands.

The Pinjarra soils are likely to have a high Phosphorus Retention Index (PRI) while the Bassendean sands are likely to have a low PRI. There is a need for a geotechnical investigation of the site to be undertaken as part of later planning for the area.

CONTAMINATED SITES

An analysis of the Department of Environment and Conservation's (DEC) Contaminated Sites database was undertaken on 9th July 2012, and no known sites were found on the subject land or in the near vicinity.

ACID SULPHATE SOILS (ASS)

The DEC ASS mapping for the Swan Coastal Plan has modelled the whole subject land as moderate to low disturbance risk of ASS.

To protect on site and downstream water resources, ASS investigations should be undertaken across the subject land to determine the potential and actual ASS risks as part of future investigatory works.

Detailed ASS investigations and management plans (where appropriate) will also be required on land modelled as 'Moderate to Low' in accordance with DEC's 2009 *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* guidelines if any of the following works are proposed:

- Soil or sediment disturbance of equal to or greater than $100m^3$ with excavation from below the natural water table.
- Lowering of the water table, whether temporary or permanent (e.g. for groundwater abstraction, dewatering, installation of new drainage, modification to existing drainage).
- Excavation to or greater than 3m below the natural ground surface level.

The ASS investigations should happen as a condition of subdivision, unless there is evidence of high risk ASS. If this is the case then it may be appropriate to undertake investigation at an earlier stage, should the proposed development stratagies be subject to high risk activities being undertaken.

Typical cleared Farmland with Isolated Casuarina Obesa Tress

Figure 4 - Landform, Soil and Geotechnical Plan

5 – ENVIRONMENT

PGV Environmental undertook an environmental assessment of the subject land. The following is a summary of this information and site visits by TME.

WETLANDS AND WATERWAYS

According to the Department of Environment and Conservation's (DEC) Geomorphic Wetlands Swan Coastal Plain dataset (as shown in *Figure 5*), the Paluasplain Multiple Use Wetland (Number 15785) covers the majority of the site. The Multiple use wetlands areas are predominately devoid of native vegetation, although there are small areas of isolated *Melaleuca rhaphiophylla, Eucalyptus rudis* and *Casuarina obesa* trees. The main vegetation is composed of pasture species. These areas have limited ecological functioning and therefore provided few habitats for fauna

There is also a small area of Paluasplain Conservation Category Wetland associated with Manjedal Brook that traverses the northern portion of the site This has the reference Number 14945. The overstorey vegetation is largely intact and forms part of a corridor of vegetation along the brook and constructed drain. The understorey is predominately composed of weeds. This area provides some basic habitat value for fauna and acts as a limited corridor for fauna movement.

The other waterways and drains tend to be very degraded in nature, with limited ecological functioning, although there is still likely to be a limited range of fauna that use these waterways. The main flora along the waterways are introduced grasses and pasture weeds. They are likely to be classified as 'D' grade waterways using the Penn and Scott method.

To the south of the site, there is some higher quality wetland type vegetation associated with the reserve along Mundijong Road. This area is regarded as a Paluasplain Conservation Category Wetland (Number 14817).

OTHER AREAS

Some of the sand mounds have parkland cleared native vegetation, with some areas of denser, although degraded native vegetation. The vegetation tends to be dominated by marri trees. This will provide some habitat for wetland and waterway dependent fauna that are also able to use these other vegetation types.

There has also been some windbreak and Landcare planting along fence lines and drains. These will also provide some limited habitat to generalist species.

VEGETATION AND FLORA

The subject land is within the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. Most of the native vegetation however has been cleared.

The different areas of vegetation include:

1. Completely cleared farmland containing pasture grasses, which is the predominant vegetation type over the entire site;
2. *Casuarina obesa* Woodland over pasture grasses which is dominant in the south western corner of the site
3. *Melaleuca rhaphiophylla* (Paperbark) Woodland over pasture grasses which is associated with the Conservation Category Wetland and has some *Eucalyptus rudis* (Flooded Gum);
4. *Corymbia calophylla* Woodland over pasture grasses which is mainly in the area around Scott Road; and
5. *Kingia australis* and *Melaleuca rhaphiophylla* over pasture grasses, which occurs in the north of the site near Bishop Road.

The degraded nature of the site means it is highly unlikely that any Threatened or Priority Flora exist on the site. The priority flora found to the south of Mundijong Road will not be impacted by the development of the subject land.

FAUNA

The degraded nature of the site's vegetation means that there is likely to be limited opportunity for endangered fauna species that rely on wetlands and waterways to use the site. Generalist species, and those suited to agricultural landscapes may be able to make use of the degraded wetland and waterway habitats occurring on site. The waterways also provide some limited ecological linkage function for fauna moving across the site.

6 – HERITAGE AND CULTURAL SITES

There is one Registered Aboriginal Site present on the northern portion of the eastern boundary. It is a scatter site located on a sand rise and doesn't impact on the existing water ways and wetland areas. (see *Figure 5*). There is also another non registered Heritage Place that crosses the eastern boundary towards the south, which is also an artefacts scatter site. This is also located out of the drainage lines that exist on the subject land.

The aboriginal heritage issues are therefore unlikely to affect the water management of the site.

Investigations should be undertaken at future planning stages to ensure that Aboriginal and heritage consent is granted for proposed designs and practices.

All contractors working on any future development of the site will be made aware of their responsibilities under the *Aboriginal Heritage Act 1972* with regard to finding potential archaeological sites. In the event that a potential site is discovered, all work in the area will cease and the DIA will be contacted.

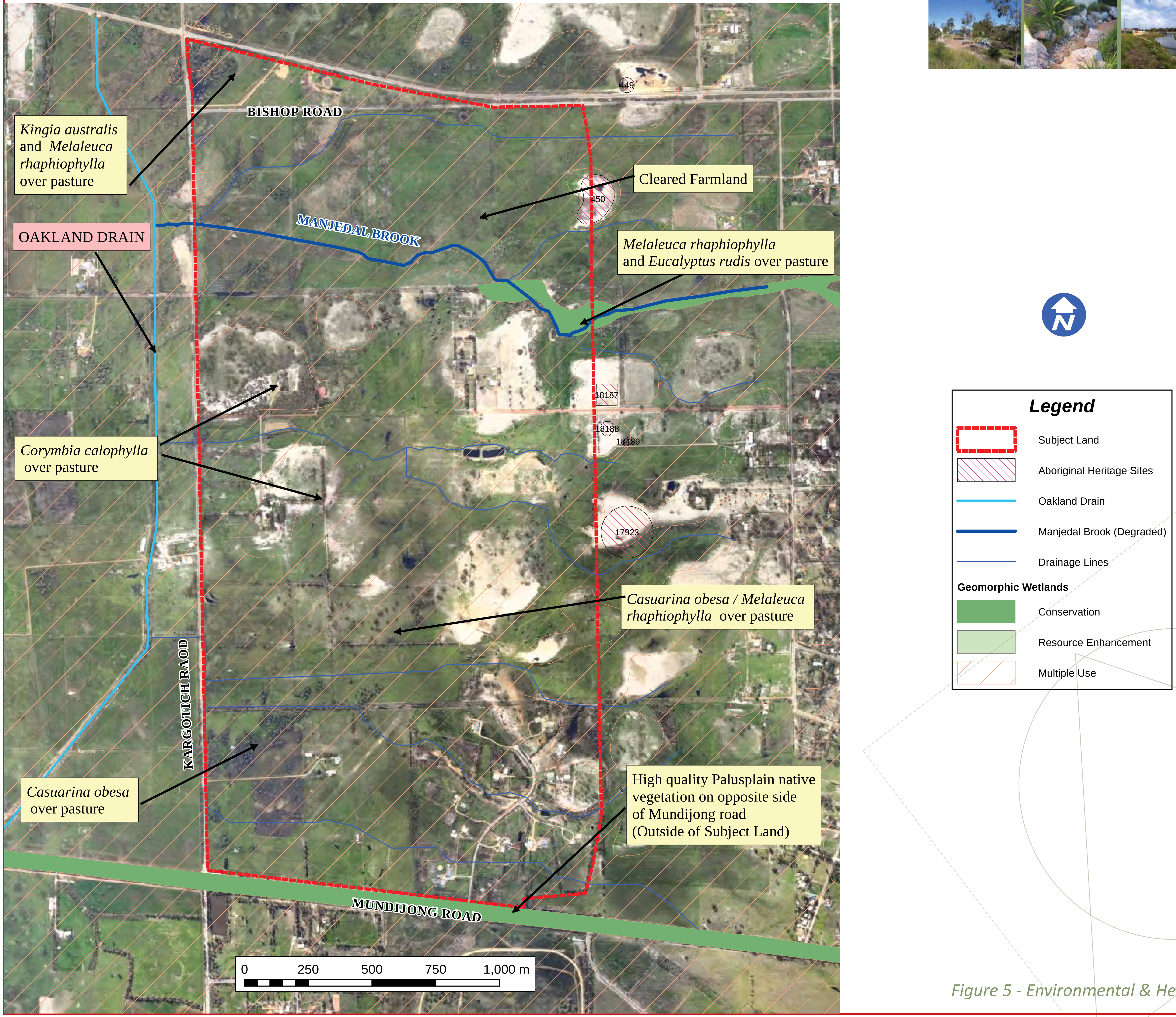


Figure 5 - Environmental & Heritage Plan

7 - GROUNDWATER PRE-DEVELOPMENT

GROUNDWATER INVESTIGATIONS

The Department of Water (DoW)has undertaken broad scale analysis of the regions groundwater levels as part of Perth Regional Aquifer Modelling Systems (PRAMS) model development. Hydrology and groundwater modelling, with a focus on the Lower Serpentine Regional Model (2008) has also been undertaken.

This information was analysed by TME, in conjunction with LIDAR. From this information, indicative groundwater levels for the site were developed.

Maximum, minimum and average maximum groundwater contours were determined as well as the depth to groundwater. From this analysis, the groundwater can be seen to be moving generally in a westerly direction.

Maximum levels ranged from 26mAHD on the eastern boundary down to 16mAHD on the western boundary. Minimum levels fell from 23mAHD to 14.5mAHD and Average levels fell from 24mAHD to 15mAHD. Seasonal variation between the minimum and maximum level was usually between 2m and 3m.

The depth to groundwater varied across the site. Approximately a quarter of the site had water at the surface, with another quarter showing water within 0.5m of the surface. Under some of the sand dunes, the ground water was at least 3m below the surface. A map of groundwater depth can be seen in *Figure 6. page 13.*

Groundwater quality has not been analysed in detail for the subject land. Due to the current land use and soil types present, it is likely that the nutrient levels of the groundwater will be elevated. This has the potential to impact on wetlands and river systems both on and downstream of the subject land.

It is also likely that the pH of the groundwater will be under 7 and have elevated levels of iron and aluminium. The salinity is likely to be in the fresh to brackish range. Groundwater exhibiting the above characteristics is common throughout the eastern portion of the Swan Coastal Plain.

AQUIFER INFORMATION

The subject land is within the Serpentine groundwater area and the Byford 3 sub area.

The DoW was contacted on 10th March 2012 regarding groundwater availability for the subject land. The Yarragadee, was noted as being fully allocated. The Perth-Cattamarra Coal Measures had an allocation over 79,000kL, the Perth Leederville had over 183,500 kL available and the Perth-Superficial Swan had over 11,768,000kL still available. This means there is currently significant groundwater resources that may be used within the development. Applications will need to be made to the DoW at later stages of planning to ascertain the actual water resources available, and in which aquifer. It should also be noted that the thickness of the superficial aquifer is generally thin and may contain clay and colluvial sediments being so close to the scarp. This may impact on the daily yields available due to a reduced hydraulic conductivity.

It should also be noted that the DoW is currently preparing an allocation plan for this area. This may change the allocation limits.

Typical area where groundwater is seasonally close to surface

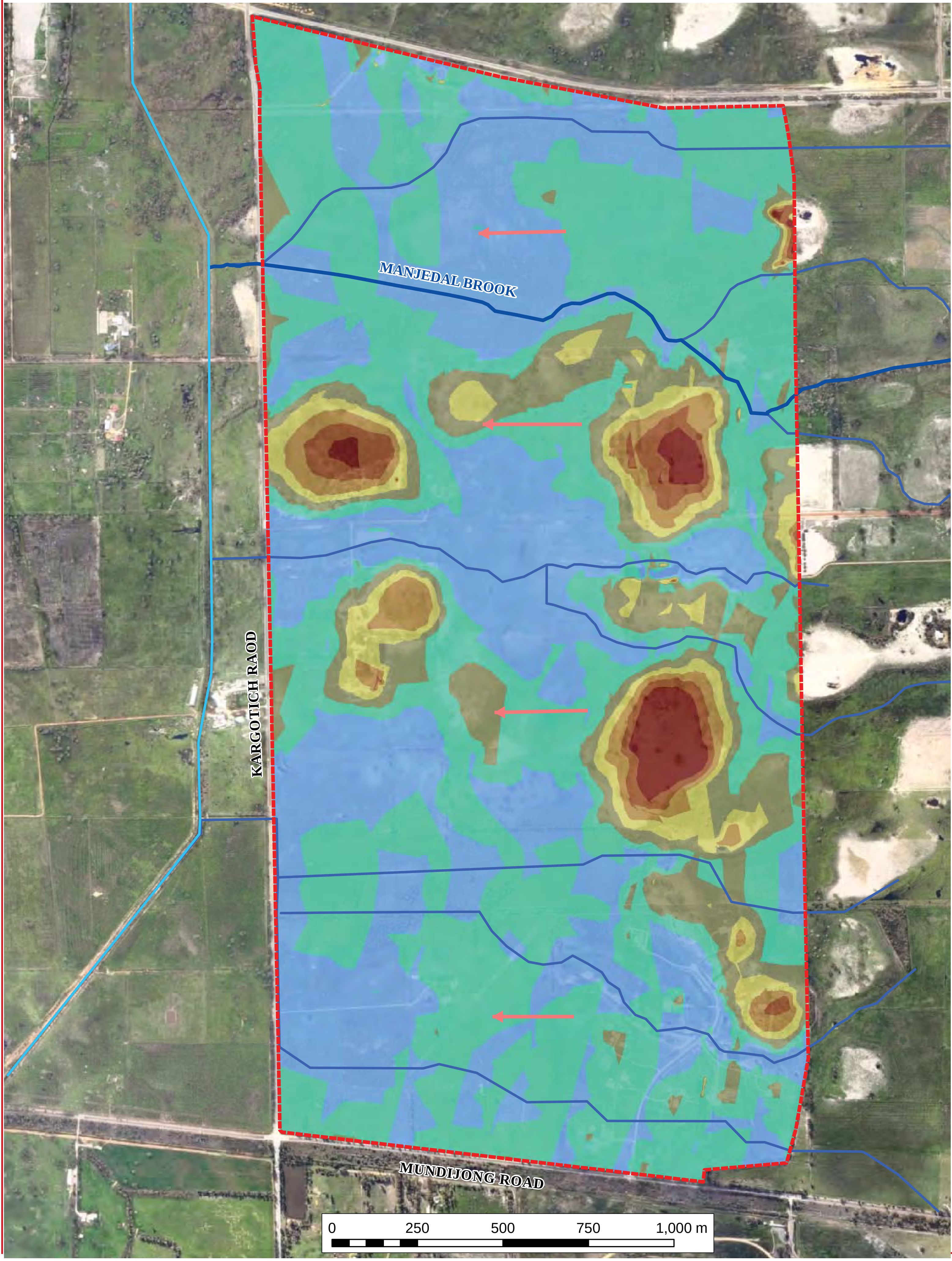


Figure 6 - Groundwater Pre-Development

8 - SURFACE WATER AND DRAINAGE PRE-DEVELOPMENT

The subject land is drained by a number of small drains and waterways that all exit the site on the western boundary. The site is also traversed by larger waterways, including Manjedal Brook, that carry significant flows. These waterways begin on the Darling Scarp. Water generated on the site, and water that enters the site from upstream all flow across Kargotich Road and into Oakland drain. This major Water Corporation drain runs southward, parallel to the subject land. Water from this drain is ultimately discharged into the Serpentine River and Peel Harvey Inlet.

PRE-DEVELOPMENT DRAINAGE ASSESSMENT

The pre-development runoff from the subject land and upstream flows was modelled to determine flows from the 1 in 10 year and 1 in 100 year events. This modelling incorporated original broad scale modelling by the DoW, with more detailed modelling within the subject land by TME.

Flood mapping information for the subject land was obtained from the DoW from their modelling. The major drainage line within the subject land is Manjedal Brook, running from east to west in the northern part of the subject land. There are another eight small drainage lines which transport external inflows during high flow events.

These drainage lines, and onsite run off, converge to three main defined outlets before discharging under Kargotich Road and into Oakland drain. These can be seen in *Figure 7 Page 15*

Pre-development inflows and outflows from the subject land were shown in *Figure 7 Page 15*. Hydrologic Engineering Centres River Analysis System (HEC-RAS) was used for modelling flood and ArcGIS for flood inundation mapping. Cross sections of drainage lines were extracted from LiDAR and inflows from Department of Water modelling were used. The two (2) models could not be fully calibrated together due to lack of data but are considered appropriate for this broad scale study. With further on site flow data and feature survey, a more accurate model can be produced.

A flood inundation map for 1 in 10 year event for the modelling exercise is presented in Figure 7 Page 15. For the 1 in 100 years flood inundation map, DoW modelling was used (Refer *Figure 8 Page 17*). These are flood inundated from external inflows.

For pre-development flows within the subject land, rational method was used for each of sub-catchments. Due to high groundwater level, a 0.5 effective runoff coefficient was used to calculate peak flows for pervious surface and 0.9 for impervious surfaces.

To get an estimate of water stored at site at 1 in 10 and 1 in 100 years Average Recurrence Interval (ARI) event in pre development situation, DRAINS (Developed by Watercom Pty. Ltd.) was utilised. Based on three major outlets, three major catchments were identified. The model identified where the water is stored during the large flood events. *Figures 7 and 8 Pages 15 and 17* show external inflows, three major sub catchments, pre-development flows and outlets. It also shows current storage as overland within the subject land.

The model shows that the existing capacities of the culverts under Kargotich Road are not adequate to cater for even the 1 in 10 years ARI pre-development flow. This results in flooding of the subject land and overtopping of the road.

It should be noted that this analysis is for broad scale study and should be refined in later stage of study.

A summary of the flow rates and storage volumes for the subject land in the 1:10 and1:100 ARI events are shown in *Table 1 Page 14*.

S.No	Catchment	PRE-DEVELOPMENT			
		Pre-Development flow as per DoW Modelling		Volume of Water storing within subject land (Pre-Development)	
		1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)	1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)
1	Catchment 1	18.47	36.59	62600	90400
2	Catchment 2	5.23	8.79	12300	17100
3	Catchment 3	6.99	16.8	57700	76400
	Total			132600	183900

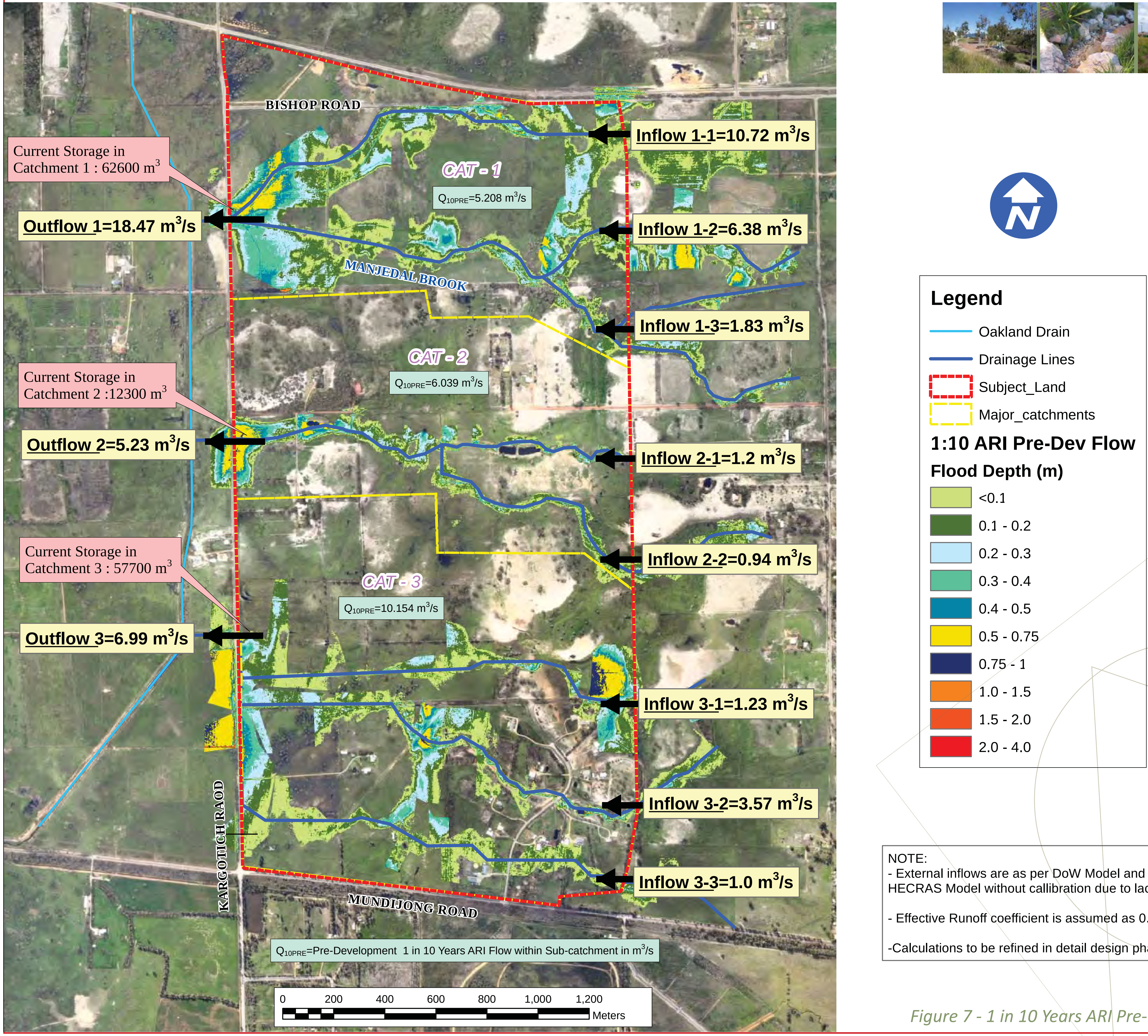
Table 1 Flow rate Summary and Storage Volumes Table

1 Current Volume of Water storing within subject land is calculated from pre-development flow from subjectland (calculated using rational method) + External inflows with permissible outlet discharge as outflow discharge from DoW Model (Pre-development)

2 Additional storage is storage required in addition with Sub-catchment/lot storage (Post-development 1 in 10 yr - Pre-development 1 in 10 yr) to limit discharge from subject land to pre-development stage

3 As current capacity of culverts in Kargotich road is not adequate to release pre-development flow detail analysis should be done in detail phase of design

TME



NOTE:
- External inflows are as per DoW Model and flood inundation is from HECRAS Model without callibration due to lack of data

- Effective Runoff coefficient is assumed as 0.5 due to high ground water

-Calculations to be refined in detail design phase

Figure 7 - 1 in 10 Years ARI Pre-Development Flows

SURFACE WATER QUALITY

No pre-development monitoring has been undertaken at the moment. There is some limited water quality data available for Manjedal Brook, which was collected in October 2007 as part of the Mundijong – Whitby District Structure Plan Environmental Study (2009). The results are typical for waterways on the eastern edge of the Swan Coastal Plain, although nutrient levels were lower than most waterways. This may be due to the larger flows of Spring diluting the results.

The results can be seen in *Table 2 Page 16*.

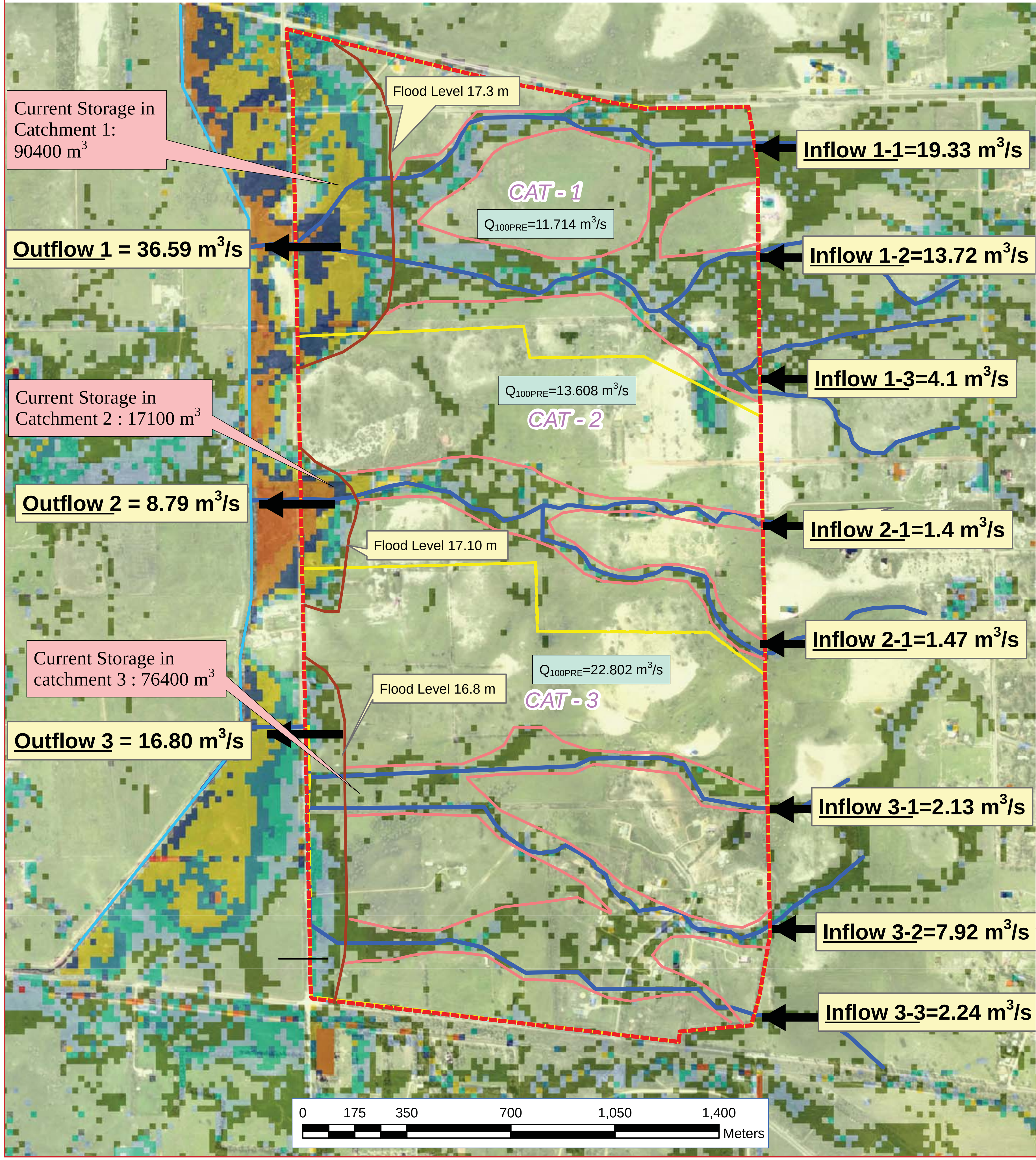
As the subject land is within the Peel Harvey Water Quality Improvement Plan (WQIP) area, the site will need to consider the recommendations outlined within this report. The Estuary and associated waterways are showing signs of stress according to the (WQIP). The Estuary is internationally, nationally and regionally significant for natural fauna and flora, recreation, aesthetics and hydrologic systems. The system has a history of water quality problems, which are derived from its large and diverse catchment and land uses.

More information on how the development of the site can assist with meeting the WQIP recommendations is outlined in *Section 11*: Water Quality Management.

Typical degraded waterway and ponding

Variable	Range	Comments
pH	6.89-8.25	Meets ANZECC water quality objectives
Electrical Conductivity	343 – 1150 μs/cm	Lower conductivity values are often associated with seasonal rainfall
Salinity	0.14 – 0.58 ppt	fresh to slightly brackish
Turbidity	5.30 – 25.8 NTU	
ORP	170-286 mV	
Dissolved Oxygen	82.7 – 138.6%	should avoid falling below 5mg/L to avoid stress to aquatic species
Heavy Metals		Within ANZECC Drinking Water Guideline Values 2004
Total Phosphorus	0.01 to 0.03 mg/L	Meets ANZECC water quality objectives
Reactive Phosphorus	<0.01 mg/L	Meets ANZECC water quality objectives
Total Nitrogen	0.35 mg/L (average) 2.1 mg/L (max)	All but site 3 meets ANZECC water quality objectives
Total Kjeldahl Nitrogen	0.2 – 0.7 mg/L	
Ammonia	>0.105 – 0.118 mg/L	Above ANZECC trigger values
Nitrite and Nitrate (NO_x)	<0.010 - 1.380 mg/L	Mostly less than ANZECC trigger values

Table 2 Surface Water Quality Results



Q_{100PRE}= Pre-development sub- catchment flow in 1 in 100 years ARI (m^3/s)

NOTE:
- External inflows and flood inundation are as per DoW Model
- Effective Runoff coefficient is assumed as 0.5 due to high ground water
-Calculations to be refined in detail design phase

Legend

- Oakland Drain
- Drainage Lines
- Indicative 1 in 100 years ARI Pre-development Flood Level near Kargotich Road
- Indicative Flood Plain of waterways in 1 in 100 years ARI in pre-development situation
- Subject_Land
- Major Catchments

1:100 Pre Development Flood Depth (m)

- <0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 4.0

Figure 8 - 1 in 100 Years ARI Pre-Development Flows

9 – CONSTRAINTS, OPPORTUNITIES AND SOLUTIONS

The subject land and surrounds present a range of constraints and opportunities, which will influence the development solutions in relation to water management. *Figure 9* identifies graphically some of the water management related constraints. *Table 3* provides a summary of these threats and a summary of the management options.

The following sections provide additional details and specific water management strategies tailored to this site.

Note:
The entire subject land has sheet flow across it in the 1:100 ARI event. Flood depths greater than 0.2 m are only shown for ease of viewing.

N

Legend

- Oakland Drain
- Manjedal Brook
- Drainage Lines
- Ground Water Flow Direction
- Subject Land
- Conservation Catagory Wetlands
- 50m Buffer to Conservation Catagory Wetland

1 in 100 Years ARI Pre-Development Flood Depth (m)

- 0 - 0.2 (Not shown for ease of viewing)
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- 1.0 -2.0
- 2.0 - 3.0
- 3.0 - 4.0

Areas of Shallow Groundwater Depth to AAMGL (m)

- Above or at Surface
- 0 - 0.5

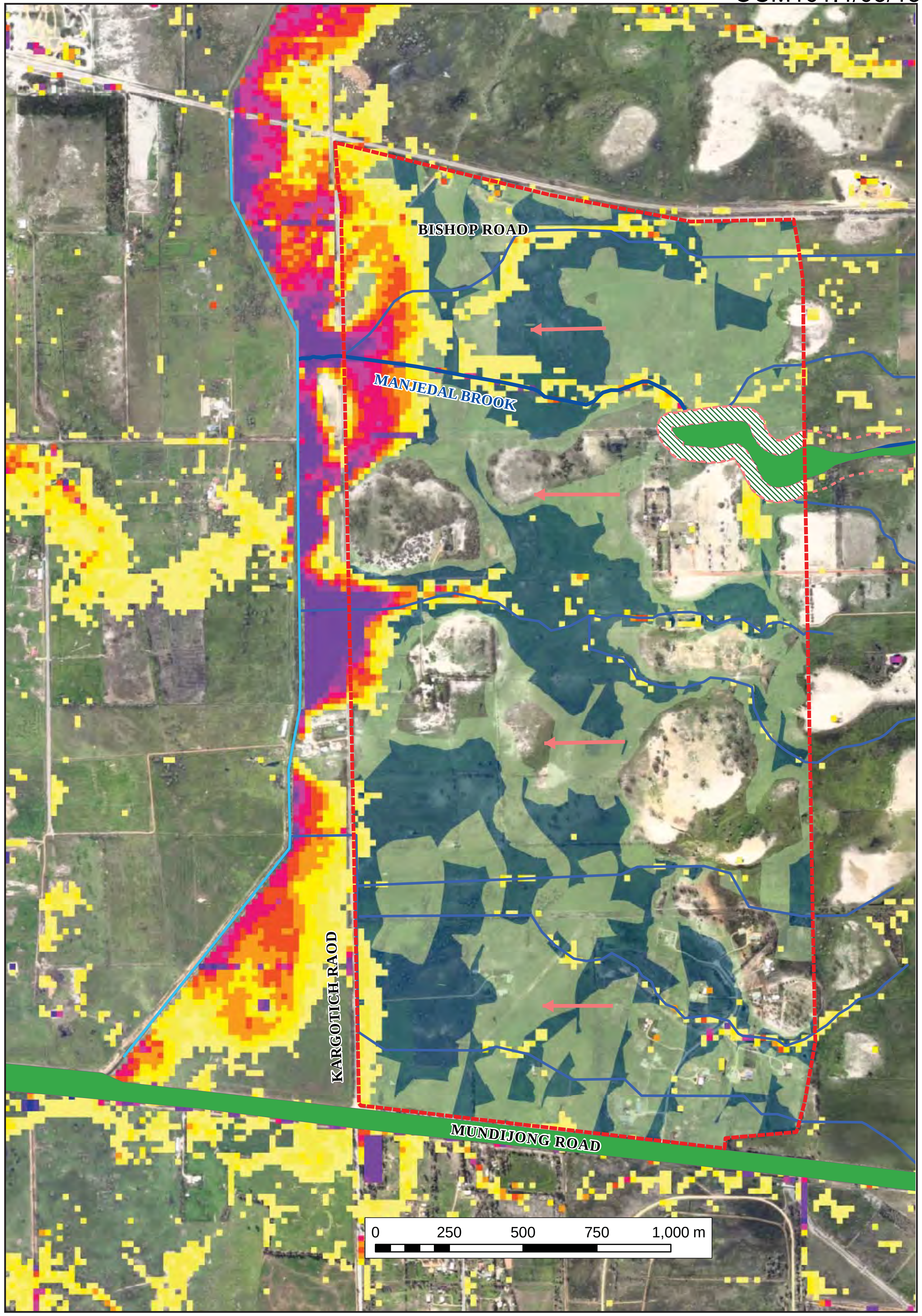


Figure 9 - Opportunities and Constraints Map

TME

Constraints/Threats		Opportunities and Management Options
Aboriginal Heritage Site	A	Investigate sites with the Department of Indigenous Affairs to ensure development works satisfies *Aboriginal Heritage Act 1972.*
Wetlands (and associated buffers)	A	Creation of buffers around applicable wetlands.
	B	Preparation and implementation of a wetland management plan for appropriate wetlands, including advice on protection and rehabilitation management strategies.
	C	Enhancement of wetlands and their functional areas.
	D	Provide refuge for fauna between the large areas of native vegetation reserved on-site and to natural wildlife corridors by including in ecological linkages.
	E	Encourage planting of locally appropriate native plants in public and private areas to provide linkages between wetlands, reserved native vegetation and wildlife corridors.
	F	Use of Water Sensitive Urban Design (WSUD) techniques to treat and improve water quality that enters wetlands.
	G	Maintenance of existing s flow rates via appropriately designed stormwater and groundwater management designs.
	H	No treatment within the wetland area with some flood storage within buffer area basins designed to mimic seasonal wetlands.
Waterways (and associated foreshore reserves)	A	Creation of foreshore reserves (buffers) around applicable waterways which are included within ecological linkages.
	B	Preparation and implementation of a ecological linkages management plan including advice on protection and maintenance management strategies.
	C	Enhancement of drainage lines so that they both transport the required volumes and flow rates while providing habitat for fauna through appropriate design.
	D	Encourage planting of locally appropriate native plants in public and private areas to provide linkages between swales and waterways.
	E	Use of WSUD to treat and improve water quality that enters waterways.
	F	Maintenance of existing water flow rates via appropriately designed stormwater and groundwater management designs.
	H	Potential construction of footpath (or interpretative trail) along and throughecological linkagesto improve recreational facilities and provide an educational resource for the greater community.
Flooding	A	No development allowed within the 1:100 floodway of the drainage system.
	B	Use of fill where necessary to achieve the required separation from appropriate flood levels.
	C	Utilise stormwater infrastructure to store and convey runoff during a flood event that protects both infrastructure and receiving water bodies. Post development release flow rates from the subject land will be designed to match pre-development flow rates and includes the existing pre development flood storage volumes.
Stormwater Flow Rate Runoff	A	Post development outflow rates to match pre-development rate.
	B	Use of Water Sensitive Urban Design (WSUD) to temporarily store and control the flow rates of stormwater runoff and discharges from the development both on private and public land.
Stormwater Nutrients, Contaminants and Pollutants	A	Use of water sensitive urban designs (e.g. bioretention units) to reduce total nutrient loads entering groundwater and leaving the subject land.
	B	Structural separation practices applied at a lot level to minimise pollution from industrial activities.
	C	Introduction of non-structural best management practice. Including provision of educational material to lot owners regarding responsible disposal and use of water from their business.
	D	Landscaping to utilise strategies that will not produce excessive fertiliser requirements and potential leaching of nutrients.
	E	Removal of potentially high nutrient loading agricultural practice currently on the land.
	F	Monitoring of water quality post development to improve treatment strategies, if required.
Groundwater Levels (including high peaks and dependent ecosystems)	A	Ensure development has no negative impact on groundwater resource, significant wetlands and waterways influenced by site.
	B	Use of suitable fill where necessary. Suitable fill should be stipulated in future geotechnical investigations, and shall include appropriate permeability requirements and a provision for soil amendments to improve nutrient retention while having a permeability which minimises mounding.
	C	Use of suitable fill, roadside swales and sub-soil drainage pipes where necessary to obtain adequate separation between controlled groundwater levels and infrastructure.
	D	Infiltration of stormwater wherever possible on both private and public lands.
	E	Monitoring of groundwater levels pre development to increase the accuracy of the site's AAMGL.
	F	Monitoring of groundwater levels post development to improve management strategies, if required.
Groundwater Quality	A	Use of WSUD (e.g. bioretention units) to reduce total nutrient loads entering groundwater.
	B	Treatment of sub-soil pipes that intercept groundwater with WSUD. Potentially this could improve the groundwater resource and dependent ecosystems (e.g. wetlands on-site) from their pre-development conditions.
	C	Landscaping to utilise strategies that will not produce excessive fertiliser requirements and potential leaching of nutrients.
	D	Removal of potentially high nutrient loading agricultural practice currently on the land.
	E	Monitoring of groundwater quality post development to improve treatment strategies, if required.
Acid Sulphate Soils (ASS) Risk	A	Undertake a preliminary ASS risk investigation of the site.
	B	Depending on preliminary ASS investigations a detailed ASS investigation and management plan may be required prior to any development (or ground breaking activities).
	C	Use of fill, WSUD and on-site effluent disposal should all minimise the disturbance to the existing soils and therefore minimise the risk of disturbing ASS.
Potentially Low Phosphorous Retention of Soils	A	Undertake a geotechnical investigation to determine PRI of soils across the site.
	B	Use of appropriate amended soils (and/or fill) to improve the phosphorous retention capabilities of the soils.
	C	Use of appropriate practices for on-site effluent disposal.
Wastewater Management	A	Development to be connected to wastewater collection system, either through connection through to existing offsite infrastructure or a stand alone system.
	B	Encourage greywater reuse schemes for businesses.
	C	Designs to be undertaken in detail at a lot level to ensure system is appropriate for lot conditions, industry use and to be approved by the local government authority.
	D	Investigation into wastewater treatment and reuse schemes.
Potable Water Supply	A	Development to be connected to reticulated water supply.
	B	Encourage on-site capture of rainwater for supplement usage.
	C	Encourage of greywater reuse schemes for businesses.
Non Potable Water Supply	A	Investigation into wastewater treatment and reuse schemes.
	B	Investigations into superficial aquifer groundwater usage, which will also assist with controlling groundwater levels.
	C	Investigation into large scale groundater usage schemes from Leederville and other deeper aquifers.
	D	Investigation into roof runoff harvesting and reuse schemes at the lot scale.
	E	Develop recommendations for water use efficiency practices and targets for both businesses and irrigation of public areas.

Table 3 Summary of Threats and their management options

10 - DRAINAGE MANAGEMENT STRATEGY

The objectives of the stormwater drainage management for the development area and relevant upstream and down stream flows, are to mimic as close as possible the pre-development flows leaving the subject land and treating the necessary volumes before the water is discharged to receiving water bodies. Stormwater discharged into the groundwater will similarly incorporate designs to mimic as close as possible the pre-development regimes and reduce nutrient and other potential contaminants entering the groundwater resource.

The subject land is divided into three major sub-catchments based on three major outlets and fourteen sub catchments based on outlets and proposed development. These can be seen in *Figure 11 page 23*.

The primary objectives of the 1:1 year average recurrence interval (ARI) event drainage designs are to treat the stormwater and to protect the ecological functions of receiving natural environments. The priorities for storm events above the 1:1 year event are to control the flow of drainage water throughout the subdivision and release the water from the subdivision at pre-development rates, whilst not creating any negative impacts to surrounding or downstream infrastructure, this will primarily be achieved via temporary storage of runoff and controlled outlets.

The conveyance and storage of the 1:10 year ARI events will be via integration of swales, pipes and storage units throughout the development. Flooding up to and including the 1:100 year ARI event will utilise the 1:10 year infrastructure, with excess runoff to be conveyed and stored within swales, road reserves and drainage easements. The protection of private property from inundation and detaining outflow rates into receiving water bodies are the primary objectives of these flood events.

Using *DRAINS* software, peak runoffs were modelled with the Rational method for the critical time of concentration for each catchment derived using the Kinematic flow equation and pre and post peak flow rates determined for each catchment for 1:10 year and 1:100 year events . Required storage volumes to detain flows for the 1:10 year event back to predevelopment levels were determined by the models with optimising basin sizes so that outlet discharge is limited to the pre-development stage.

The following three sections discuss and provide further details on how water is to be treated, conveyed, stored and discharged in three different ARI scenarios. Also catchment boundaries, discharge points and volumes of flow rates are depicted within the respective sections plans.

A – The 1:1 year 1 hour event.

B – The 1:10 year flood event.

C – The 1:100 year flood event.

The following sections outline the guidelines the development may follow to ensure that best management practices of stormwater management and flood protection are achieved.

Detailed drainage designs, models and drawings will be required at the structure plan and subdivisional stages, to accompany the Local Water Management Strategy (LWMS) and Urban Water Management Plan (UWMP) respectively.

10A - DRAINAGE MANAGEMENT STRATEGY – 1 YEAR 1 HOUR EVENT

The drainage management system for the development will be designed to capture and provide treatment for the 1 year 1 hour event, which effectively captures approximately 95% of all stormwater flow. The designs will also provide protection of the ecological functions for all receiving natural environments post development. For this site, the 1 year 1 hour event equates to 17.2 mm per hour. The flow generated from this rain volume will be collected and treated.

Surface water on the land will take two main directions; infiltration to the groundwater and surface run off. Two separate treatment trains have been designed and specified to treat and manage the two different flow paths.

INFILTRATION TO GROUNDWATER

The majority of the water that falls on pervious surfaces in the development area will infiltrate through to the shallow groundwater because of the high hydraulic conductivity of the imported fill's free draining nature that will be laid across the majority of the developable area. This will include any overflow from installed rainwater tanks, on-site bioretention systems, swale bases and property soak wells. Any fill used will ensure that the fines content of the fill is restricted to less than 5% to promote drainage across the site. Appropriate soil amelioration products will be used where any water infiltrates through gardens, and public spaces where fertilisers would be applied.

Piped subsoil drains will be used to intercept and convey ground water flows to the drainage system and ensure levels across the site do not rise above the designated CGL for the site. These pipes will also ensure the required clearances to lots are maintained, allowing soakwells and basins to function as per their design parameters.

It should be noted that the decrease in evapotranspiration from the pre development to post development means that there is a general increase in groundwater volumes.

The Subsoil system will transport this water out of the soil profile to the swale systems, which is likely to produce a base flow through the drains for an extended period of time.

Rainwater tanks, with air gaps, will be encouraged for each lot and business throughout the development. The tanks would assist in reducing the peak runoff flows from the lots, providing some of their on-site storage requirements especially during summer storm events. Overflow from these will be directed to infiltration areas and soak wells. The base of the soak wells and infiltration areas will be installed generally 300mm above the CGL Water that enters the soak wells will infiltrate into the soil profile and ultimately into the groundwater. There is no direct link between roof runoff and the street drainage network.

Capture of rainwater via tanks with air gaps can also provide opportunities for water conservation.

SURFACE FLOW

Runoff within the development will occur off the lots and off the road reserves. Each lot will be responsible for capturing, detaining and treating all lot runoff for the 1 year 1 hour event on-site. The runoff could be detained and treated by a variety of methods and combinations, including shallow landscaped bioretention basins, rainwater tanks and soak wells.

For the runoff from the road reserves the 1 year 1 hour event will also be captured, detained and treated..

This treatment will generally be provided in road side bioretention gardens and swales. The bioretention gardens and swales will be protected from traffic, where appropriate. They will also be located so that they do not obstruct lot access. the water entering the bioretention gardens will pass through an amended soil layer to reduce the quantity of sediments and nutrients entering the groundwater. The gardens will be constructed according to the latest FAWB adoption guidelines for filter media in biofiltration systems and the stormwater management manual for wa design guidelines. The three graphs in *Figure 13* are sourced from the Stormwater Management Manual for WA (DOW, 2008) and demonstrate the effectiveness of bioretention systems in removing nutrients from stormwater, when built to the aforementioned guidelines.

A typical arrangement for the swales in each street is shown in *Figure 10*.Bioretention gardens may require irrigation during the initial 2 to 3 years to assist with the establishment of plants. Irrigation and fertiliser applications should be met by storm water runoff after this period, although subsequent watering may still be required in drier years. The units should be designed to latest FAWB guidelines to ensure functionality assists the removal of nutrients, sediments and other potential contaminants from an industrial subdivisions runoff.

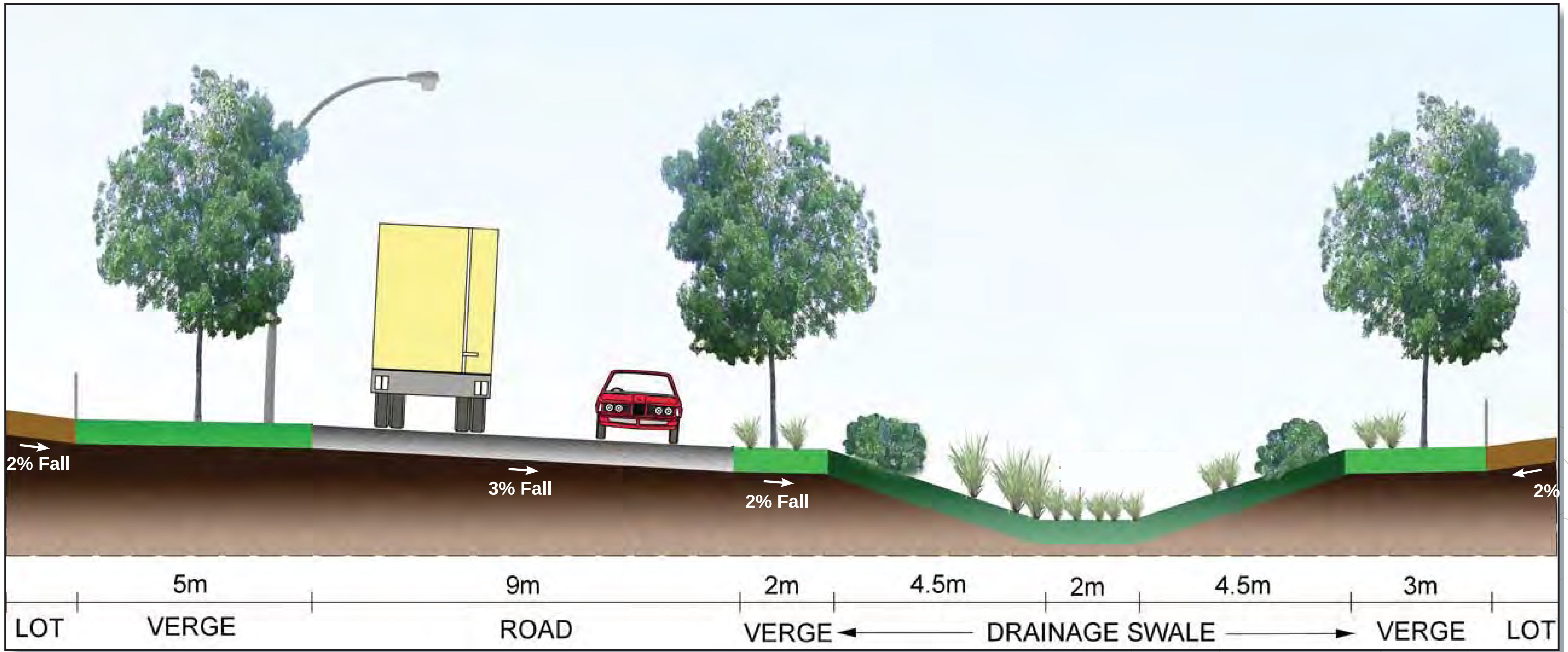


Figure 10- Road and Swale Cross-section Typical Arrangement for major drainage lines (smaller swale for other roads)(Concept only)

10B - DRAINAGE MANAGEMENT STRATEGY – 1:10 FLOOD EVENT

The drainage management system for the subject land is to be designed to manage the 1:10 year ARI events utilising pipe, swale and detention basin systems with controlled outlets. The objective of the drainage systems in 1:10 year events is to store the required volumes of water off the roads and lots, and transport the excess water to drainage infrastructure designed to either convey and/or infiltrate the runoff. The drainage system is to be designed to slow the rate of water flow, allow for partial infiltration of water on-site, and control discharged water out of the development at pre-development rates to the Oakland Drain.

In the 1:10 year event on the post development site, the flows will initially flow to the 1 year 1 hour treatment and storage devices on the lots and road reserves. Once these are filled the flows will then overflow into the swale systems in the road reserves where they will be detained and then conveyed to the outlet of the systems. At the outlet, flow spreaders will be used to reduce velocities to acceptable levels.

As existing drainage lines are not well defined, indicative major drainage lines/swales for post development are proposed to be located along roads without impacting on final drainage flows or significant ecosystems. Adequate sized swales to carry 1 in 10 years external inflows in addition with 1 in 10 years pre-development runoff from sub-catchments with sufficient free-board are to be designed as part of future water management strategies. Detail analysis will be carried out in detail design phase.

In addition to the lot storage to maintain pre-development flow rates, the modelling also shows the requirement of additional storage for external inflows to maintain pre-development flow rates at the final outlets. *Table 4* shows summary of storage requirement to maintain pre-development flow rates which will be refined in later stages of design. This includes the existing pre development storage on the subject land plus the extra generated as part of changing the land use from rural to industrial.

Stormwater that infiltrates to the groundwater during a 1:10 year event will have minimal effect on the flood peak. However, later expressions through seepage into the perforated sub-soil pipe system may occur. If expressions do occur, they may extend the period of time that water will continue to move through the sub-soil pipe network, although at a much reduced rate.

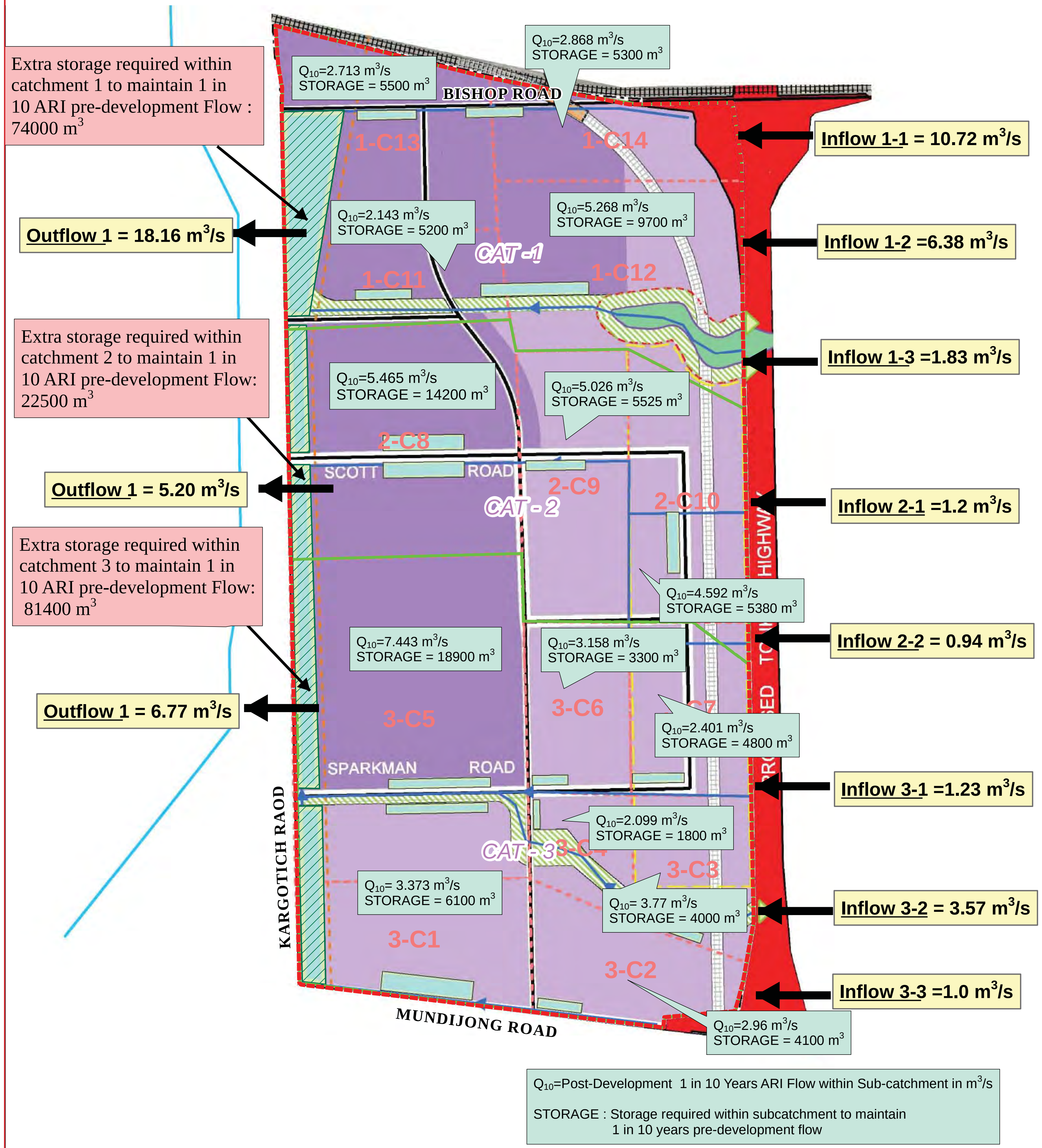
It is not an objective of managing 1:10 year flood events to treat runoff for quality, but the bio retention units and conveyance would allow for trapping and settling of suspended sediments, especially after the flood peak has passed. This is due to the slowing of water near the surfaces of the swales from the in-stream and bank vegetation, and the residence time.

		PRE-DEVELOPMENT				POST-DEVELOPMENT				
S.No	Catchment	Pre-Development flow as per DoW Modelling		Volume of Water storing within subject land		Lot /Sub-catchment Storage with outlet discharge of 1 in 10 pre-development(m^3)	Additional storage for 1 in 10 Years ARI (m^3)	Additional storage for 1 in 100 Years ARI (m^3)	Total storage Required	
		1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)	1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)				1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)
1	Catchment 1	18.47	36.59	62600	90400	25700	74000	111000	99700	136700
2	Catchment 2	5.23	8.79	12300	17100	25105	22500	42700	47605	67805
3	Catchment 3	6.99	16.8	57700	76400	43000	81400	117100	124400	160100
			Total	132600	183900	93805	177900	270800	271705	364605

Table 4 Post Development flow rates and required storage

Note:

1. Current Volume of Water storing within subject land is calculated from pre-development flow from the subject land (calculated using rational method) + External inflows with permissible outlet discharge as outflow discharge from DoW Model (Pre-development)
2. Additional storage is storage required in addition with Sub-catchment/lot storage (Post-development 1 in 10 yr - Pre-development 1 in 10 yr) to limit discharge from subject land to pre-development stage
3. As current capacity of culverts in Kargotich Road is not adequate to release pre-development flow detail analysis should be done in detail phase of design



NOTE:
- External inflows are as per DoW Model
- Permissible discharge at Kargotich Road is assumed as pre-development flow as per DoW Model
- Existing culverts in Kargotich Road does not have capacity to allow permissible flow (pre-developemnt flow) and hence need to be confirmed and improved
- Catchments are based on post development
- Effective runoff coefficient assumed to be 0.5 due to high Ground Water
- Calculations to be refined in detail design phase

Legend

- Oakland Drain
- Indicative major post-development drainage lines
- 330 V Power Lines
- Buffers
- Major Roads
- Subject Land
- Multiple Use Corridor
- Indicative Post-Development Drainage and Flood Storage Area (10 Years ARI)
- Indicative Post-Development Drainage and Flood Storage Basin to maintain 1 in 100 Years ARI Pre-development flow
- General Industry
- Light Industry
- Indicative Ecological Linkage
- Possible Intermodel Facility
- CAT-1 Major Catchments
- 1- CAT-11 Sub-Catchments (Based on Post-Development)

Figure 11 - 1 in 10 year Post Development Drainage Plan

10C - DRAINAGE MANAGEMENT STRATEGY – 1:100 FLOOD EVENT

The development is to be designed to safely convey the 1:100 year ARI flood event so that impacts on infrastructure, the environment and people's safety are minimised. All road and lots levels are to be designed to maintain a minimum 300mm separation clearance between buildings and the internal 1:100 ARI flood levels. A minimum 500mm separation clearance will also be required between building levels and the 1:100 year flood levels of the major waterways that travers the site, as well as the back water effect from Oakland Drain. The 1:100 year flood event's runoff is to predominantly be conveyed via the road reserves, waterways within the ecological corridors and the drainage swale network. The drainage network within the development area would flow at capacity with excess water flooding the adjoining road reserves. Some roads would be expected to partially flood however they shall remain serviceable for emergency vehicles.

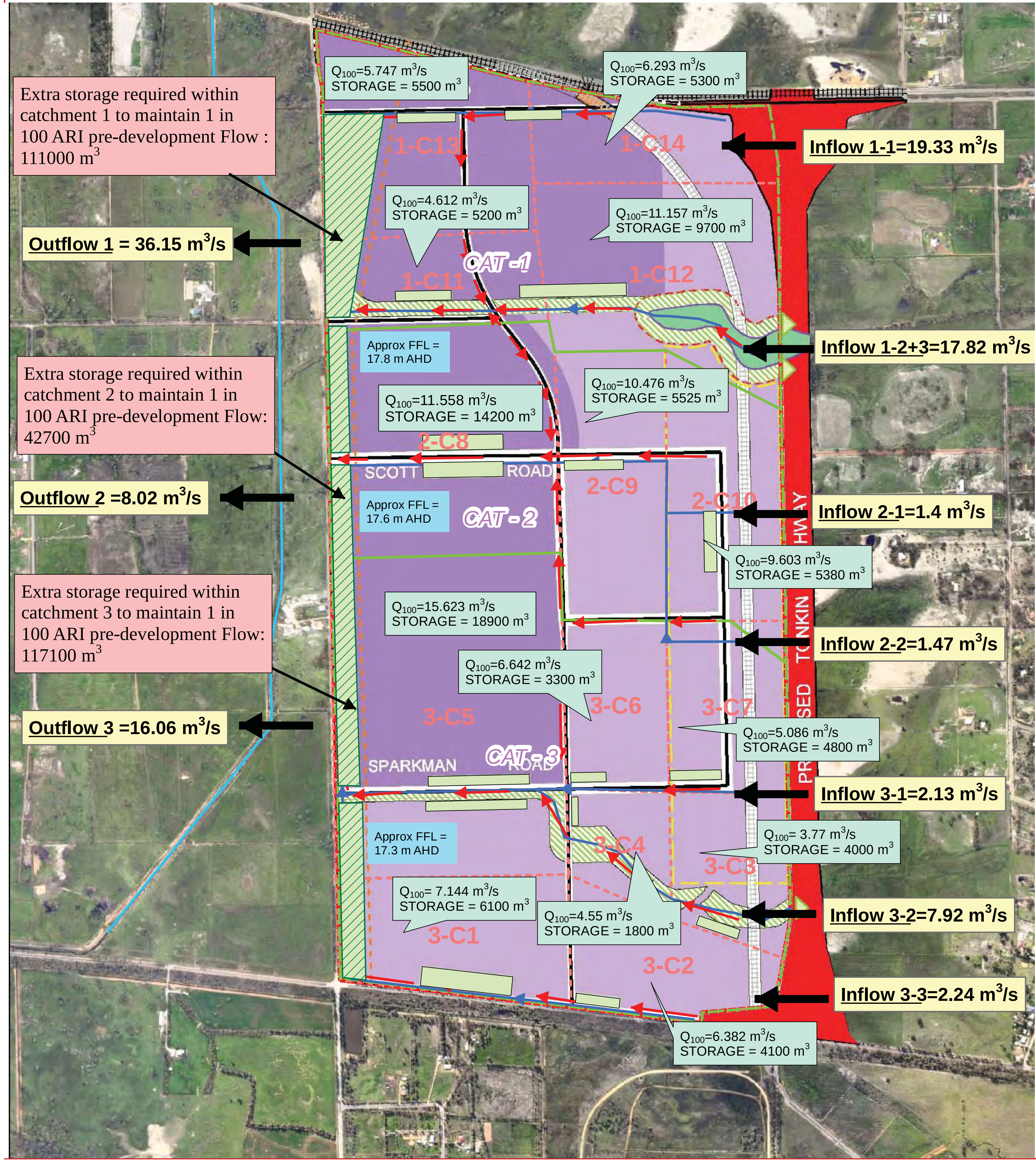
During a 1:100 year flood event the roadside swales would flow at capacity with extra water flooding into the adjoining road reserves and public areas. These will fill the drainage basins as well as linking with the larger swales which transport the upstream flows through the development.

Large flows that traverse the site will be mainly conveyed within swale/living stream systems that are designed to handle the designated flow.

Using *DRAINS* software, peak runoffs were modelled with the rational method for the critical time of concentration including 1 in 100 years' external inflows. The drainage investigation modelled that utilisation of the 1 in 1 year 1 hour lot storage in addition with 1 in 10 years storage (outlet with 1 in 10 year pre-development) within sub catchments will require additional storage to maintain final outlet to 1 in 100 year pre-development stage. These storage requirements in addition with sub-catchment storage requirement are shown in *Figure 12 and Table 4.*

It is assumed that outlet flow from the subject land after development to be 1 in 10 years pre-development in 1 in 10 year's event and 1 in 100 years pre-development in 1 in 100 year's event. Detail analysis of existing capacity of outlets at Kargotich Road will be carried out in detail design phase. It is also assumed that flow from upstream on the development to be kept at pre-development flow rates.

The 1 in 100 Years Pre-development flood extents is shown in *Figure 12.* Maximum flood level near outlet 1 is 17.3 m, outlet 2 is 17.1m and outlet 3 is 16.8 m. A flood level separation of 0.5m to the finished floor level should be maintained to these maximum 1 in 100 flood levels



0 250 500 1,000 Meters

Approx FFL = Approximate Finished Floor Level (0.5m separation from 1 in 100 year Flood Level)

Q_{100}=Post-Development 1 in 100 Years ARI Flow within Sub-catchment in m^3/s

STORAGE : Storage required within subcatchment to maintain 1 in 10 years pre-development flow

NOTE:
- External inflows are as per DoW Model
- Permissible discharge at Kargotich Road is assumed as pre-development flow as per DoW Model
- Existing culverts in Kargotich Road does not have capacity to allow permissible flow (pre-developemnt flow) and hence need to be confirmed and improved
- Catchments are based on post development
- Effective runoff coefficient assumed to be 0.5 due to high Ground Water
- Calculations to be refined in detail design phase

Legend

- Oakland Drain
- Indicative major post-development drainage lines
- 330 V Power Lines
- Buffers
- Major Roads
- Indicative 100 Years Flow direction 100 years ARI flow will be carried by swales and road reserves
- Subject Land
- Multiple Use Corridor
- Indicative Post-Development Drainage and Flood Storage Basin to maintain 1 in 100 Years ARI Pre-development flow
- General Industry
- Light Industry
- Indicative Ecological Linkage
- Possible Intermodel Facility
- Major Catchments
- Sub-Catchments (Based on Post-Development)

Figure 12 - 1 in 100 year Post Development Drainage Plan

11 - WATER QUALITY MANAGEMENT

The development will utilise a range of best management practices to manage water quality across the site. The major practice will be the implementation of best practice water sensitive designs to manage stormwater up to 1:10 flood events. Most of the other management practices will involve minimising the quantity of nutrients added to the surface and groundwater within the development. The development designs should concentrate on managing practices on lots for effluent disposal and stormwater runoff.

CONSTRUCTION CONTROLS

A key aspect of managing water quality for the development will be involved in the construction of the subdivision. At the subdivision stage of development there will be a requirement to prepare and implement erosion and sediment control plans. Management options should also focus on minimising potential pollutants during the construction phase. The management options may include:

- assessment of erosion risks;
- stabilisation of stock piles;
- minimise the exposure times for disturbed areas;
- sediment curtains, fences, and filters at inlets and other control points;
- cut off drains;
- temporary sediment basins;
- stone mattresses; and
- hydro-mulching and interim plantings.

ON-SITE LOT TREATMENT

It is proposed that individual lot owners will provide attenuation and treatment options for the 1 year 1 hour event lot runoff. The on-site flows can be detained in with a variety of methods including shallow landscaped bioretention basins, rainwater tanks and on-site soak wells.

The most effective method in implementing best practice in industrial precincts is to ensure that pollution sourced from work areas does not discharge into the stormwater infrastructure (the concept of structural separation is displayed in *Figure 13*). Practices that land managers and owners can undertake involve roofing work areas, directing wash-down water to storage or onsite effluent systems, and controlling activities undertaken in areas that link with the stormwater infrastructure. The guiding principles and practices in the construction and management of industrial lots should be an intention to separate areas subject to pollutants and contaminants from paths that would transport water to the stormwater infrastructure. The developer will encourage structural separation, and the local government agencies will be encouraged to ensure elements are included for building application approvals.

Furthermore facilities will be encouraged to be constructed to ensure that contaminated wastewater is separate from uncontaminated wastewater, such as clean stormwater or cooling water, and sewerage.

EDUCATION

Education of employees is very important to ensure that they are knowledgeable about the different systems and potential impacts on the environment that their workplace could have. It is essential for the management of water quality within the subject land that employees are educated on the following:

- The difference between the stormwater and on-site treatment systems for each business;
- Do not sweep or dispose of litter or waste into gutters or drains, and keep the footpath, gutter and outside areas near their business free of litter. This includes providing adequate refuse storage for litter and cigarette butts;
- Where possible, all waste skips and bins should be stored in a designated area with a roof and surrounded by toe walls to prevent any leakage entering the stormwater system;
- Lids on bins and skips should be kept closed to stop loose litter being blown away. This also stops rain getting in which can wash oils, solvents and chemicals out of rags and into the stormwater;
- Spills from loading and unloading operations are a common source of stormwater pollution. Where possible conduct all activities with the potential to pollute water (e.g. loading and unloading, transfer of materials) within roofed and bunded areas or indoors;
- Storage of potential pollutants, including precautions in case of leakages, should be in secured areas. The storage may require roofing, a physical barrier for leaks to leave the storage (e.g. a lip at openings) and possibly a bund if appropriate.
- When moving, pumping, loading or unloading liquids make sure that a spill kit is available for use in case of a spill. Depending on the type of liquid, spill kits can be as simple as a drum full of sand or sawdust and a shovel; and
- How to handle materials to reduce waste and prevent spills.

CONTAMINANT RISK MANAGEMENT

The greatest risk to contamination of the natural environment from the subdivision will be industrial waste which can include petroleum hydrocarbons, heavy metals, surfactants, toxins and/or salts (DoW, 2009b). Details in regards to wastewater management, including contamination risks have been documented in the *Section 14 Water Supply & Wastewater Management*.

As previously mentioned, structural separation and education will be paramount to minimising the risks of contamination from any of the lots within the subdivision. The *Western Australian Business and Environment Manual* developed by the WA Chamber of Commerce and Industry and the Centre of Excellence in Cleaner Production provides an online resource. The manual is designed to assist WA businesses to successfully manage their environmental issues together with their business operations. Importantly it provides information relating to environmental legislative requirements and obligations at local, State and Commonwealth level for a range of industry practices.

Statutory requirements, approvals and managing agencies are outlined in environmental guidelines, codes of practice and *Water Quality Protection Notes* for a range of businesses and activities in Western Australia. Generally the Department of Environment and Conservation, Department of Water and Department of Health are the three major State government agencies involved in waste management and contaminated sites.

Contingency plans and emergency responses should also be developed where appropriate for the industry on the lot. The DoW's *WQPN 10: Contaminant Spills – Emergency Response* is a useful reference for lot owners.

Bio Swale Example - Perth Airport

Bio Swale Example - Perth Airport

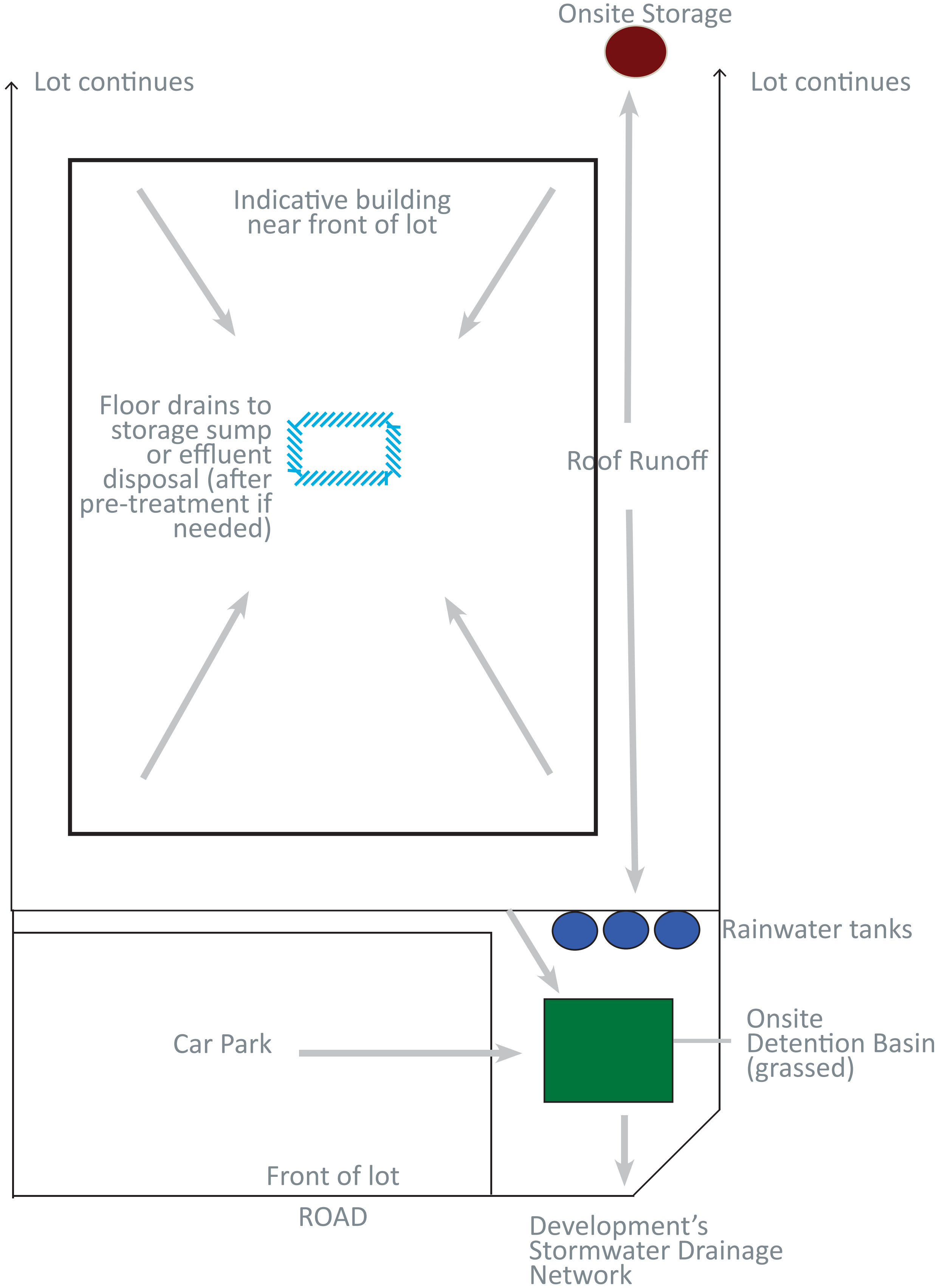


Figure 13 - Structural Separation Concept

BIORETENTION GARDENS

At the time of development, bioretention gardens and swales will be constructed within the road reserves of the development and be sized to capture and treat the 1 year - 1 hour event. The bioretention gardens will be designed and constructed according to the latest *FAWB Adoption Guidelines for Filter Media in Biofiltration Systems* and the *Stormwater Management Manual for WA* design guidelines, and in consultation with the Shire engineers.

A standard bioretention garden will be planted with appropriate native species, which should only require irrigation during the initial 2 to 3 years of establishment, depending on the seasons. They should require no fertiliser application and irrigation demands should be met by stormwater alone, after this initial establishment period, with possible subsequent watering only in drier years. The gardens will be designed to assist in the removal of nutrients and sediments from stormwater before the water reaches the groundwater. The indicative design for the gardens composes a filter media of amended soils to 500mm below the surface, with an average particle size of 0.5mm. A plastic root barrier will also be incorporated to provide a vertical separation layer from surrounding soils to assist in maintaining adequate moisture levels for species planted in the gardens and assist with nutrient reduction. The plants will also assist with nutrient absorption because of the surface area provided by their roots for the formation of bio-films and nutrient uptake. Where practical, saturated zones should also be incorporated in the base of the bioretention gardens.

Bioretention gardens have been demonstrated to achieve a 50% decrease in nitrogen, 80% decrease in phosphorus and a 90% decrease in total suspended soils (DoW's Stormwater Management Manual). The graphs shown on *Figure 14 Page 29* illustrate the potential removal performance of total solids, total nitrogen and total phosphorus by a bioretention garden under FAWB design guideline conditions.

LANDSCAPING

Landscaping within private lots and public areas (including road reserves and drainage reserves) is to have a focus on utilising native species that will require minimal watering and fertiliser application. By implementing this strategy, the landscaping will not contribute to the pollution of the groundwater or surface water generated on the site. Furthermore, by utilising native plants with a high ability to absorb excess nutrients, the landscaping can help remove nutrients within the swale and basin systems, as well as take up nutrients from the groundwater. This can help reduce the overall load of nutrients leaving the site.

MONOTIORING

Pre and post development monitoring of surface and groundwater quality is to be undertaken.

The pre development monitoring will provide a clear picture of the site and the quality of water flowing across the site and through the groundwater. This can be used to set a base line for future monitoring as well as assist with developing any tailored treatment mechanisms to improve the existing and future water quality.

The extent and details of the monitoring programs is dependent on the treatment trains employed throughout the development. Detailed drainage plans for the development will be constructed at the relevant subdivision stage, and from these detailed plans post development surface quality monitoring requirements will be determined in consultation with DoW and the Shire. It is expected that the surface water quality samples would be required at all dispersal points and typically event based.

The Swan Coastal Plain water quality criteria of 0.1 mg/L for total phosphorus and 1.0 mg/L for total nitrogen will be adopted for monitoring of all water discharged from the development area. This criteria has been adopted as the targets for lowland tributaries in the *Peel Harvey Water Quality Improvement Plan*. These targets have been adopted in the Peel-Harvey, Swan Canning and Vasse Wonnerup-Geographe Bay water quality improvement plans, and are considered appropriate guidelines for other regions on the Swan Coastal Plain (DoW, 2010).

Further investigations will be required at the Local Water Management Strategy and Urban Water Management Plan stages to determine monitoring requirements.

District level monitoring will also be subject to a Development Contribution Scheme, to allow for ongoing monitoring.

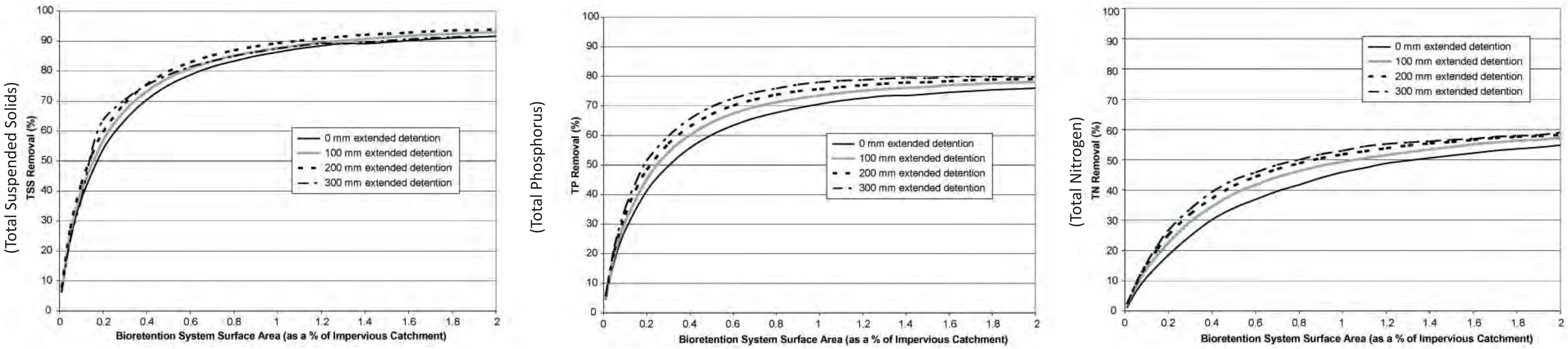


Figure 14 - Removal Performance of Bioretention Systems built to FAWB Specifications (source DOW stormwater management manual)

12 - WATER DEPENDENT ECOSYSTEMS MANAGEMENT

The main water dependent ecosystems (WDE) influenced directly by the development of the subject land are the CC wetland Number 14945 and the waterways that traverse the subject land. There are also a number of downstream and nearby significant WDE that have the potential to be influenced by water management on the subject land. Stormwater and groundwater will be managed so that the significant WDE areas retain hydrologic regimes comparable to pre-development. The water quality of the flows into these ecosystems will be managed through the treatment of surface and groundwater. *Section 11 page 26* of this DWMS details the water quality management for the development. Protection of the ecological functions of the receiving natural environments from the development is detailed below, and visually portrayed in *Figure 15 page 31*.

MANJEDAL BROOK – NORTHERN ECOLOGICAL LINKAGE,

The Manjedal Brook and its associated Conservation Category wetland will be protected through the use of appropriate buffers and a detailed Management Plan. The Management Plan is to detail strategies, practices and an implementation schedule that will provide protection and enhancement opportunities for the water dependent ecosystem. The final buffer distance is to be determined prior to completion of the LWMS. The buffer distance, and the activities that will happen within the buffer will need to be determined by this time. The buffer distance will also be partly determined by the immediate landuses surrounding the area, the direction of groundwater flow and the types of practices and infrastructure employed in the surrounding area to maximise the quality of water that will enter the wetland. Indicative radial distances are show on *Figure 15*, which will need further refining as the development planning progresses.

Treated stormwater runoff is to be controlled into the waterway to retained its pre-development hydro regime or agreed upon rates.

The waterway/wetlands will be located within reserves or public open space (POS), and this zoning will assist in providing appropriate buffers for ecological sustainability.

The length of Manjedal Brook that traverses the site after the recognised Conservation Category wetland area will be enhanced. The degraded waterway will be realigned with the road network. As part of this process the waterway will be configured to act as a stable waterway and will be planted out with appropriate native species. This will enhance the ecological functioning of the waterway compared to its current characteristics of being a weedy drain with erosion issues and limited native species. The waterway and surrounding area will be designated as a ecological linkage.

This whole system is also known as the Northern Ecological Linkage

SOUTHERN ECOLOGICAL LINKAGE

To further enhance the ecological connectivity of the district, an ecological linkage will be developed along a drainage line within the southern third of the site. This is an existing drainage line which is predominately a low flow, ephemeral constructed drain. It currently has little ecological functioning. This drain will be aligned with the road system. It will be planted and landscaped in a similar fashion to the northern ecological linkage.

BIORETENTION SWALES

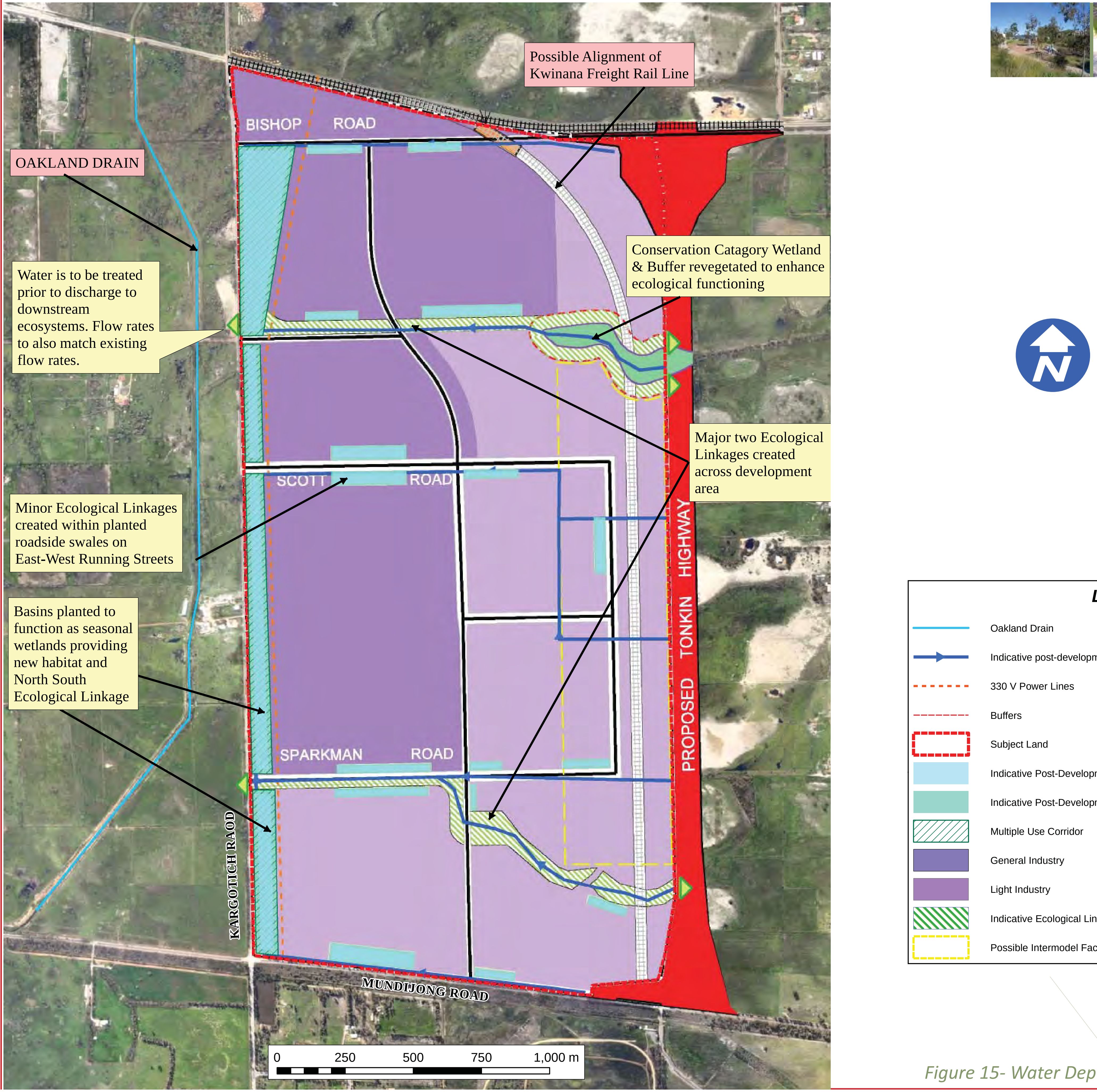
The bioretention swales that traverse the sites will also act as ephemeral streams and provide habitat values for fauna, especially avifauna and herpetofauna. This will be due to their use of native species for the plantings and the seasonal nature of their water regime, which will minimise small seasonal streams on the Swan Coastal Plain.

GROUNDWATER TREATMENT

Groundwater captured by the subsoil system will be directed to planted swales. These swales will provide an opportunity for the treatment of groundwater discharged to them. Furthermore, the groundwater will assist with the growth of the plants within the base of the swale, helping to increase the wetland/ waterway attributes of the swale system. This treatment of groundwater will also assist with improving the quality of water prior to it leaving the site and entering downstream sensitive environments.

DOWNSTREAM WDE

The downstream WDE will be protected primarily through the management of water on the site. This will include the release of stormwater at pre development rates up to the 1:100 ARI event. Stormwater and groundwater will also be treated so that the water leaving the site will be of an adequate quality to support the ecological functioning of the downstream ecosystems. See Section 11 for more details on water quality management.



Legend

- Oakland Drain
- Indicative post-development drainage lines
- 330 V Power Lines
- Buffers
- Subject Land
- Indicative Post-Development Drainage and Flood Storage Area(10 Years ARI)
- Indicative Post-Development Drainage Basin
- Multiple Use Corridor
- General Industry
- Light Industry
- Indicative Ecological Linkage
- Possible Intermodel Facility

Figure 15- Water Dependent Ecosystem Management

13 - GROUNDWATER MANAGEMENT

The focus of groundwater management for the development area is to maintain groundwater as close as possible to existing average maximum levels, which has been defined as the CGL for the site, while maintaining adequate separation from infrastructure. There may be some modification of groundwater levels within the site; however, the areas that feed the Conservation category wetland on Manjedal Brook and South of Mundijong Road will be maintained at levels that support key wetland functions.

The increase in total groundwater volumes, due to decreased evapotranspiration will be controlled through the subsoil and swale system to minimise the potential rise in groundwater levels.

Opportunities are also to be explored to utilise excess groundwater within the superficial aquifer that is generated due to the lower evapotranspiration of the site post development.

Furthermore groundwater will be managed to achieve a high water quality.

INFRASTRUCTURE SEPARATION

Appropriate separation between lot levels and the CGL will be achieved across the entire subject land. The separation will be achieved through three main methods: use of porous clean fill where necessary; open swales and sub-soil pipes.

The distance between sub-soil pipes will be determined by the permeability of the soil within that section of the development. With subsoils placed along the side boundaries, the separation distance will be approximately 40m. Swales will be along the road reserves and drainage corridors. With this configuration, maximum mounding of groundwater can be kept to approximately 0.4m. This has been determined through modelling which focused on the maximum groundwater mounding from a 1:5 ARI event occurring in the wettest month of the year. For the majority of the time mounding will be significantly less than this. More details on the groundwater mounding modelling can be found in the Fill Assessment report which is included in the CD of attachments.

At the LWMS, more detailed modelling of optimum subsoil spacing and fill levels are to be undertaken, based on the same principals.

Swales will generally be set at the CGL level and will assist in groundwater control. Subsoil drains would also discharge at just above the CGL level to the swales to ensure the subsoils remain free draining between storm events.

By maintaining the groundwater at a level similar to the current average maximum levels, the development will have minimal impact on the groundwater dependent ecosystems that exist on the subject land. Groundwater will still be fed into the wetland systems and the receiving rivers.

Certain areas of industrial lots require less fill to actually function without being impacted upon, or adversely impacting the groundwater. These are areas that don't contain significant infrastructure such as buildings or soakwells. These areas of lower fill requirements include, parking areas, laydown areas and general vehicle movement areas. The drainage basin areas are also able to utilise less fill, provided they are designed to have their bases close to the groundwater. By being close to the groundwater, the basins can actually function similar to an ephemeral wetland.

The building envelopes should require a maximum of 1.0m of fill/separation to the groundwater. The surrounding lot really only requires 0.3m of fill above the maximum groundwater mound (in the middle of the lot). For the spacing of subsoils suggested, this equates to an average fill height of 0.7m (assuming the groundwater is traditionally at the pre development soil surface). On the edges of the lot, the depth to groundwater will be less, tending to be closer to 0.6m -0.7m. These are the areas where stormwater basins/soakwells and buildings etc should preferentially be located.

Porous clean fill will be used where necessary to achieve the required separation. Any fill of imported sands will require compaction to relevant standards. The sand fill will be required to have a high permeability to allow water to easily infiltrate down and into the original soil layer.

A diagrammatic representation of a typical industrial lot can be seen in *Figure 18a page 34*. A diagrammatic representation of how the groundwater system links together can be seen in *Figures 16,17 & 18a/b pages 33 and 34* respectively.

LOWERING OF GROUNDWATER LEVELS

Lowering of groundwater to below the existing annual maximum level can assist with minimising fill. This may be an option for areas away from significant natural environments such as the Manjedal Brook and associated wetlands.

The risk of Acid Sulphate Soils will need to be carefully considered as well, although if the levels are only slightly reduced below the maximum and don't impact the minimum levels, then there is unlikely to be significant impact on both the production of ASS and the mobilisation of acidic groundwater and pollutants mobilised by the increase in acidity. The potential to lower groundwater levels will be limited on the subject land, due to the flat nature of much of the land and the invert of the existing drainage points, which currently control groundwater discharge when it is at its peak. This discharge is controlled by the existing on site drains and the swale drain along the boundary roads.

Due to these limitations, the calculations of fill required for the site have assumed that the AAMGL will be very similar to the post development CGL. For the coarse calculations undertaken, the CGL has been assumed to be at the natural surface of the site. As detailed design is undertake, there may be opportunities for localised lowering of the groundwater to a small degree in the order of 200-300mm.

PUMPING AND REUSE OF GROUNDWATER

Pumping of the superficial groundwater for potential reuse is assumed to not impact the peak groundwater level as the system may fail during critical periods of heavy rain. It may however provide an option for generally keeping the groundwater down. It can also provide a water source for use within the subject land or nearby.

QUALITY MANAGEMENT

Groundwater quality will be improved through the use of soil amendment products incorporated into the development's bioretention systems. This will provide treatment of all surface water runoff collected within the drainage network prior to infiltration into the groundwater. These products bind nutrients and other contaminants that are mobile within water infiltrating from the surface.

ASS MANAGEMENT

Subject to further investigation, the impacts of any actual ASS or potential ASS would be integrated with the works on the site through a detailed ASS Management Plan. Deep sewers are the most likely activity to disturb ASS if any are present on the site. Vacuum or pressure sewer systems may be used to avoid this issue, subject to future detailed design. It is not expected that ASS issues will occur on-site that conventional methods cannot adequately manage.

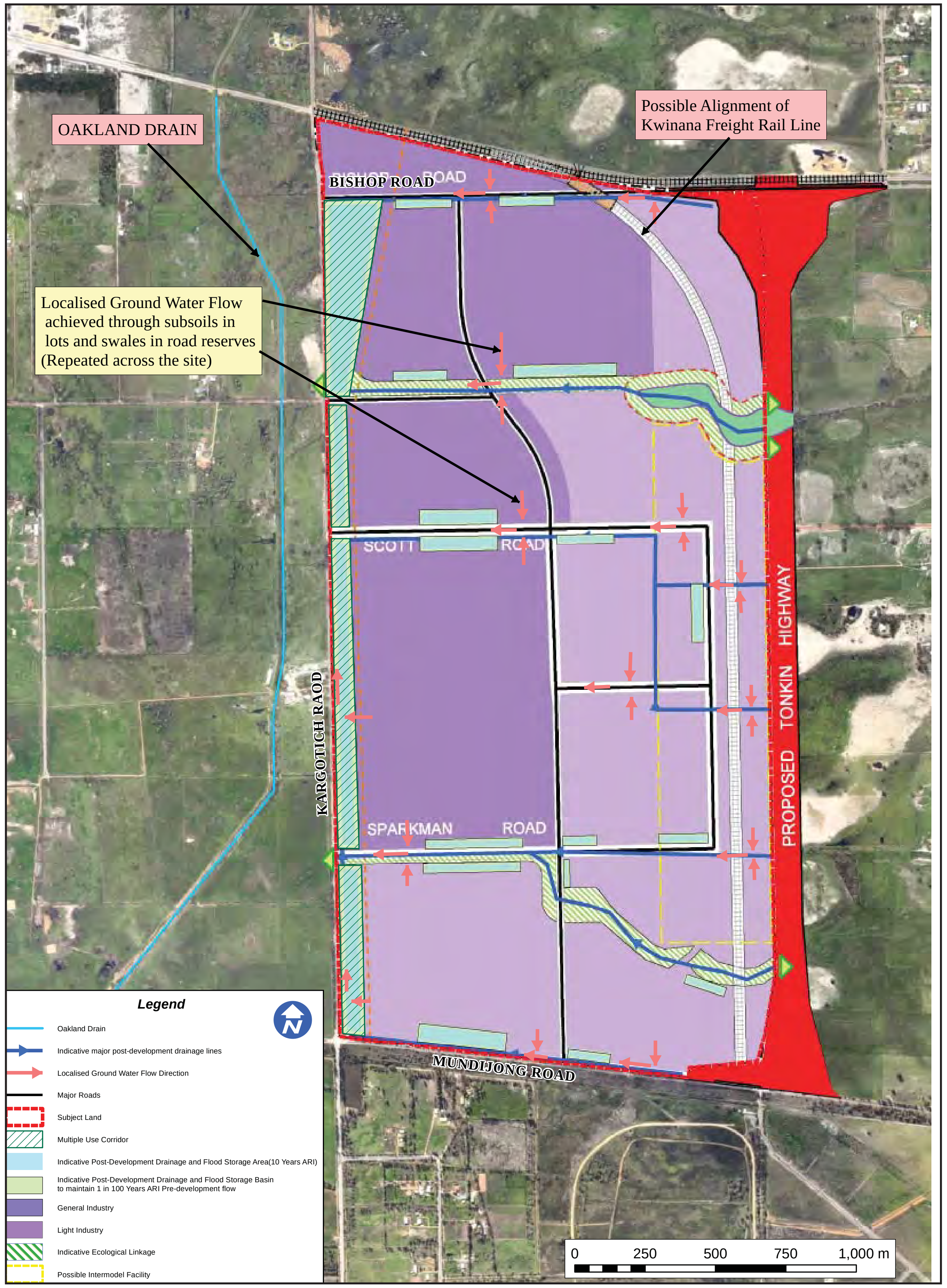


Figure 16- Post Development Ground water Management Plan

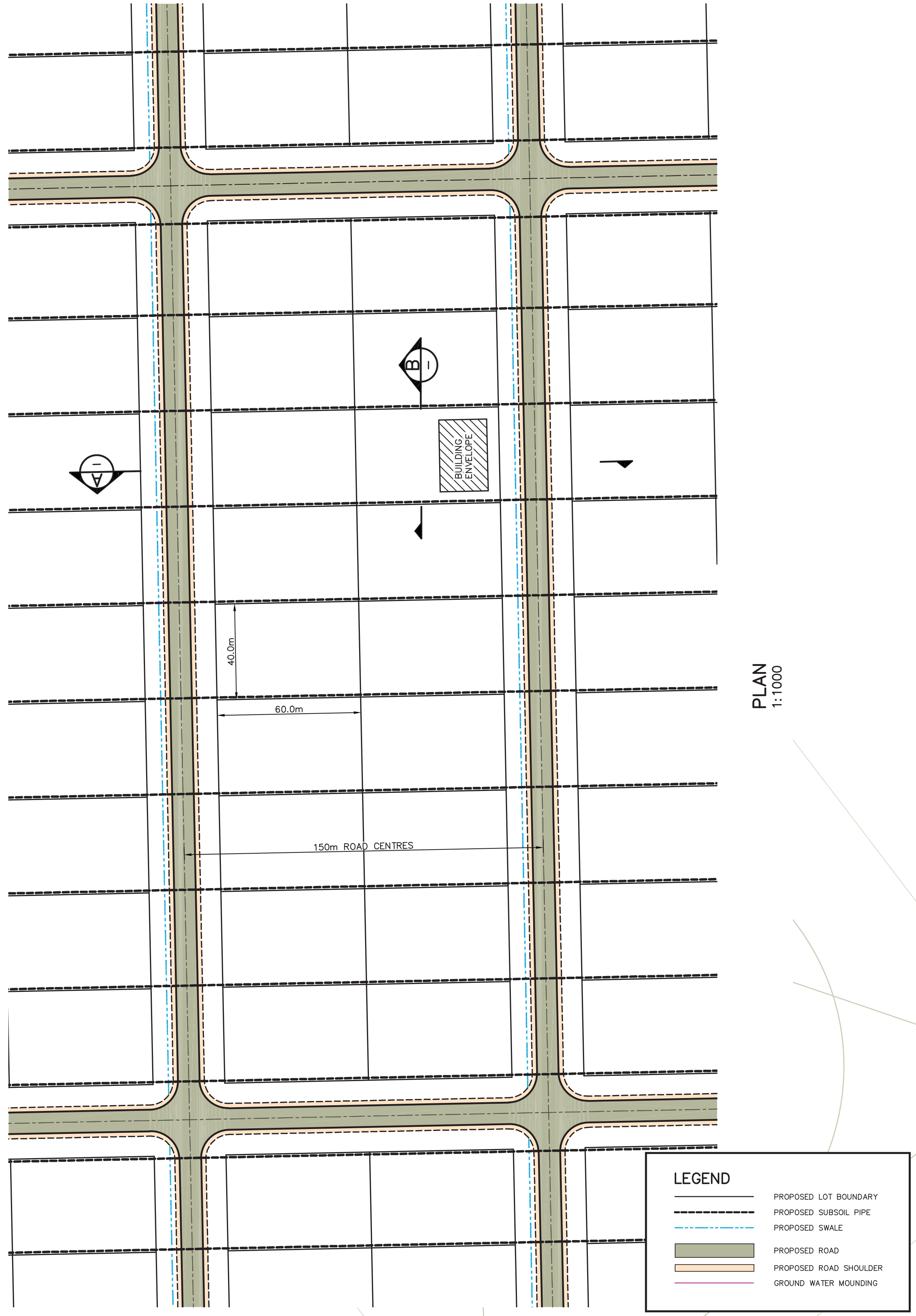


Figure 17- Typical Subsoil and Drainage Layout Plan

MONITORING

Pre and post development monitoring of groundwater levels and quality will be undertaken. The extent and details of the monitoring programs is dependent on the extent and depth of fill required across the development, and any other intrusions of the development on the groundwater management. Detailed earthwork and engineering plans for the development will be constructed at the relevant subdivision stages, and from these detailed plans post development groundwater levels and quality monitoring requirements will be determined in consultation with DoW and the Shire.

Monitoring of the groundwater's quality at the sub-soil discharge points and selected bores will suffice for post-development quality monitoring.

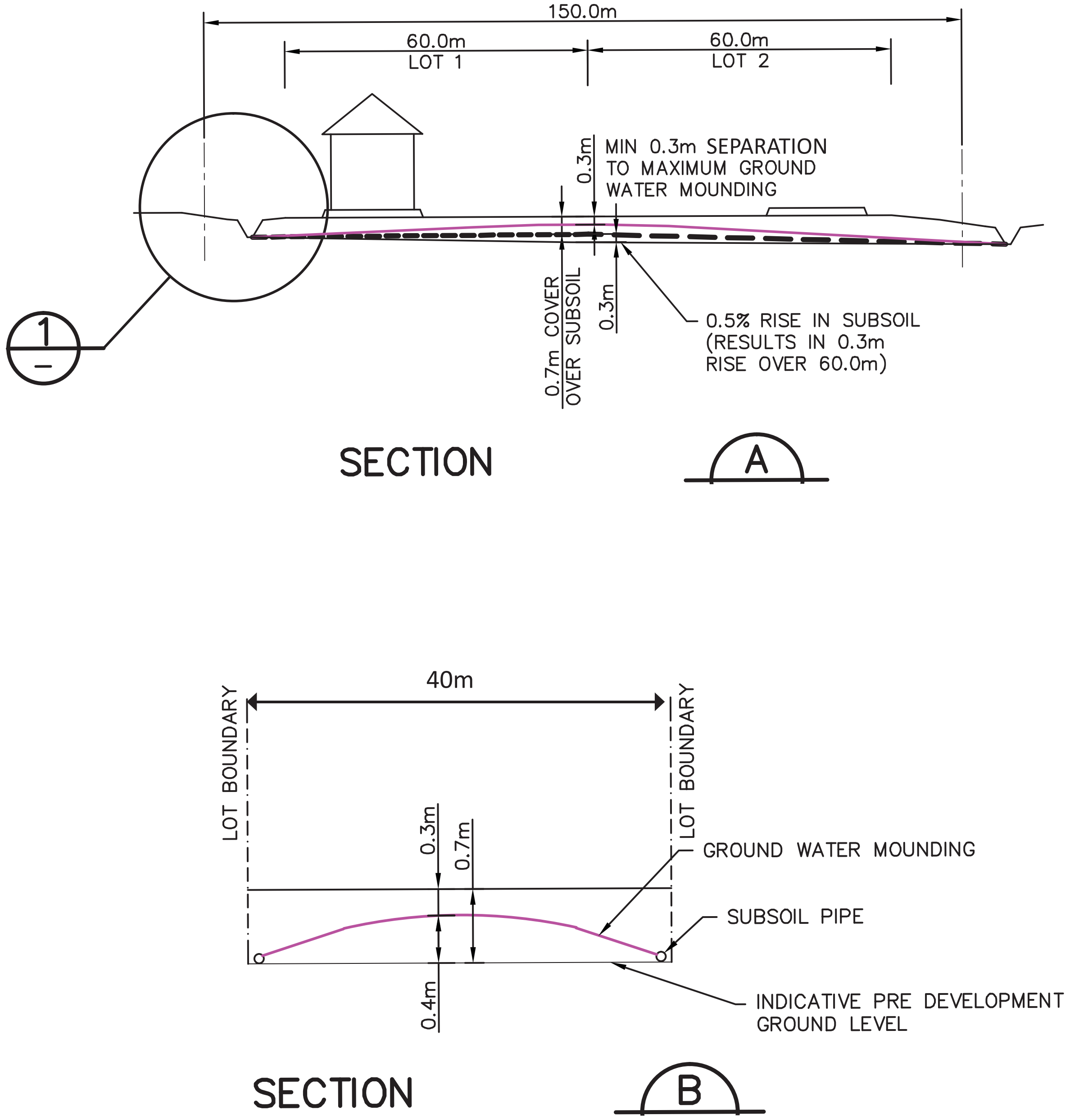


Figure 18a - Typical Lot Ground Water Management

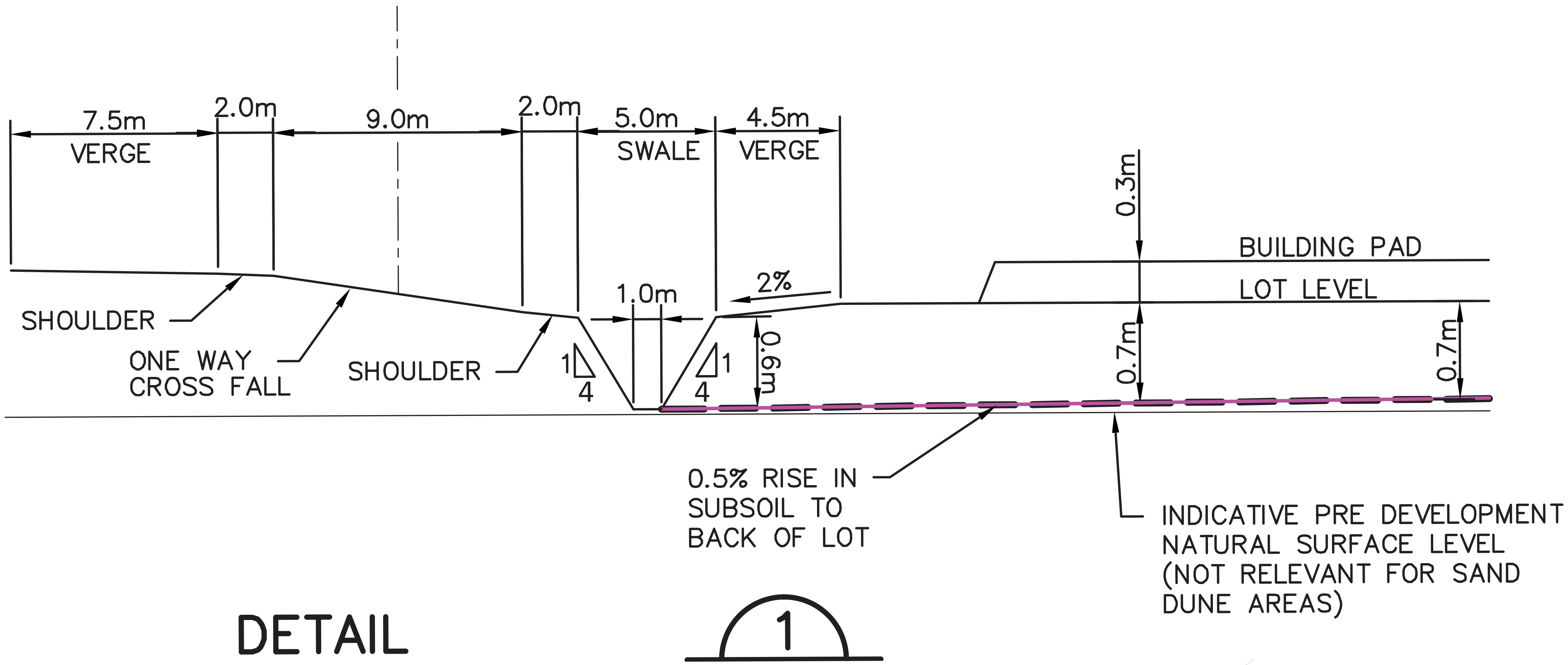


Figure 18b - Subsoil and Drainage Details and Section

14 – WATER SUPPLY AND WASTEWATER MANAGEMENT

WATER SUPPLY

STANDARD POTABLE

The Water Corporation has advised that potable water may be accessed from Mundijong town site. There may be limited capacity for some industrial processing. This source may be able to supply the early stages of development.

The Serpentine reticulation main (150mm) is located approximately one (1) kilometre to the west of the investigation area whereas the serpentine trunk main (1200mm) is located approximately seven (7) Kilometres south of Mundijong Road. Subject to approvals from the Water Corporation, the trunk main may be accessed to provide potable water requirements. There will be significant capital expenses related to the supply of the area with larger volumes of standard potable water.

ALTERNATIVE WATER SUPPLY

STORMWATER

Subject to further investigation there is the potential to harvest storm water for processing. This water could potentially be used for industrial uses throughout the year. Alternatively, it could be stored and utilised for the watering of POS areas and sporting facilities.

RAINWATER

There is likely to be significant areas of impervious roof catchment throughout the subject land. This represents an opportunity to harvest and reuse relatively clean water on a lot by lot basis or as an integrated scheme across the industrial precinct.

Due to the higher quality of this water, there is the potential to investigate the option of aquifer recharge.

TREATED RECYCLED WASTEWATER

The Water Corporation is not proposing to construct a wastewater treatment facility within the site, or for that matter anywhere in the locality that can be used for wastewater generated within the development. The Corporation has also stated:

a) Relative to other industry, industry at West Mundijong is unlikely to generate significant demand for processing water. On this basis it is unlikely that a business case could be developed and supported for installation of infrastructure to enable re-use of treated wastewater at Mundijong

An alternative service provider may however treat wastewater on the subject land via sewer mining, or alternatively bring a supply line back from a treatment plant. Further investigation into this option for the west Mundijong area is being undertaken by Essential Environmental. This investigation highlights the options specifically for the land adjoining to the east, however there is the possibility to expanded it into the subject land as a non potable water source.

Subject to further feasibility, grey water harvesting and recycling by individual industries may still be feasible

GROUNDWATER

There is the possibility to utilise groundwater resources from both shallow and deeper aquifers located under the subject land. These will be subject to licences granted through the Department of Water and relate to the allocations available.

Within the superficial aquifer there is potential to harvest the increase volume of groundwater that is often generated by development of land from agricultural to industrial. This extra water is due to the potential for increase infiltration and reduced evapotranspiration, leading to a build up of water stored within the soil profile. This can be further enhanced through the use of fill which increases the level of available storage height prior to running off the land. This extra groundwater can be harvested through pumping and/or subsoil drainage piping.

A secure storage system would need to be developed in conjunction with this option. Further investigation will be needed prior to completion of the LWMS to determine the feasibility and details of this system.

MANAGED AQUIFER RECHARGE SYSTEM

A Managed Aquifer Recharge System may be a viable option to store clean water from the subject land for later use within the development or in nearby areas. One options is to collect excess roof runoff and inject this into an appropriate deeper aquifer. This would also assist with controlling excessive groundwater rise within the superficial aquifer, by reducing the volume of water being infiltrated on site.

Rainwater would require minimal treatment prior to injection into an aquifer, making it a potentially viable source. Other sources may also be viable but are likely to require further treatment to minimise the risk of polluting the chosen aquifer.

A detailed investigation will need to be undertaken into the viability and details of this option. The study should adhere to the Managed Aquifer Recharge Policy developed by the Department of Water.

WASTEWATER

MAINS SEWER

Currently, the subject land is not connected to deep sewerage.

There is some initial planning for a new wastewater pumping station to be constructed to the east of the subject land. Advice to date is that this will not take water from the subject land. Should this change in the future, it is likely the area required for the pumping station and its buffer would increase. The plant would also be uphill of the subject land, requiring pumping of effluent to this point.

At this point in time, wastewater from the subject land is planned to be conveyed to the Woodman Point wastewater treatment plant (City of Cockburn) via Byford.

The Water Corporation is proposing to install a 1 meter diameter trunk main within the Mundijong Road reserve. The main will ultimately convey wastewater from Mundijong to the proposed East Rockingham wastewater treatment plant scheduled for completion in 2015.

The future wastewater planning will need to consider the types and flow rates of wastewater that will be generated from the industrial area and the suitability of these for discharge to the Water Corporation's wastewater system. Some industries may require their wastewater to be pre treated prior to discharging to the Water Corporation system. Should an agricultural food precinct be developed, there is likely to be a demand for a wastewater system that can accommodate high flows.

ON SITE TREATMENT AND DISPOSAL

The high groundwater within the subject land would make on site disposal difficult. This option could be utilised for some dry industry, especially in the early stages, however is not the preferred option for the development of the entire site.

Should on site treatment and disposal be utilised the following design considerations will need to be included:

- appropriate systems for the site fill and existing soils;
- requirement for installation to be a minimum of 5m from foundations;
- proximity of disposal systems to subsoil systems on-site to ensure no mobilisation of nutrients into subsoil systems;
- any water recycling and/or reuse schemes implemented;
- the source and composition of the wastewater, including quality and contaminants present); and
- the volume of wastewater for the lot (affects type of system installed, number of systems required and area required for the system to function appropriately).

The onsite disposal systems will require careful design to ensure all objectives are met but there are numerous systems available that would meet most requirements expected with Alternative Treatment technologies.

The DoW's *water Quality Protection Note (WQPN) 51 – Industrial Wastewater Management and Disposal* provides guidance for industrial sites on appropriate facility designs and best operational management practices to minimise risk of contamination. The developer will emphasise the significance of understanding and achieving the notes within this document.

GREYWATER RE-USE SCHEMES

The greatest potential for grey water reuse on this site is at the individual lot level. With appropriately designed on-site effluent treatment systems, the treated effluent may possibly be reused on each lot's landscaped areas or other fit for purpose uses. The feasibility of this option should be undertaken at the LWMS stage in relation to other water supply, treatment and reuse schemes developed for the site.

REGULATIONS

Any of the above schemes where non-drinking water is used will need to comply with the *Draft approval framework for the use of non-drinking water in Western Australia* (DoW).

The schemes will need to comply with the *Australian Guidelines for Water Recycling* where relevant.

There may also be the need for a licensed operator depending on the characteristics of the scheme. This may include having the scheme approved through the Economic Regulation Authority.

Approval by other relevant authorities which may include Department of Health, Department of Water, Department of Environment and Conservation and Local Government Authority, may also be required.

These aspects should be further refined as part of the LWMS's and UWMP's for the subject land.

15 – WATER CONSERVATION

According to the *State Water Plan of 2007* by the Western Australian government, 16% of the state's total water consumption in 2005 was by the commercial and industry sector. The Plan did not set a goal for this sector, unlike the 100kL objective per person set for residential areas.

The state government of Western Australia does however require all businesses that use more than 20,000kL of scheme water per year to participate in the Water Corporation's Waterwise Business Program. This Program involves:

- Undertaking a water management assessment annually with the Water Corporation (or Aqwest);
- Developing a five (5) yearly Water Efficiency Management Plan (WEMP); and
- Annual review of WEMPs and reporting the progress against the water savings action plan.

These are requirements under the *Water Agencies (Water Restrictions) By-laws 1998* and are mandatory. The WEMP involves the preparation and implementation of water consumption targets over a five 5 years period. The business has to monitor water usage throughout each year of the plan, and a report is to be submitted to the Water Corporation annually.

There is an opportunity as part of this process to develop ways to manage, recycle and conserve water within individual businesses and even sectors of the industrial park.

EDUCATION AND AWARENESS

Business owners are to be encouraged to promote water efficient behaviour amongst employees through awareness raising material and opportunities. Possible measures to encourage water efficient behaviour may be:

- Installing signs at all water using fixtures;
- Installing shower timers to encourage shorter showers where these facilities are provided;
- User education for dishwashers, washing machines and glass washers to ensure there is a full load, where these are provided;
- Include water conservation practices in staff or tenant inductions;
- Ensure water conservation or management is continually brought up at meetings;
- Promote their businesses water-saving initiatives or outcomes within the local community;
- Encourage employees to identify water-saving measures; and
- Offer an incentive scheme to encourage water-saving innovations and ideas.

Further details are to be developed in the relevant LWMS's and UWMP's

RAINWATER TANKS

Businesses are to be encouraged to install rainwater tanks, with a level controlled air gap, to reduce the quantity of water consumption from the water mains. The water may be used for a variety of fit for purpose uses, related to the industry and feasible treatment levels.

A suitable tank size should be determined according to the roof area of the buildings on a lot and the water usage practices and applications by the business.

There is also the possibility to utilise a larger scheme that takes excess roof runoff for storage within a suitable aquifer or water body. This scheme will require more detailed investigation prior to the LWMS being completed.

ONSITE INFILTRATION AND STORMWATER DISCHARGE

Excess roof runoff will be directed to a property connection soakwell, rainwater tank or basin. The soils at the site are suggested to infiltrate runoff into the soil profile and groundwater below. Overland runoff from the gardens and hard surfaces around the house, excluding the roof, will be directed predominately to the road drainage network discussed in the drainage management sections. The remainder will infiltrate into the soil and groundwater within the lot. This water will partly assist with maintaining the native landscaping through direct discharge to areas containg this vegetation, and through recharging of the groundwater.

WATERWISE LANDSCAPING

Natural rainfall alone should be sufficient to maintain water wise landscaped areas once established. Front of lot landscaping and street reserve landscaping is to be composed of water wise plantings suited to the local environment.

Details on appropriate species and areas of planting/landscaping are to be established as part of future planning for the site.

The source of water for any landscape irrigation will require further investigation. Details regarding water supply and irrigation of landscape areas are to be provided in the LWMS. The landscaped areas could potentially be watered from groundwater, treated wastewater, harvested stormwater or rainwater.

The use of swales and potentially bioretention gardens, planted with native species will receive a significant portion of their irrigation requirements directly from stormwater runoff.

16 – IMPLEMENTATION FRAMEWORK AND MONITORING

PRE-DEVELOPMENT

GROUNDWATER

Pre-development monitoring for the subject land will need to include a minimum of two (2) years of groundwater levels and quality. This is to include 2 winter peaks. The focus for the monitoring is to determine the maximum and minimum levels of groundwater throughout the year and general quality. These results are to be compared against more regional data produced by DoW and surround developments.

The indicative locations for sampling are shown in *Figure 19 page 40*. These bores should be a minimum of 3m below the surface.

The quality parameters should include the following:

Physical

Electrical Conductivity (EC), pH, salinity, temperature and Alkalinity.

Chemical

Nitrate (as NO3), Ammonia (as N), Total Nitrogen, Total Phosphorous, Filterable Reactive Phosphorous (P), and metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Zn).

SURFACE WATER

Monitoring of quality within the main waterways that traverse then land is recommended. This should happen for a minimum of two (2) year prior to development, with a focus on the period that the waterways are flowing. At least two (2)samples per site should be collected each year. Samples are to be collected at the point at which the waterways enter and exit the subject land. The indicative locations for sampling are shown in *Figure 19 page 40*.
The tested parameters should include:

Physical

Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), salinity, temperature, Oxygen Replacement Potential (ORP) turbidity, total suspended solids and Alkalinity.

Chemical

Nitrate (as NO3), Ammonia (as N), Total Nitrogen, Total Phosphorous, Filterable Reactive Phosphorous (P), and metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Zn).

WETLAND

An assessment of Conservation Categorey Wetland Number 14945 should be undertaken, with this information used as an existing pre development baseline. The assessment should include indicative hydro regimes, flora present, vegetation complexes, weed issues and likely fauna habitat. As part of the surface water and groundwater monitoring regimes, sampling points are to be set up so that they can provide data on the hydro regimes for the wetland.

CONSTRUCTION PHASE

Installation of drainage control structures is to occur ahead of the construction phase of the development. This will include the use of water sensitive design techniques such as sediment curtains, hydro-mulching and temporary detention basins to maintain the quality of the water leaving the development area during construction. The collection pits will be monitored for any damage, including sediment build up and litter accumulation during, and at the completion of, construction to ensure the pit's effectiveness is not diminished post-development.

Some WSUD works, such as planting of Bioretention gardens, may be delayed until building construction is substantially complete. This is to minimise contamination of the system with sediments and other debris generated as part of the building phase.

All contractors working on any future development of the site will be made aware of their responsibilities under the *Aboriginal Heritage Act 1972* with regard to finding potential archaeological sites. In the event that a potential site is discovered, all work in the area will cease and the DIA should be contacted.

POST-DEVELOPMENT

WATER SENSITIVE URBAN DESIGN (WSUD) INFRASTRUCTURE

Routine monitoring within the development area that checks the status of key functional WSUD elements is to be undertaken to ensure they meet specified design requirements. This will include:

- ensuring the inlet and outlet structures are free of debris;
- vegetative cover of the systems is maintained;
- sediment build up is not impeding the functionality;
- erosion is not present;
- soils are not compacted;
- litter is removed; and
- hydrocarbons are not present in the system.

Monitoring of the established WSUD elements operations can provide important insights on the likely performance of them in pollution reduction and stormwater management functionality. Inspection of the WSUD elements will be undertaken by the developer until an agreed upon time between developers and the Shire. The indicative timeframe is for two (2)years after the completion of works with inspections every three months. This is to be reviewed at the LWMS and UWMP stages. *Table 4* summaries the particular items to monitor and the purpose of monitoring, the trigger signs that require immediate action and the maintenance action required.

Compared to traditional engineered structures for stormwater runoff management, the WSUD elements will only require minimal routine maintenance similar to a landscaping and ecological corridor maintenance nature. The most common maintenance is the removal of weeds, debris and siltation. The most time intensive period of maintenance for a vegetated WSUD system is during plant establishment (which typically includes two growing seasons), when supplementary watering, plant replacement and weeding may be required.

It is recommended that vegetated WSUD elements are monitored by personnel with floristic knowledge and/or qualifications, as they will be capable of identifying evasive species within the natively vegetated WSUD systems. Furthermore, personnel in charge of monitoring should have a good understanding of principles and the functional design of the WSUD elements and the treatment system. The maintenance activities prompted through monitoring activities will generally require coordination between landscape and civil services.

The WSUD elements will be constructed and utilised in different stages so that the functions of the WSUD elements are protected from elevated pollutant loads generated from a developing catchment.

Maintenance inspections should be scheduled to be conducted after a significant storm event. Inspections should focus on ponding time for the different systems, unequal surface flow distribution, sedimentation and scouring, as well as deposition of coarse litter.

Performance monitoring of WSUD elements via detailed water sampling and testing for contaminant concentrations has not been scheduled at this stage. The exact parameters and monitoring schedule is to be further detailed in the LWMS and subsequent UWMP for the site.

GROUNDWATER

Groundwater monitoring may be required post development to determine that the development is not impacting on nearby significant wetlands through changes in levels or poor water quality. The exact parameters and monitoring regime will be determined by the final land uses. For this reason, further details on post development monitoring are to be developed as part of the LWMS and UWMP.

SURFACE WATER

Surface water monitoring may be required post development to determine that the development is not impacting detrimentally on the surface water quality leaving the site. Sampling points should be set up at the discharge points from the subject land or on site significant wetlands. These should be checked against established guidelines and the quality of water entering the site from upstream. The exact parameters and monitoring regime will be determined by the final land uses. For this reason, further details on post development monitoring are to be developed as part of the LWMS and UWMP.

District level monitoring is also likely to be subject to a Development Contribution Arrangment.

WETLAND

The monitoring of the wetland is to be related to the rehabilitation works and the monitoring of water resources above. A Wetland Management Plan should be established for the wetland with this plan outlining the most appropriate monitoring regime. This should be done at the UWMP, with preliminary concepts developed as part of the LWMS.

RESPONSIBILITY AND REPORTING

The developer of the land will be responsible for the monitoring and reporting of all aspects listed above. Advice should be sort from the DoW, DEC and the Shire on exact parameters and regimes.

Information collected from monitoring programs, where necessary should be recorded and provided in an agreed format to the DoW and the Shire and other relevant stakeholders. All monitoring is to be as per the Department of Waters, *Water Monitoring Guidlines for better urban water management strategies and plans - October 2012 or* updated versions of this report

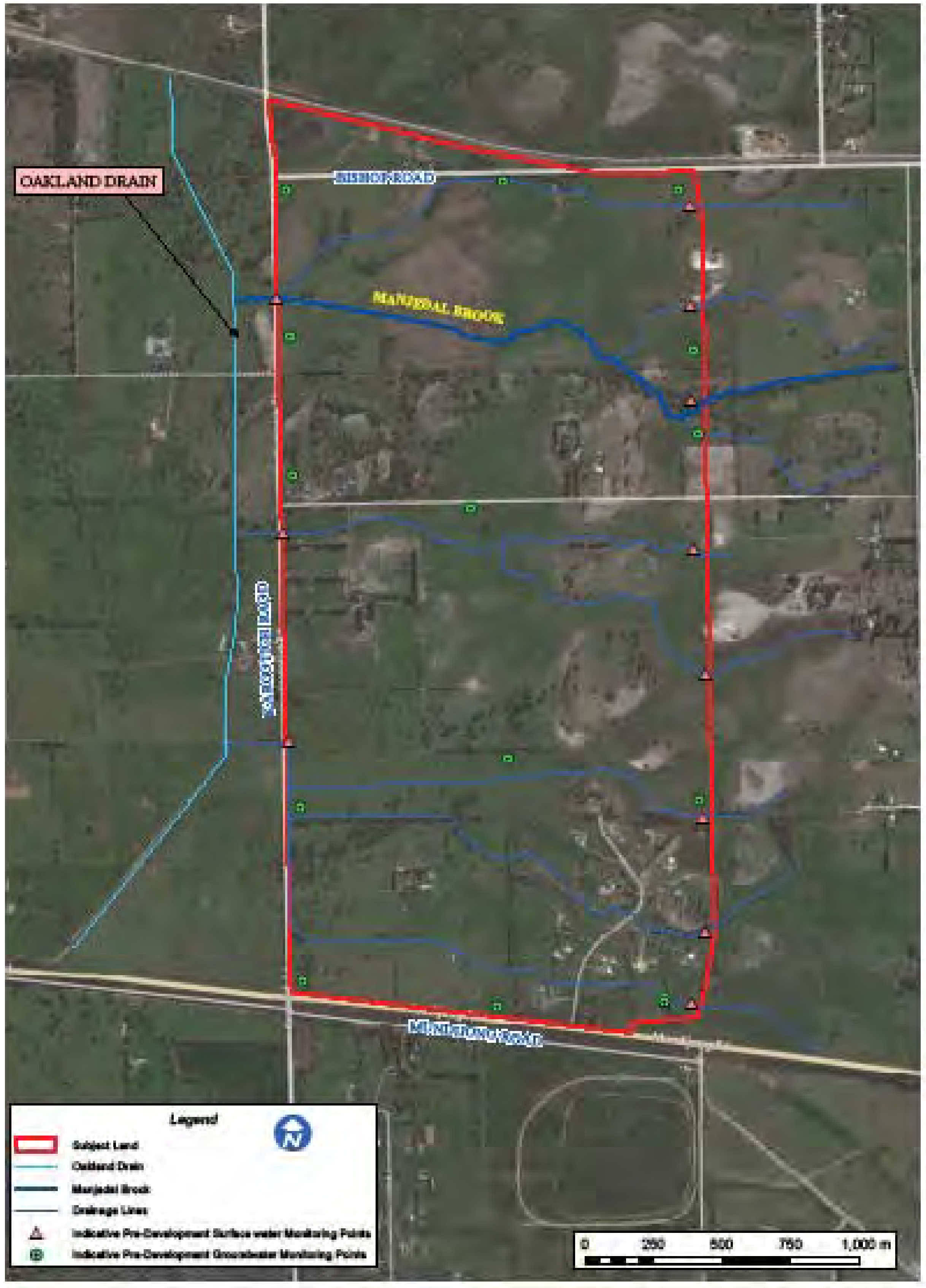


Figure 19 - Indicative monitoring points

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsibility
PRE-DEVELOPMENT						
Groundwater	Quality	To determine pre-development quality to assist with setting base lines for the subject land.	NA	NA	Minimum of two samples a year for 2 years	Developer
	Levels	To determine pre-development levels to assist with setting AAMGL for the subject land.	NA	NA	Monthly sampling over 'winter' period, 3 monthly over summer. Minimum of 2 winters, or as determined at LWMS stage.	Developer
Surface Water	Quality	To determine pre-development quality to assist with setting base lines for the subject land.	NA	NA	Minimum of two samples a year for 2 years, or as determined at LWMS stage.	Developer
CONSTRUCTION PHASE & POST-DEVELOPMENT (more details on this section to be provided in LWMS and UWMP)						
Groundwater	Quality	To determine post-development quality to assist with determining if site is meeting guidelines.	Values siginificantly outside recommended guidelines	Determine cause and rectify	Minimum of two samples a year for 2 years	Developer
	Levels	To determine post-development levelsy to assist with determining if site is meeting guidelines.	Values siginificantly outside recommended guidelines	Determine cause and rectify	Monthly sampling over 'winter' period, 3 monthly over summer. Minimum of 2 winters.	Developer
Drainage Management Systems	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to the City/Shire
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Every 3 months	Developer until handover to the City/Shire
	Sediment and Silt Build Up	Inspection for sediment and silt accumulation within pits, on the surface of bioretention systems and within basins.	Accumulation of large volumes of sediments and/or silts in pits or on the surface (according to City standards).	Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed.	Every 3 months	Developer until handover to the City/Shire
	Compaction	Inspection of filter media for compaction.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to the City/Shire
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Every 3 months	Developer until handover to the City/Shire
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Every 3 months	Developer until handover to the City/Shire
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Every 3 months	Developer until handover to the City/Shire
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Every 3 months	Developer until handover to the City/Shire
	Oil/Hydrocarbons	Inspection for the occurrence of oil on surface.	Oil coverage persists for more than 3 weeks, and is thick.	Notify the EPA of the spill and clean up requirements.	Every 3 months	Developer until handover to the City/Shire
	Surface Water Quality	Sampling of water quality (TSS, TN & TP) at discharge (outlet) points.	0.1mg/L for TP and 1.0mg/L for TN.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination. More detailed assessments may be required.	Every 3 months	Developer
POST-DEVELOPMENT ONLY						
Water Conservation	Water Consumption	Review and report on WEMP to the Water Corporation.	Determined by WEMP and Water Corporation.	Determined by WEMP and Water Corporation.	Yearly for at least 3 years.	Business Owners
Groundwater	Quality	To determine post-development quality and testing to be done at sub-soil discharge points.	0.1mg/L for TP and 1.0mg/L for TN.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Minimum of two samples a year, for at least 3 years.	Developer
	Levels	Monitoring required to sub-soil drainage system is operating as designed.	Levels exceeding controlleg groundwater level.	Undertake appropriate responses to address the issue.	Monthly sampling over 'winter' period, for at least 3 years.	Developer (agreed handover)

Table 5 Monitoring and Maintenance Table

17 – RECOMMENDATIONS FOR FUTURE STUDIES

For future development of the land past the rezoning stage the following additional studies may be required to support the LWMS and subsequent UWMP;

- Preliminary ASS investigation
- Wetland Assessment and Management Plan
- Detailed Earthworks and Services Strategies
- Alternative water supply and treatment options
- Managed Aquifer Recharge assessment
- Detailed Drainage Design

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ANNEXURE -A-

DRAINAGE STUDY FOR WEST MUNDIJONG INDUSTRIAL AREA

Town Planning Management Engineering

Serpentine Jarrahdale Shire

Drainage Study for West Mundijong Industrial Area

Research, Design & Delivery of Sustainable Development

Date January 2013
Job No. 12099

Project Management Planning Environmental Engineering

WEST MUNDIJONG DRAINAGE STUDY

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DOCUMENT QUALITY CONTROL

Prepared for: **Shire of Serpentine Jarrahdale**

Project: **Drainage Study For West Mundijong Industrial Area**

Project Job No: **12099**

Date: **25th January 2013**

Prepared by: **Bishwa Mishra**

Reviewed by: **Brendan Oversby**

Revision History

Revision No.	Revision Date	Details	Authorised by	Signature
0				
1	24/01/2013	Amendments as per Shire Requirements		

TME Town Planning Management Engineering Pty Ltd
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1.0 INTRODUCTION

TME Town Planning Management Engineering Pty Ltd (TME) has been engaged by the Shire of Serpentine Jarrahdale (the Shire) to undertake a drainage study of the West Mundijong Industrial Area.

The Subject land is approximately 1.5 Km west of the existing Mundijong town site. The subject land is bounded by Mundijong Road (South), Tonkin Highway Road reserve (East), Bishop Road (North) and Kargotich Road (West). It is approximately 474 hectares in area.

The majority of the site is a mildly sloping wet plain. The landform slopes from East to West with fall from 25-26m AHD to 16m AHD. The slopes vary from 0.2 to 1% with the slope generally flattening towards the West. Low Bassendean sand ridges area located sporadically across the subject land being peak up to 27 m AHD.

The subject land is drained by a number of small drains and waterways that all exit the site on the Western Boundary. The site is also traversed by larger waterways, including Manjedal Brook, that carry significant flows. There are significant external inflows entering the site from East and draining out to West under Kargotich Road to the Department of Water (DoW) drain namely Oakland land which finally drains to the Serpentine River and Peel Harvey Inlet. The Oakland drain runs North to South parallel to the subject land.

The major thrust of this study is to analyse the existing drainage situation and provide indicative storage requirement in post development situation to assist with preparation of District Water Management Strategy. On the basis of availability of information and scope of the study this drainage study is purely intended for District Water Management Strategy and requires refinement and detail study during detail phase of design.

In order to get flood extent of drainage lines within the site Hydrologic Engineering Centres – River Analysis System (*HECRAS*) software is utilised whereas for storage requirements *DRAINS* software is utilised. For external inflows broad scale modelling done by the DoW is used.

2.0 STUDY OBJECTIVES

The study objectives were to:

- Review existing drainage situation of the site;
- Develop HECRAS model for Pre-development situation; and
- Develop drainage models using the latest version of the *DRAINS* computer program. Run the *DRAINS* Model for 10 and 100 year Average Recurrence Interval (ARI) to identify the storage requirements to assist with the preparation of the District Water Management Strategy.

3.0 AVAILABLE INFORMATION

Considerable information was available which includes:

i. Light Detection and Ranging (LiDAR) data of the "Subject Land";

ii. External inflows and flood mapping of the subject land from DoW ; and

iii. Broad scale planning of the subject land by TME.

4.0 METHODOLOGY

Based on the site condition and available information, drainage modelling has been undertaken in two parts. Firstly, drainage lines were identified on the basis of LiDAR and information provided by the DoW. Using ArcGIS and *HEC-GEORAS*, cross sections and other required geometric information were generated and exported to *HECRAS*. Utilising external inflows at 8 locations along the eastern boundary 1 in 10 years and 1 in 100 years steady flood modelling was performed. Roughness of 0.038 was used based on modelling done by the DoW. This should be refined in later stages. Results from *HECRAS* modelling were imported to *ArcGIS* and using *HEC-GEORAS* interface. From this flood mapping was undertaken.

Secondly, using LiDAR and an onsite investigation, which identified existing three (3) outlets, three (3) major catchments and 14 sub catchments were defined. Flow lengths and slopes were also derived from LiDAR.

0.5 pervious and 0.9 impervious effective runoff coefficients were used to reflect the high groundwater table. Since the rational method does not produce hydrographs, Extended Rational Method was used to model flow so that hydrographs could be produced and storage requirement could be derived. The pre development flows were assumed as permissible flow for post development situation. Storage requirements, based on this assumption were estimated by optimising basin sizes in each of the sub catchments running the model several times.

Currently the subject land is storing flood water in higher flood events. To work out the current flood volume within the site in higher flood events, separate drain modelling was performed. Three dummy storage basins were placed near three outlets. With external inflows (provided by the DoW), sub catchment flows calculated by drains model and permissible outflow from three dummy basins as pre-development flows (provided by the DoW), basin sizes were optimised with several runs of the model. These are the volumes that the site currently holds during higher rainfall events and hence assumed extra storage to be provided in addition to the sub-catchment storage requirements.

In summary, the steps utilised in this study were as follows:

i. Gathered available information;

ii. Carried out site inspections;

iii. Prepared HECRAS base model based on external inflows and prepared pre development flood inundation map for drainage lines;

iv. Prepared *DRAINS* base model for pre-development situation and extra storage requirements were estimated by optimising basins with several runs of the model; and

v. Prepared *DRAINS* base model for post-development situation and storage requirements within sub catchments with pre-development flows as permissible outflow from the sub catchment were estimated by optimising basins with several runs of the model.

5.0 SOFTWARE AND MODELLING ASSUMPTIONS

Software Version

DRAINS Version

DRAINS is a Stormwater Drainage System design and analysis program. It is managed by *Watercom Pty Ltd*. The general practice when developing models was to use the latest version of *DRAINS*. Versions 2012.15 was used to generate the runs reported in this study, operating in "Standard hydraulic calculation" mode.

HECRAS Version

Hydrologic Engineering Centres River Analysis System (*HEC- RAS*) performs one-dimensional steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modelling. *HEC-RAS 4.1.0* is used for this study.

Hydrological Model

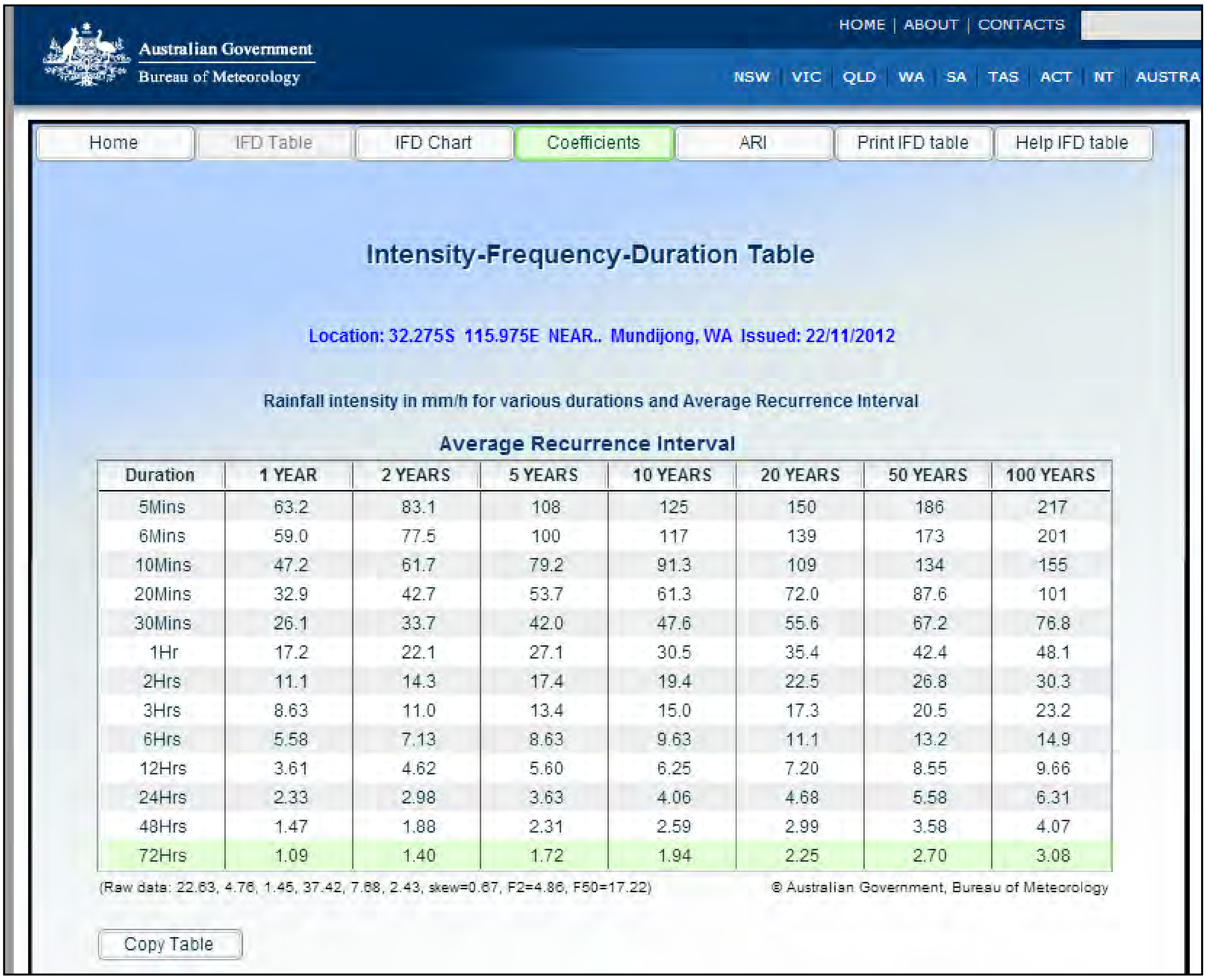
DRAINS
The hydrological model applied in *DRAINS* was an Extended Rational Method model operated in Standard hydraulic calculation which is steady analysis.

HEC-RAS

One dimensional steady flow analysis has been performed and *HEC-GEORAS10* for *ArcGIS 10* is used to prepare flood inundation map.

Rainfall Data

The models utilised the standard rainfall data from BoM's website. The model was run for ARIs of 10 and 100 years storms with durations 5 minutes, 10 minutes, 20 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 3 hours, and 6 hours. Modelling by the DoW showed that the 6 hour event is the critical event for the majority of the site.



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Intensity-Frequency-Duration Table

Location: 32.275S 115.975E NEAR.. Mundijong, WA Issued: 22/11/2012

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Duration	Average Recurrence Interval						
	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	63.2	83.1	108	125	150	186	217
6Mins	59.0	77.5	100	117	139	173	201
10Mins	47.2	61.7	79.2	91.3	109	134	155
20Mins	32.9	42.7	53.7	61.3	72.0	87.6	101
30Mins	26.1	33.7	42.0	47.6	55.6	67.2	76.8
1Hr	17.2	22.1	27.1	30.5	35.4	42.4	48.1
2Hrs	11.1	14.3	17.4	19.4	22.5	26.8	30.3
3Hrs	8.63	11.0	13.4	15.0	17.3	20.5	23.2
6Hrs	5.58	7.13	8.63	9.63	11.1	13.2	14.9
12Hrs	3.61	4.62	5.60	6.25	7.20	8.55	9.66
24Hrs	2.33	2.98	3.63	4.06	4.68	5.58	6.31
48Hrs	1.47	1.88	2.31	2.59	2.99	3.58	4.07
72Hrs	1.09	1.40	1.72	1.94	2.25	2.70	3.08

(Raw data: 22.63, 4.76, 1.45, 37.42, 7.68, 2.43, skew=0.67, F2=4.86, F50=17.22)

© Australian Government, Bureau of Meteorology

Copy Table

Sub-Catchments

Sub-catchments were defined based on LiDAR, outlets and post-development. For external inflows, inflows provided by the DoW were incorporated as base flow.

Permissible Outflows

Pre development 1 in 10 years and 1 in 100 years flow (provided by DoW) at three (3) outlets at Kargotich Road is assumed as permissible flows for 1 in 10 years and 1 in 100 years post development situation respectively.

The outlet capacity at Kargotich Road and Oakland drain should be analysed in detail and confirmed in later stages of planning.

Runoff Coefficient

0.5 Effective pervious runoff coefficient and 0.9 impervious runoff coefficients were assumed for this study to reflect the high ground water table on the subject land.

Surface Runoff

The assumed Manning's roughness coefficient for pervious areas was 0.035, and 0.015 was adopted for impervious areas. These coefficients were used in the model for calculation of times of concentration.

Hydraulic Conductivity of Soil

A conservative approach of zero infiltration has been adopted in the present analysis due to the high ground water table. This can be refined in later stages of planning after the actual groundwater depths are known.

6.0 RESULTS

<u>Pre- Development Situation</u>

As explained in the methodology, one dimensional steady flood modelling has been performed for 1 in 10 years and 1 in 100 years after preparing geometric files with LiDAR in *HEC-GEORAS-10* within *ArcGIS10* and importing to *HECRAS 4.1.1*. *Figure 1* (Page 9) shows digital elevation model and 2m contours derived from LiDAR. *Figure 2* (Page 10) shows 1 in 10 years predevelopment flood inundation from external inflows (provided by DoW). 1 in 10 years predevelopment flows within major sub catchments are shown in text boxes which were estimated from *DRAINS* Modelling. Extra storages necessary to limit outflows to 1 in 10 pre development flow are shown in the map, which were estimated from optimisation with *DRAINS* modelling. Similarly 1 in 100 years predevelopment flood inundation due to external flows are shown in *Figure 3* (Page 11). Catchment flows and required extra storages were also estimated using this modelling.

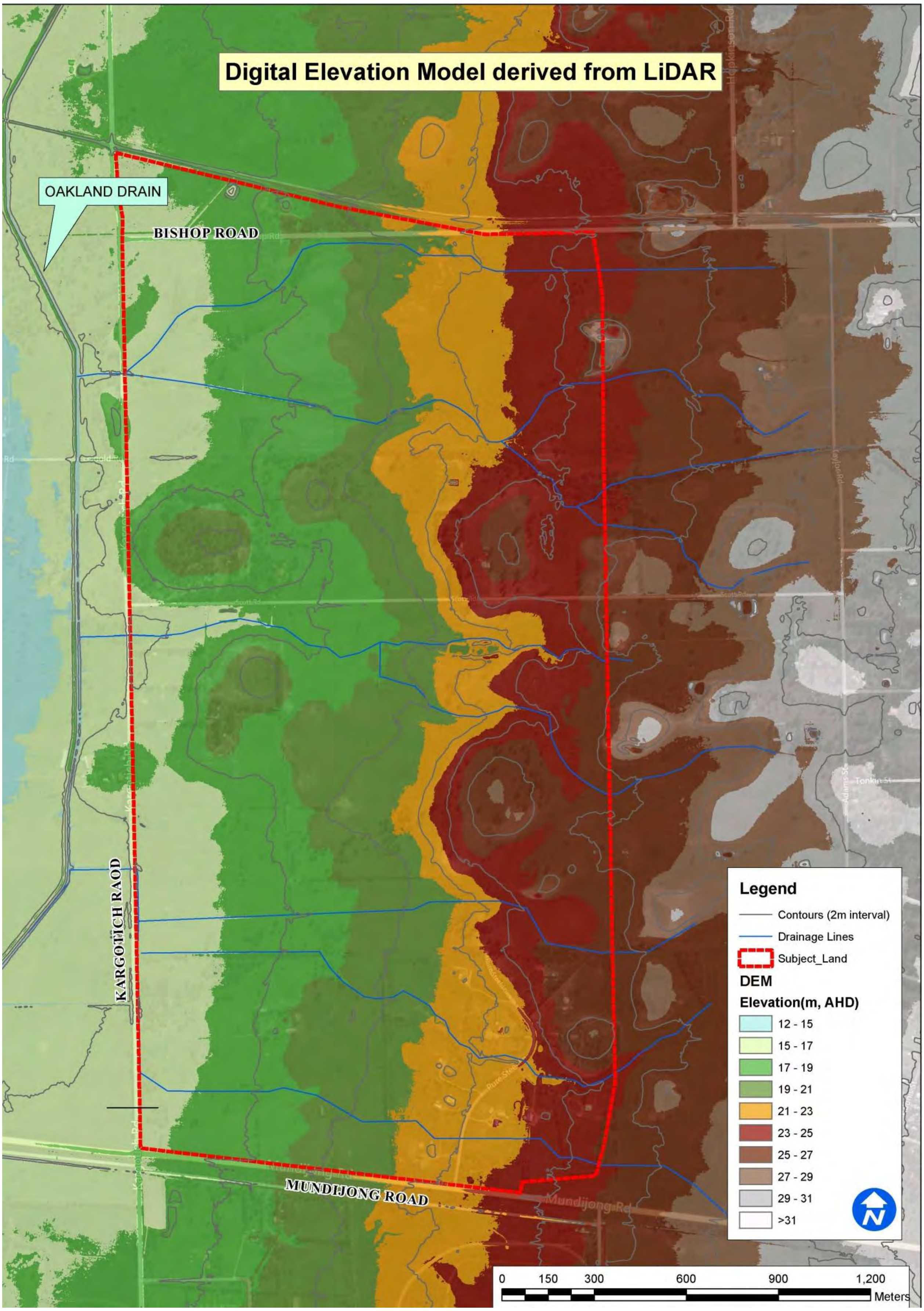

Figure 1 – Digital Elevation Model

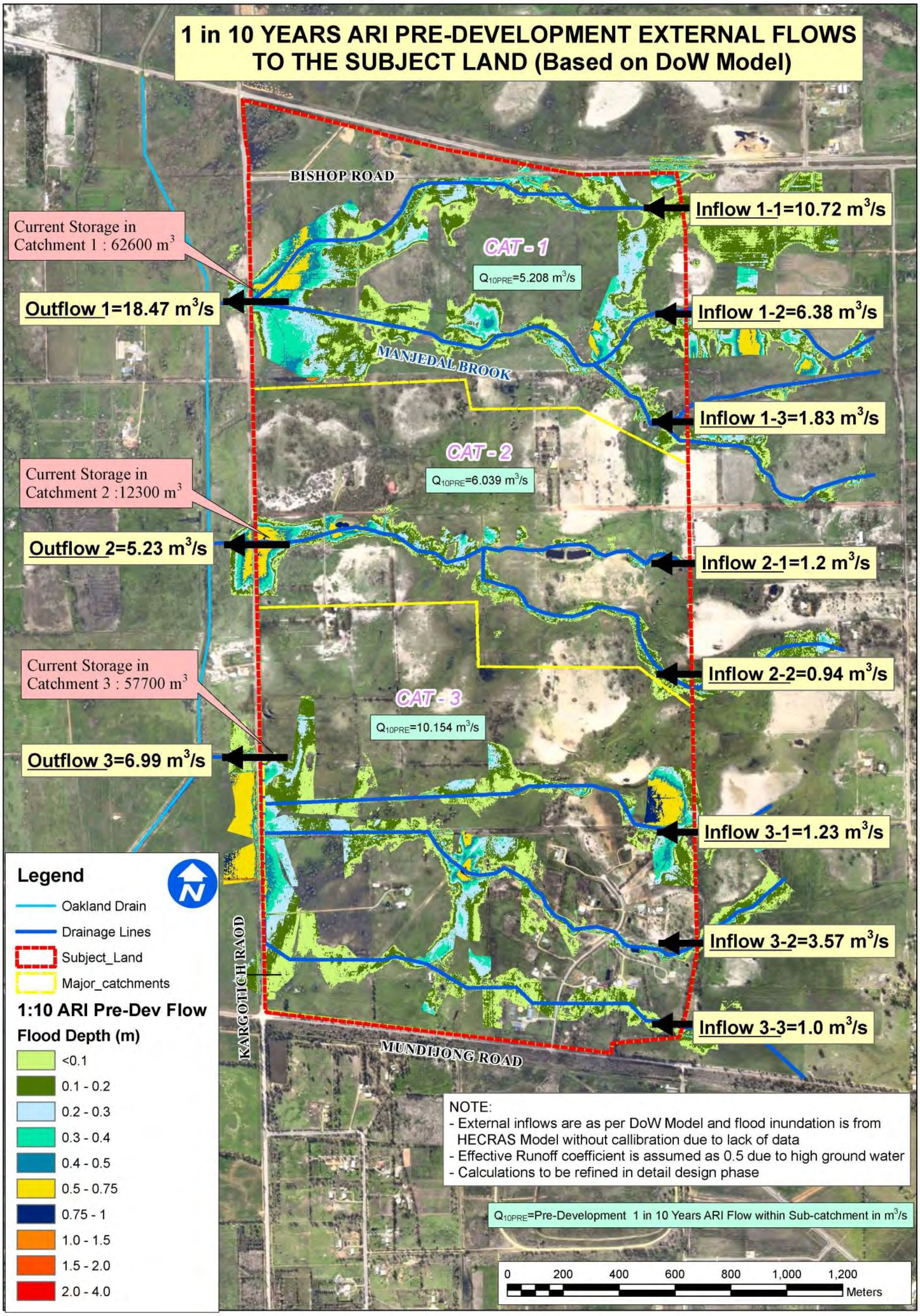

Figure 2 – 1 in 10 years pre development flows due to external inflows

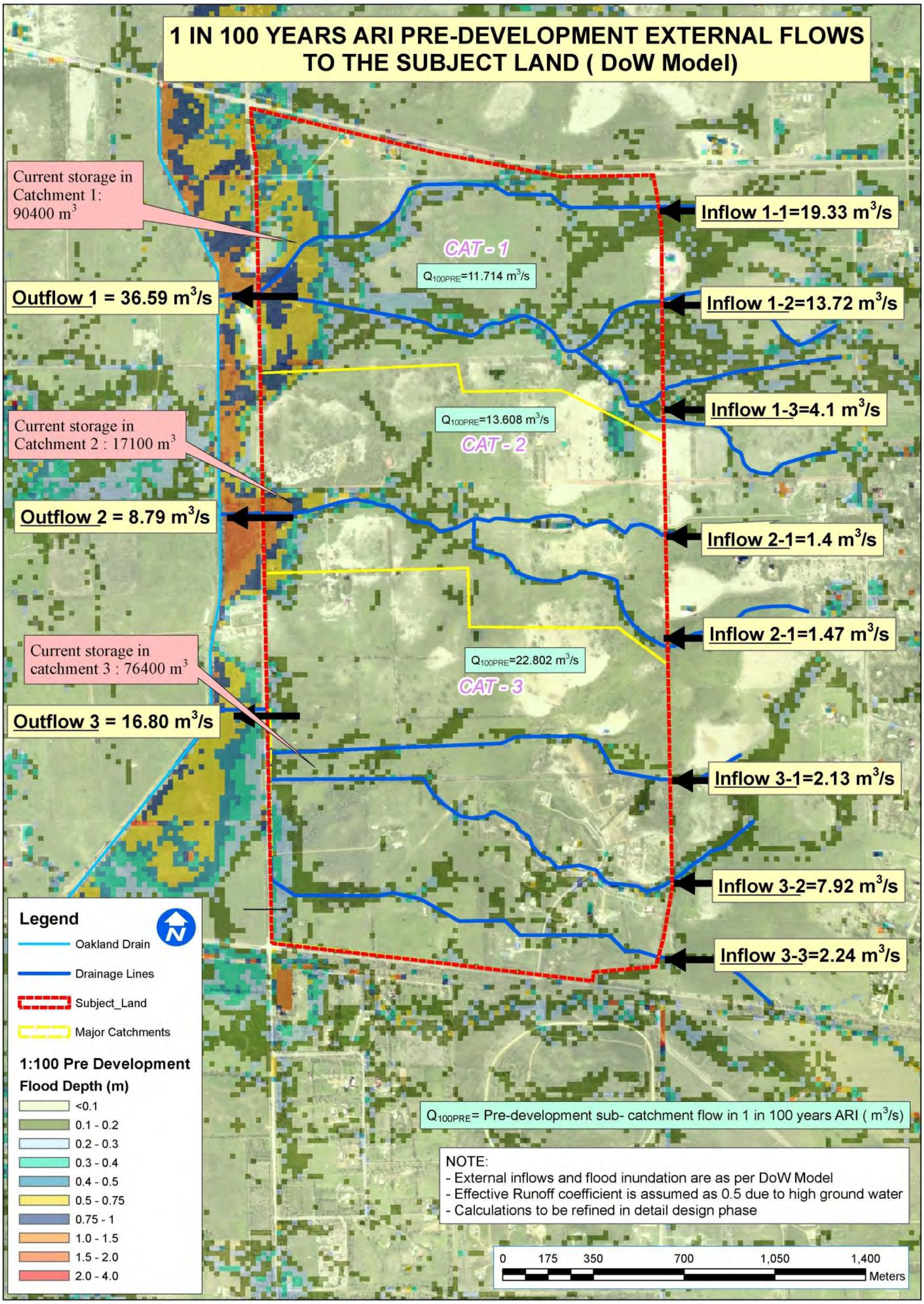

Figure 3 : 1 in 100 years flood inundation map due to external flows (DoW Model)

Post Development Situation

For post development 1 in 10 years and 1 in 100 years, flows were estimated using the *DRAINS* extended rational method and shown in *Figure 4* (Page 13) and *Figure 5* (Page 14) respectively. Assuming corresponding pre-development flow as permissible outflow, basin sizes were optimized in the model and final storage requirements within the sub-catchments were estimated and shown in *Figure 4* (Page 13) and *Figure 5* (Page 14) respectively. Similarly, limiting outgoing flows to corresponding pre-development flows, the final extra storage requirements were estimated by optimising basins in *DRAINS* model. Final extra storage requirements are shown in *Figure 5.*

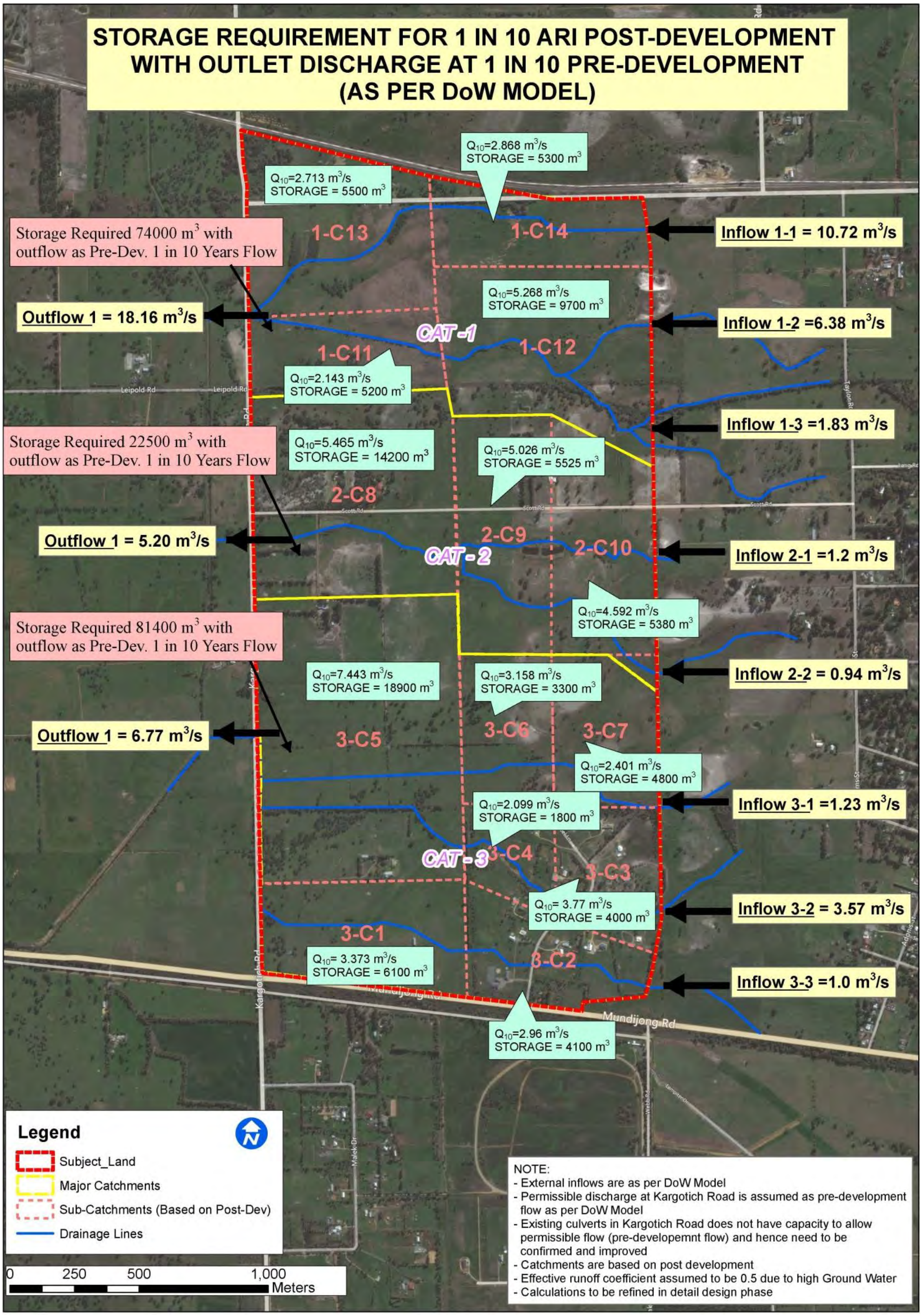

Figure 4 : 1 in 10 years Post-development storage requirements

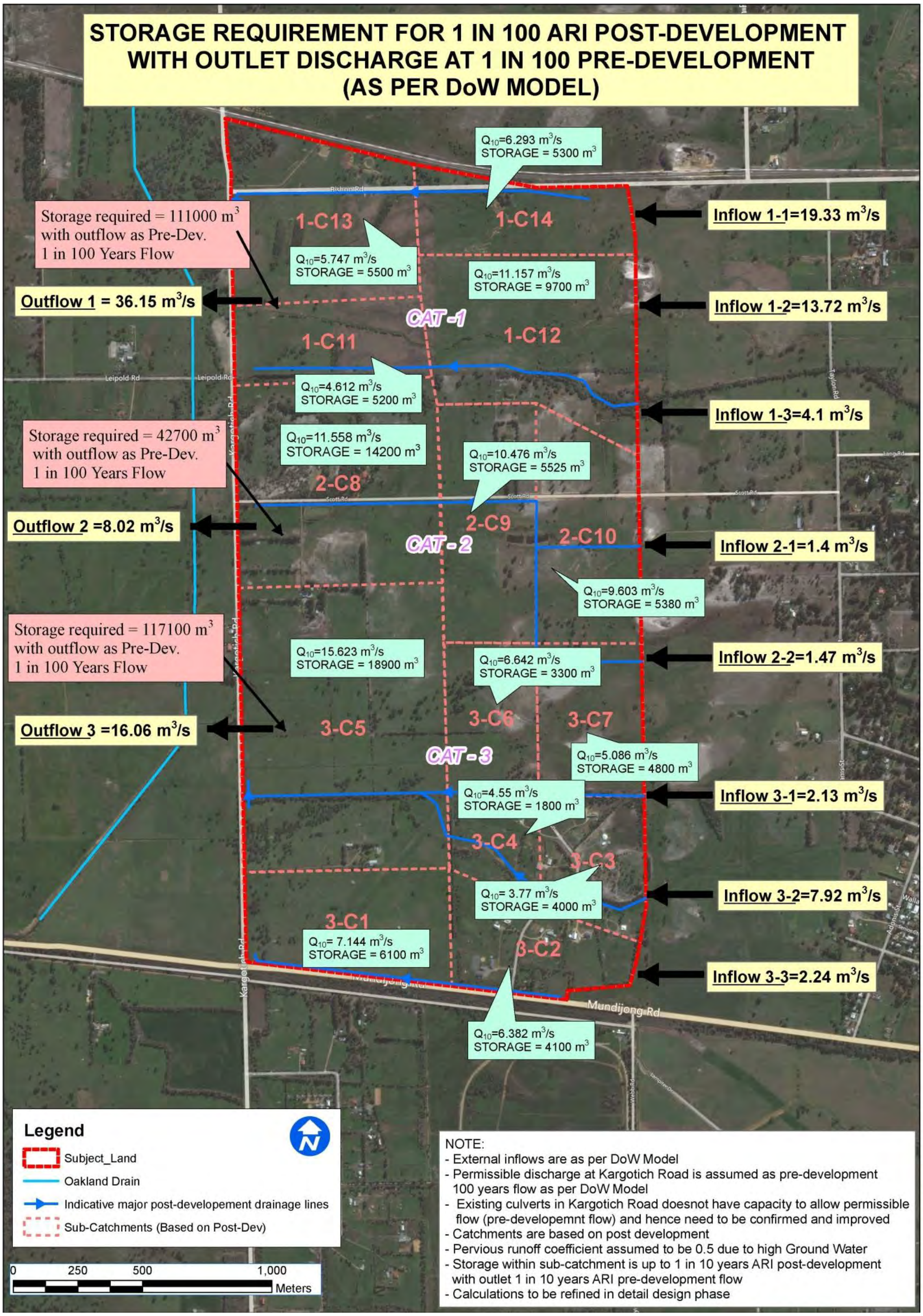

Figure 5 : 1 in 100 years Post-development storage requirements

The following table summarises storage requirements to limit outflow from the subject land to pre development flow;

S.No	Catchment	PRE-DEVELOPMENT				POST-DEVELOPMENT				
		Pre-Development flow as per DoW Modelling		Volume of Water storing within subject land (Pre-Development)		Lot /Sub-catchment Storage with outlet discharge of 1 in 10 pre-development(m^3)	Additional storage for 1 in 10 Years ARI (m^3)	Additional storage for 1 in 100 Years ARI (m^3)	Total storage Required	
		1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)	1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)				1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)
1	Catchment 1	18.47	36.59	62600	90400	25700	74000	111000	99700	136700
2	Catchment 2	5.23	8.79	12300	17100	25105	22500	42700	47605	67805
3	Catchment 3	6.99	16.8	57700	76400	43000	81400	117100	124400	160100
		Total		132600	183900	93805	177900	270800	271705	364605

Note:

1 Current Volume of Water storing within subject land is calculated from pre-development flow from subject land (calculated using rational method) + External inflows with permissible outlet discharge as outflow discharge from DoW Model (Pre-development)

2 Additional storage is storage required in addition with Sub-catchment/lot storage (Post-development 1 in 10 yr - Pre-development 1 in 10 yr) to limit discharge from subject land to pre-development stage

3 As current capacity of culverts in Kargotich Road is not adequate to release pre-development flow detail analysis should be done in detail phase of design

8.0 CONCLUSIONS AND RECOMMENDATIONS

Due to significant external inflows at various locations to the subject land it is necessary to provide extra storage within the site in addition to other storage required to maintain pre development flows. Estimation of storage requirements presented above is indicative and should be refined and confirmed during the detail design phase. The Current capacity of outlets at Kargotich Road is not adequate for the pre development 1 in 10 and 1 in 100 years flow and hence detail analysis with the site survey data is recommended in the detail design phase. In this study it is assumed that permissible outflow from the site is corresponding to pre-development flows and hence should be confirmed in later stage of study.

ANNEXURE -B-

WEST MUNDIJONG INDUSTIAL AREA FILL ASSESSMENT

TME Town Planning Management Engineering

West Mundijong Industrial Area/Sand Fill Analysis




Research, Design & Delivery of Sustainable Development

12098
December 2012

Project Management Planning Environmental Engineering

DOCUMENT QUALITY CONTROL

AUTHOR Brendan Oversby	DATE 11.12.2012
CHECKED BY Peter Jones	DATE 11.12.2012

REVISION TABLE

No.	Purpose	Date

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FIGURES

APPENDICES

1.0 INTRODUCTION

Recent industrial development in high groundwater areas on the east of the Swan Coastal Plain have utilised extensive fill to provide separation to the groundwater. The level of separation has been driven by the attempt to both achieve practical separation distances for infrastructures such as roads and buildings as well as providing a separation that can contribute to the improvement in or protection of the groundwater quality. Various approving authorities have also sometimes taken a low risk approach and have applied standardised fill depth requirements, regardless of other mitigating factors or workable strategies.

With the rising cost of suitable sand resources, and rapid depletion of this resource, there is a need to seek viable alternatives. These alternatives need to provide protection to infrastructure and the quality of the groundwater, while minimising the excessive use of fill.

This report outlines options for the West Mundijong Industrial Area that minimise the fill that will be required for the future development of the site. (See *Figure 1*) It provides detail at the lot and block scale and extrapolations of this information across the estate. It should be noted, that the extrapolation is at a very coarse scale as the final design of the estate is not yet available. It does however provide strategies for how the estate should be developed to minimise the amount of fill used.

Due to the lack of detail within the intermodal area, this portion of the estate was excluded from the calculations undertaken at an estate scale. Once a basic layout and usage details is available for the intermodal area, fill calculations can be undertaken.

DISCLAIMER

These parameters and calculations within this report have been produced at a District Scale. The results and recommendations should therefore only be used as an indication only. Refinement of these aspects can be undertaken as detailed designs are produced for the site. The information provided in this report expresses the results of preliminary investigations only. Detailed design has not been undertaken in preparation of the estimates in this report. Information within this report is provided to the reader as background material and to provide a general assessment of possible project costs. No information in this report should be regarded as final or conclusive and the reader should not use this report as the basis for budgeting or investment decisions without obtaining independent analysis or detailed studies from the authors. The reader must acknowledge the underlying premise on which the information has been prepared may change significantly as a result of changes in State or Local Government or Departmental Policy, changing advice of officers in the bodies consulted, unforseen geotechnical problems or latent conditions during the construction phase of the project, changes in market demands and variations in the wider Australian or World economies.

2.0 GROUNDWATER MODELLING

The calculations assumed that the majority of the site has groundwater at the surface. Initial very coarse modelling shows most of the site either has groundwater ponding at the surface or it is less than 0.5m below. (See *Figure 2*) More detailed modelling from on site future bore readings will be able to provide a greater level of accuracy and may be able to reduce the amount of fill required. With the basic groundwater level modelling available , the areas likely to be more than 0.7m above the groundwater have been separated out, with these area not being included in the calculation of total fill requirements.

The total volume of sand that is more than 0.7m above the groundwater already on site is approximately 377,000m³. This may be able to be cut to be used for fill in other areas, however the sand will need to be analysed to determine if it is suitable.

3.0 SURFACE FLOOD SEPARATION

The site currently experiences some minor shallow flooding associated with the backing up of water from the Oaklands drain and Kargotich Road. Building floor levels will need to be at least 300mm above the flood height. To accommodate this, the majority of building envelopes will be at least 300mm above the rest of the lot. With a 100mm floor pad, this provides 400mm of separation from local flooding of the lots. There may be a requirement for isolated areas close to Kargotich Road to have the building set slightly higher to avoid the backwater effects. The final height will be subject to detailed design, however, from a preliminary analysis, building close to the existing drainage discharge points under Kargotich road are likely to require and extra 200-400mm of fill. The total volume of extra fill compared to the amount required for the entire estate will be negligible and so has not been included in the broad scale calculations of fill.

There is also a requirement to store large volumes of flood waters that back into the site. This includes the current flood storage volumes, and the extra volumes generated from post development. The surface area required for this storage is in the region of 36 hectares. This area has also been taken out of the calculations of area requiring fill.

4.0 OPTIONS TO MINIMISE FILL

There are a variety of practical ways to minimise fill within an industrial estate. These include:

- Minimisation of groundwater mounding
- Reduction in areas that actually require fill
- Lowering of groundwater levels
- Pumping of groundwater

These options are explored further below.

4.1 Minimisation of Groundwater Mounding

To minimise mounding of groundwater within the fill, a combination of roadside open swales and subsoil piping is recommended. This combination will reduce the horizontal distance that groundwater will need to travel through the soil profile until it reaches a preferential flow path (eg swale/subsoil pipe).

The land tends to slope east to west. To facilitate surface drainage, roadside swales will be constructed along the east-west running roads. The base of these swales will be set at approximately the Annual Average Maximum Groundwater Level (AAMGL). These swales will control groundwater and will form a new Controlled Groundwater Level (CGL).

The swales will effectively control groundwater rise within the road reserve and the immediate area of the lots adjoining them.

The fill calculations have assumed that lots will be 40m wide and 60m long. With this configuration, the centre points between one east-west running road and the next will be 150m (includes 2x60m lots, plus a 30m road reserve of verge, swale and road). This cross section can be seen in *Figure 5*.

To control the groundwater further into the lot, a subsoil system is to be laid down the east/west boundary of each lot (and the north-south running roads). This configuration can also be seen in *Figure 4.*

With a 60m run of subsoil, laid at a slope of 1 in 200, the subsoil will rise 0.3m from the drain invert to the back of the lots.

By using subsoil along the east/west boundaries of each lot, which discharges north and south into the swales, the horizontal distance to a preferential flow path is reduced to 20m (from the centre point of each lot). This means the mounding on each lot is only 0.4m above the subsoil invert, after the maximum monthly rainfall, combined with intense rainfall from a 1:5 ARI event.

For larger lots, subsoils can also be located directly along the edge of the building pad, so that this area is preferentially drained, reducing the need for excessive fill.

The horizontal permeability of the sand also influences the mounding. For the calculations used as part of this analysis, the horizontal permeability is assumed to be 5m/day. This is representative of typical fill used on the Swan Coastal Plain once compacted on site.

The calculations that show the mounding associated with the above scenario can be seen in the appendices.

4.2 Reduction in areas that actually require fill

Certain areas of industrial lots require less fill to actually function without being impacted, or adversely impacting the groundwater. These are areas that don't contain significant infrastructure such as buildings or soakwells. These areas of lower fill requirements include, parking areas, laydown areas and general vehicle movement areas. The drainage basin areas are also able to utilise less fill, provided they are designed to have their bases close to the groundwater. By being close to the groundwater, the basins can actually function similar to an ephemeral wetland. Incorporation of filter media will assist with protecting groundwater quality.

The building envelopes should require a maximum of 1.0m of fill/separation to the groundwater. The surrounding lot really only requires 0.3m of fill above the maximum groundwater mound (in the middle of the lot). For the spacing of subsoils suggested, this equates to an average fill height of 0.7m (assuming the groundwater is traditionally at the pre development soil surface). This fill allows for the 0.4m of maximum mounding plus 0.3m of separation.

On the edges of the lot, the depth to groundwater will be less, tending to be closer to 0.6m -0.7m. These are the areas where stormwater basins/soakwells and buildings etc should preferentially be located.

The lot surface will also slope towards the road, at a similar slope percentage to the subsoil pipe. This allows the lot to also have enough slope to drain surface water to the basin areas at the front of the lots.

Due to the small area taken by the stormwater basins, the reduced fill for these areas has not been included in the calculation of potential fill reductions. The basin areas have just been assumed to require the average fill depth for the remainder of the lot (0.7m).

Combining the information above the actual fill will rise from 0.7m at the front to 1.0m at the back of the lot (to accommodated the subsoil rise requirements). There will also be 1m of fill under the building envelope, which is assumed to cover the front third of the lot. This assumes groundwater is at the surface.

A diagrammatic representation of a typical industrial lot can be seen in *Figure 5*.

4.3 Lowering of groundwater levels

Lowering of groundwater to below the existing annual maximum level can assist with minimising fill. This may be an option for areas away from significant natural environments such as the Manjedal Brook and associated wetlands.

The risk of Acid Sulphate Soils will need to be carefully considered as well, although if the levels are only slightly reduced below the maximum and don't impact the minimum levels, then there is unlikely to be significant impact on both the production of ASS and the mobilisation of acidic groundwater and pollutants mobilised by the increase in acidity. The potential to lower groundwater levels will be limited on the subject land, due to the flat nature of much of the land and the invert of the existing drainage points, which currently control groundwater discharge when it is at its peak. This discharge is controlled by the existing on site drains and the swale drain along the boundary roads.

Due to these limitations, the calculations of fill required for the site have assumed that the post development CGL will be very similar to the AAMGL. For the coarse calculations undertaken, the CGL has been assumed to be at the natural surface of the site. As detailed design is undertake, there may be opportunities for localised lowering of the groundwater to a small degree in the order of 200-300mm.

4.4 Pumping and reuse of Groundwater

Pumping of the superficial groundwater for potential reuse can assist with reducing maximum groundwater levels, and remove the extra groundwater that is generated through the change in land use from agriculture to industry. However, there is a potential for groundwater pumps to not be working during critical wet periods, either due to malfunction or because there is no requirement for the groundwater. For the sake of fill calculations it is therefore assumed that pumping will not impact the peak groundwater level.

This does not however preclude the use of the superficial groundwater as a viable non potable water source for use within the subject land and surrounding areas.

4.5 Groundwater treatment

The swales provide treatment to the groundwater discharged into them via direct seepage and from the subsoil system. The use of native vegetation within the swales combined with the microbiological communities on the plant structures and soil profile, will assist with the uptake of nutrients, sediments, metals and other potential pollutants.

Treatment of the groundwater can also be achieved through the use of fill with a high Phosphorus Retention Index. This will assist with binding phosphorus moving through the groundwater. Basins and other structures that store and treat groundwater can also be designed so that they treat surface water prior to its discharge into the groundwater.

More information on groundwater quality management can be found in the District Water Management Strategy for the subject land.

5.0 CALCULATION OF ACTUAL FILL

Taking into account the strategies outlined above, an indicative volume of fill can be determined for a lot as well as the entire development area (excluding the intermodal area). It should be noted that these *figures* will need to be refined as lot sizing and the layout of the site is finalised.

Assuming each lot is 2400m² (60m deep by 40m wide), that the lot has a 0.5% slope and a building pad that stretches 20m back into the lot, 2280m³ of sand will be needed for each lot. The road reserve in front of the lot, will also require 354m³. This assumes the road reserve is designed as per *Figure 5*.

This gives an indicative total sand volume of 2634m³ for the lot and associate road reserve.

This can then be extrapolated out across the entire site, to provide an indicative total fill volume.

It should be noted that this precludes the wetland and buffer areas (9.5ha) and the major flood storage areas (36ha), which would not be filled. It also precludes some areas where the site is already at least 0.7m above the AAMGL which covers an area of 45.5ha. The areas above 0.7m are designated as the sand dune areas.

The calculations also doesn't include the intermodal area. This is dealt with separately below.

In summary:

Total Area: 491.5ha

Wetland and buffer area: 9.5ha

Flood Storage areas: 36ha

Areas already with 0.7m of sand: 55ha

Possible Intermodal Area: 71.4ha

This leaves a total area requiring fill sand of 319.6ha.

The following calculations assume the CGL will be at the current natural surface. In reality, parts of these areas will already have some separation, so the total fill is likely to be slightly less.

For the 319.6ha area the volume of sand is in the order of 2.3 million m³.

Furthermore, the sand contained within the sand dunes, that is higher than 0.7m above the AAMGL, could potentially provide some fill material for other lower areas on the site. This volume of potential fill is in the order of 377,000m³. Further testing of this material will be needed to determine if the soil within the sand dunes is viable as fill.

6.0 COSTS FOR MINIMAL FILL OPTION

APH Contractors, who regularly undertake sand supply, laying and compacting on development sites within the Perth Metropolitan area, were consulted on current sand fill costs. As of November 2012, the indicative costs to supply, lay and compact sand in Perth, is $\$21/m^3$.

Based on needing in the order of 2.3 million m^3 of sand fill for the minimal fill option, this equates to $48.3million, for the development area (excluding the intermodal area)

Divided per $2400m^2$ lot and the associated road reserve, this is approximately $55,000/lot.

7.0 STANDARD SCENARIO

To assist with comparing the concepts suggested for the subject land, basic details are provided for a business as usual approach to fill. The assumptions used in this standard model for industrial developments on the eastern swan coastal plain is:

- Piped stormwater system or roadside swale
- Subsoil set along roads and at the back of lots
- Fill to be between 1.2m and 1.5m across the entire estate (business as usual)

Averaged over a standard 60mx40m lot and associated road, the total fill requirement would be in the order of 4320m^3 -5400m^3 per lot (1.2m -1.5m of fill). For the subject land minus the intermodal area, the total fill requirement would be in the order of 3.8 million – 4.8 million m^3.

7.1 Comparison to standard scenario

Using the fill requirements of 3.8million to 4.8million m^3 of fill, the cost of fill for the entire site would be approximately $80million to $100 million (1.2m – 1.5m) to supply lay and compact on site, at the current cost of $21/m^3.

This equates to a difference of between $31.7 million and $51.7 million compared to the minimal fill option outlines in this report.

8.0 INTERMODAL AREA

This area has not been analysed due to a lack of information on likely layouts. Nevertheless, should the site be developed in a similar fashion to the adjoining industrial land, then fill requirements will be similar. Fill would also need to accommodate the requirements associated with the rail infrastructure.

For a very basic analysis and assuming an average of 1m of fill will be needed, then the total fill requirement of this area is 714,000m³ (for an area of 71.4ha). At \$21/m³ this is a cost of approximately \$15million.

9.0 SUMMARY AND RECOMMENDATIONS

The site will require extensive volumes of fill to allow for the development of the site for industrial uses.

The strategies outlined above will allow for the minimisation of fill, however this will still be a substantial cost of any development of the site. Nevertheless, the cost of fill using the alternative options outlined in this report, place the cost within the range that is typical for other, currently feasible, industrial developments across the Swan Coastal Plain. The cost of the fill will need to be included in a full feasibility study to determine the overall viability of the development.

More detailed analysis of fill requirements can be undertaken as the detail of the development is undertaken.

As part of this assessment, the following activities should be undertaken to facilitate fill calculations:

- Feature survey
- Groundwater level and quality monitoring
- Modelling of minimum, maximum and AAMGL groundwater contours based on site specific monitoring
- Assessment of soils on site to determine suitability as future fill material and soil classifications.
- Flood storage areas
- Final wetland buffer areas.

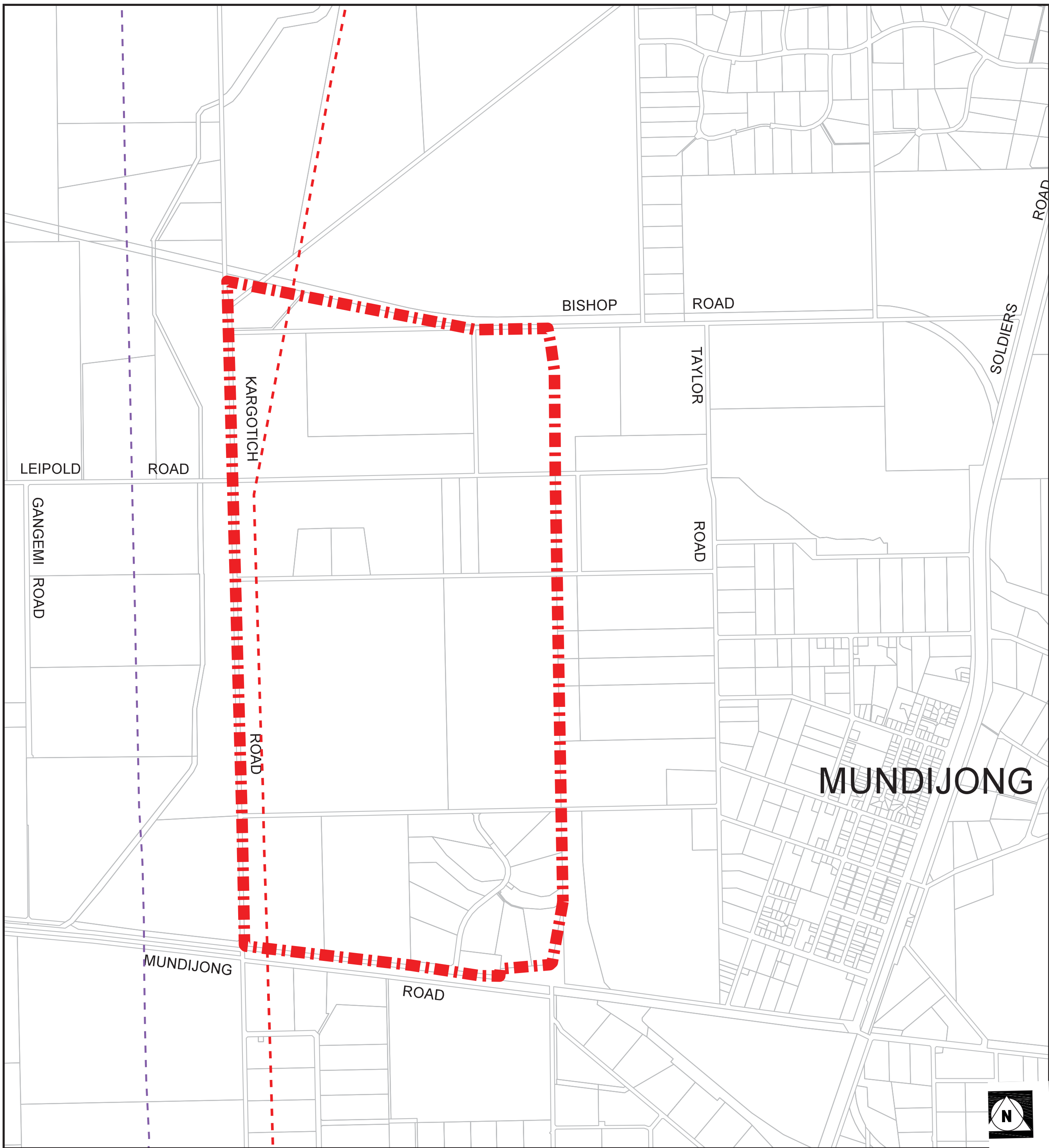


Figure 1 -Site Location Plan

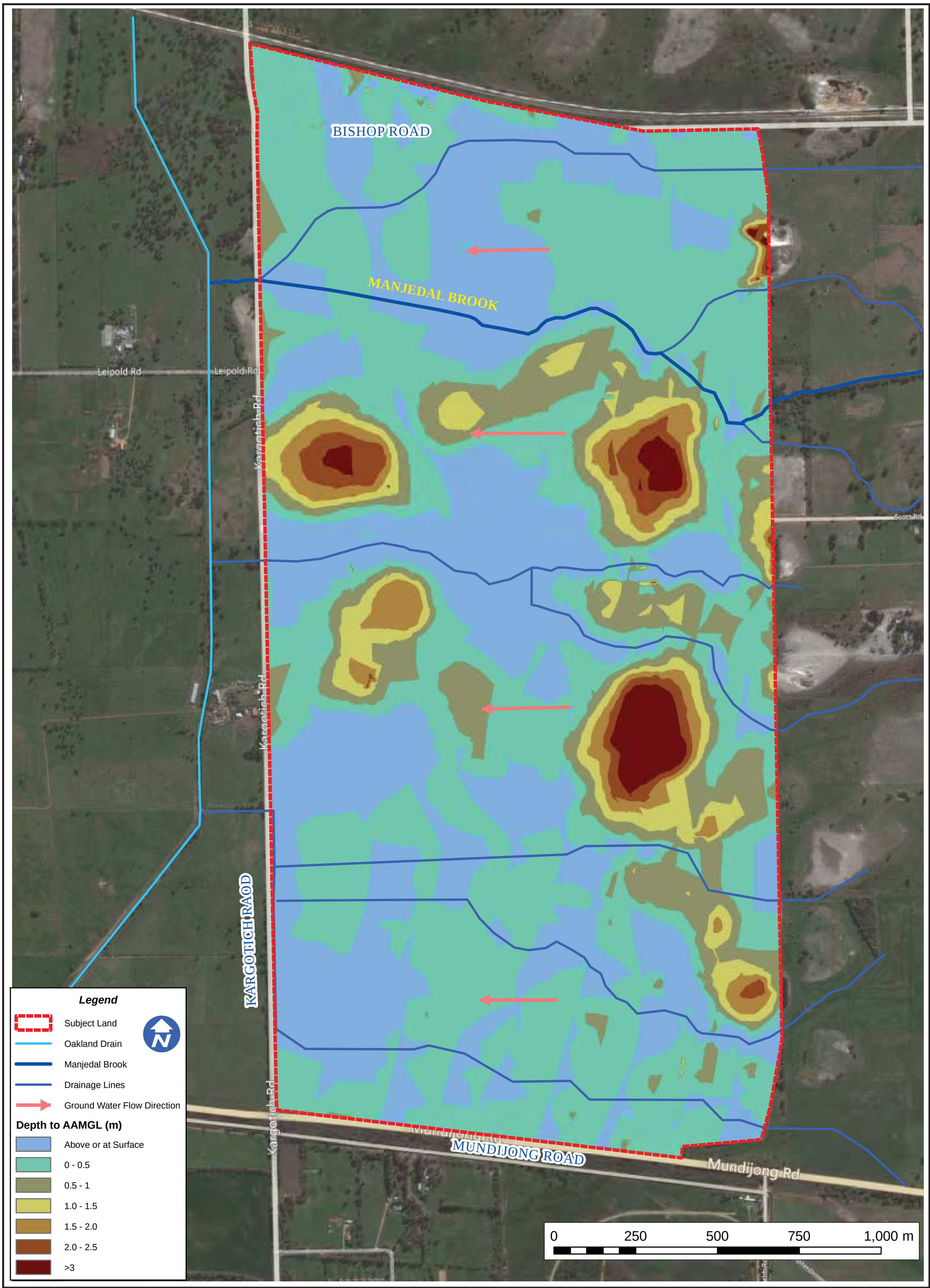


Figure 2 - Depth To Groundwater Plan

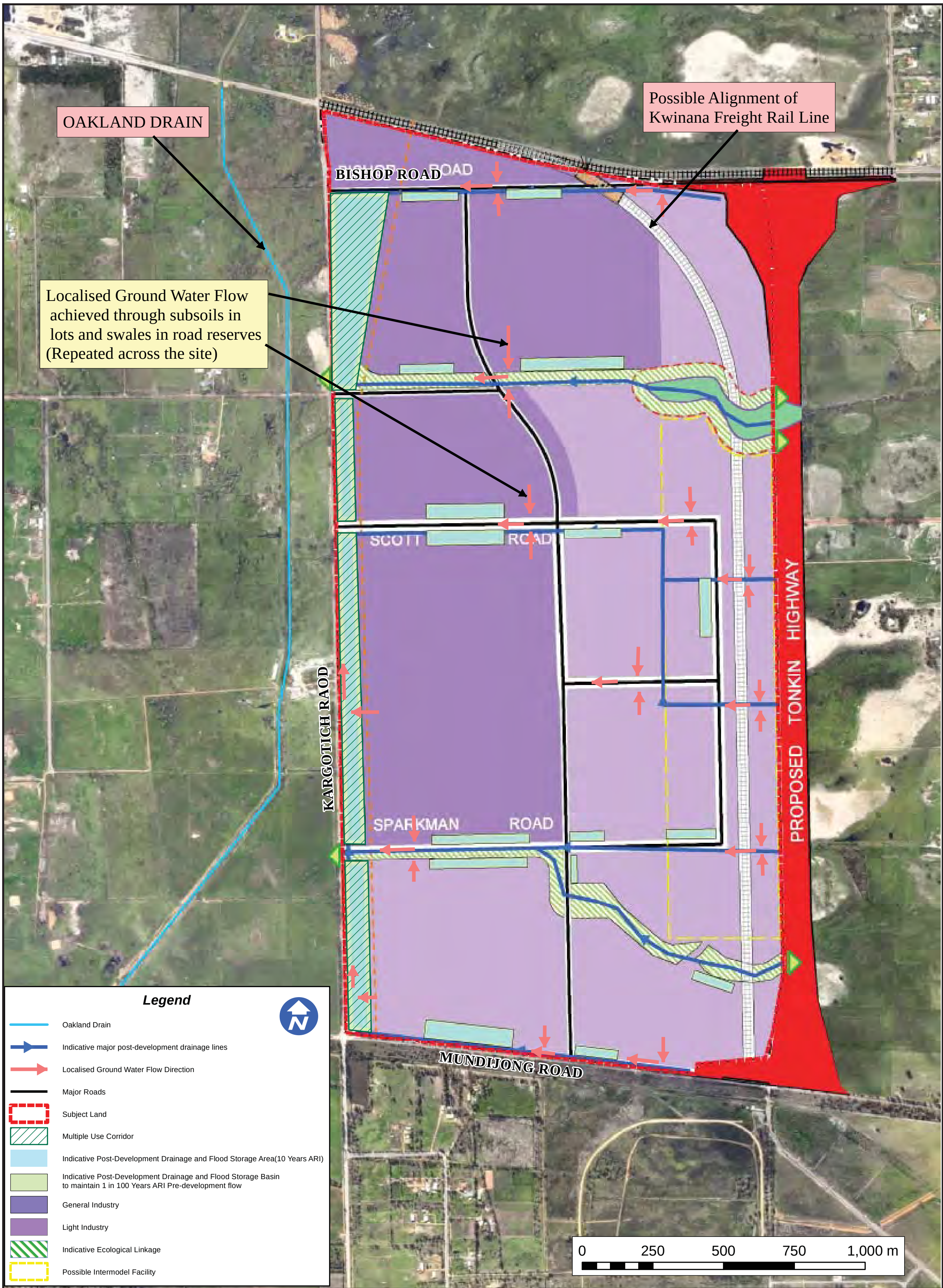


Figure 3- Post Development Ground water Management Plan

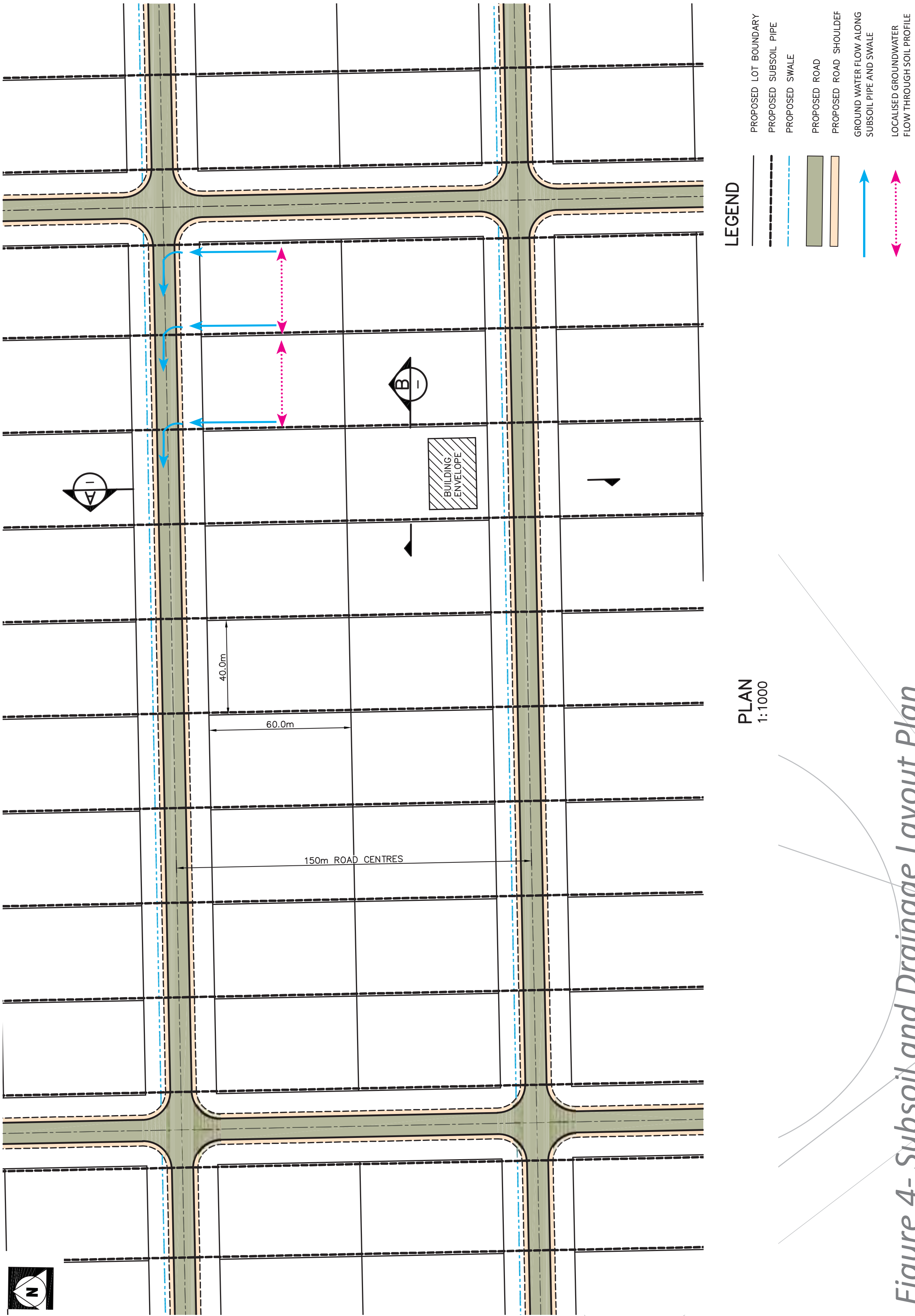


Figure 4- Subsoil and Drainage Layout Plan

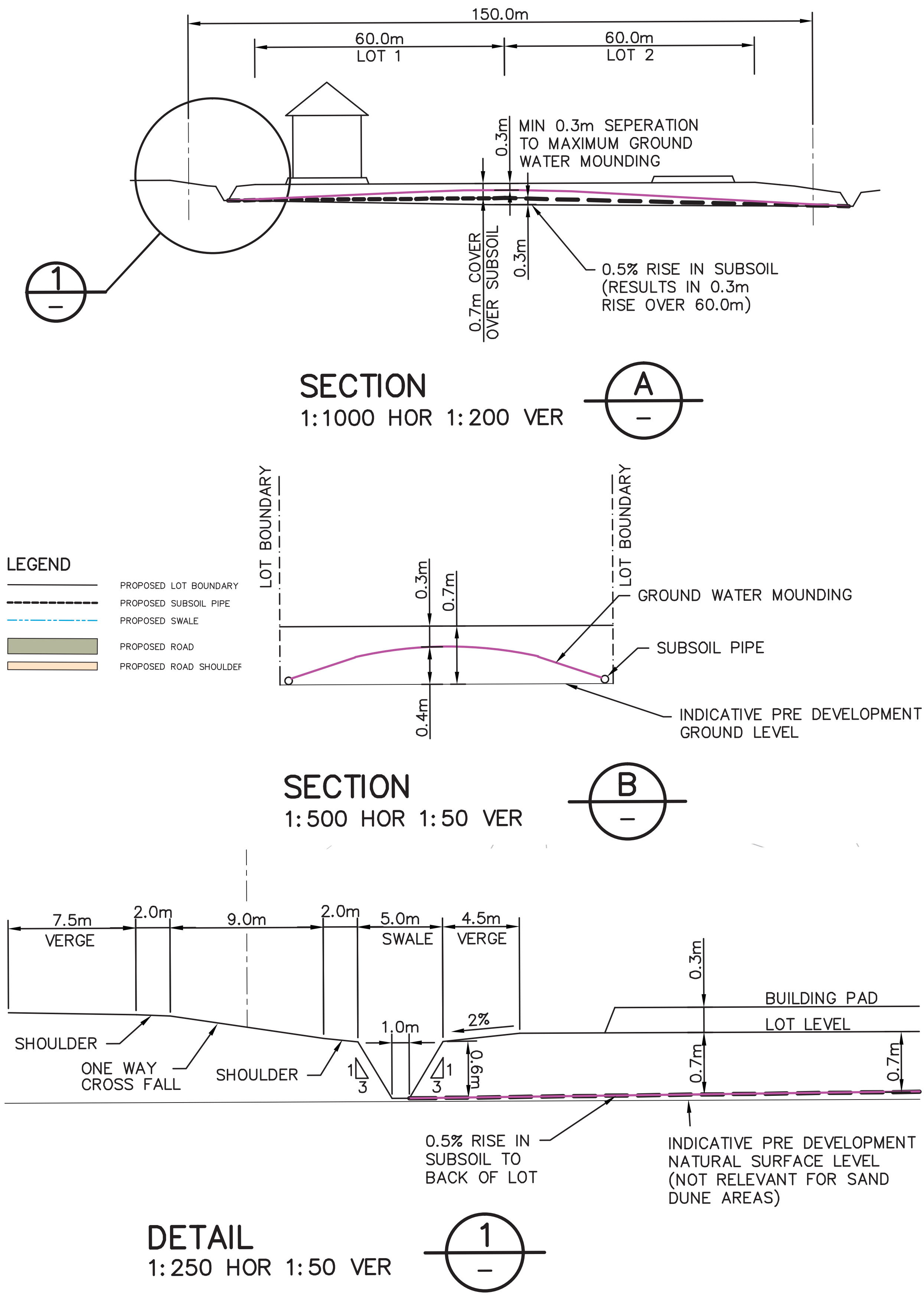
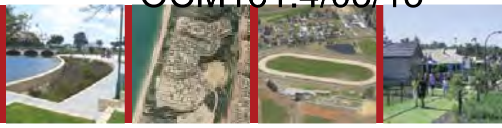


Figure 5- Subsoil and Drainage Details and Section

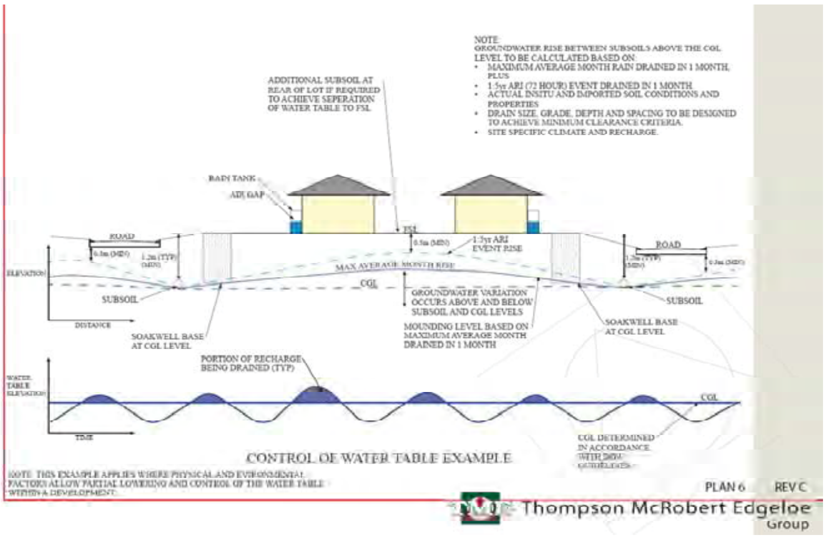
APPENDIX 1

SUBSOIL DESIGN SHEET



SUBSOIL DESIGN SHEET

West Mundijong Industrial Area



Project Fill Assessment for West Mundijong Industrial Area

Input Data

Insitu Soil Permeability	5	m/day
Maximum Average Monthly Rain	148	mm
1:5yr 72 hr event	1.51	mm/hr
Assumed recharge	50	%
Depth to impermeable layer below subsoils	0.2	m
Drain Spacing	40	m
Total Development Area	4500000	m2

refer table below

Calculations

Average max monthly recharge	2.39	mm/d
1:5yr 72 hr event total rain	108.72	mm
1:5yr 72 hr recharge drained in 1 month	1.75	mm/d
total design recharge rate	4.14	mm/d

solve equation using quadratic equation

a= 4K=	20	m/d
b= 8KD=	8	m^2/d
c= $-QL^2$	-6.63	md

maximum rise between subsoils **0.41**

subsoil flow rate for total development 18632.90 m^3/d
215.66 l/s

Design Criteria

GROUNDWATER RISE BETWEEN SUBSOILS ABOVE THE CGL LEVEL TO BE CALCULATED BASED ON:

- MAXIMUM AVERAGE MONTH RAIN DRAINED IN 1 MONTH, PLUS
- 1:5yr ARI (72 HOUR) EVENT DRAINED IN 1 MONTH.
- ACTUAL INSITU AND IMPORTED SOIL CONDITIONS AND PROPERTIES
- DRAIN SIZE, GRADE, DEPTH AND SPACING TO BE DESIGNED TO ACHIEVE MINIMUM CLEARANCE CRITERIA.
- SITE SPECIFIC CLIMATE AND RECHARGE.

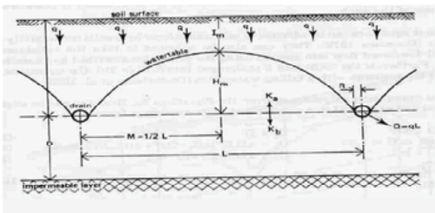


Figure 1. Illustration of the parameters involved in Hooghoudt's equation

Steady State simplification of Hooghoughdt equation

$Q=(8KDH+4KH^2)/L^2$

Q	m/d	steady state recharge of water percolating to the water
K	m/d	hydraulic conductivity of soil above drain level
D	m	depth to impermeable levl below drain inverts
H	m	height of water table rise midway between drains
L	m	subsoil drain spacing

Table 11 Estimated annual groundwater recharge (Perth region office, Bassendean soil, deep watertable)

Landuse code	Descriptions	Recharge (mm)	Recharge as % of rainfall
1	Banksia – high density	85	10%
22	Banksia – medium density	135	18%
2	Banksia – low density	300	38%
3	Pasture	360	46%
5	Market garden/parkland	320	40%
6	Pine - high density	0	0%
17	Pine – medium to high density	0	0%
7	Pine – medium density	0	0%
18	Pine – low to medium density	65	8%
8	Pine – low density	220	28%
9	Urban – residential	400	50%
11	Urban – commercial/industrial	500	63%
10	Lakes/wetlands	-500	-85%