Environmental

Swan Valley Bypass

- Initial desktop and field surveys completed;
- Referred to EPA and DoE to establish level of assessment;
- Controlled Action – Public Environmental Review;
- Bilateral Agreement not applicable due to Commonwealth Land required for Project;
- Close co-ordination between EPA and DoE;
- Environmental Scoping Document Agreed; and
- Carnaby's Black Cockatoo, Wetlands, Gnangara Water Mound.

Tonkin Grade Separations

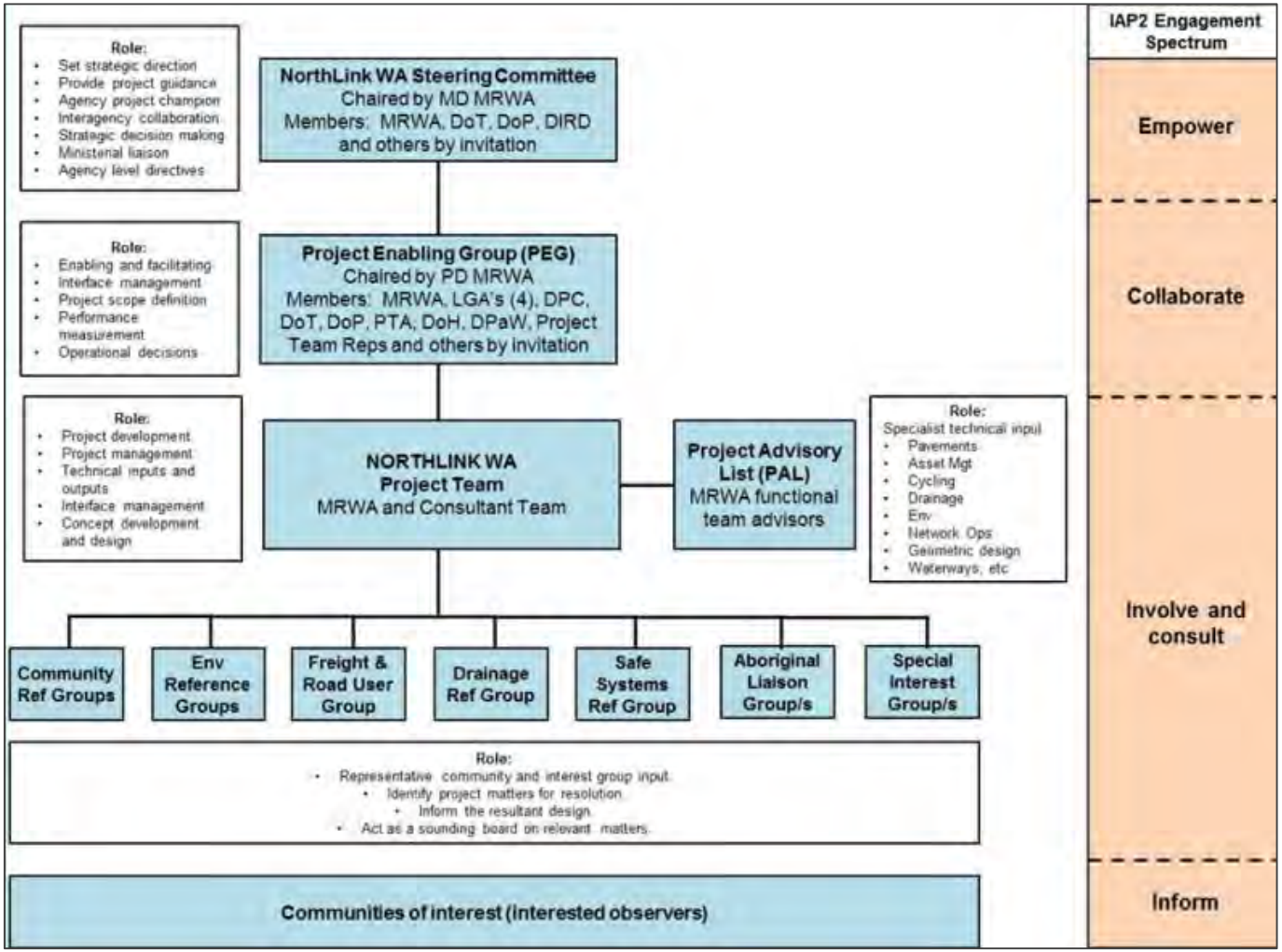
- Field surveys recently completed;
- Referral to EPA and DoE for Level of Assessment in coming months; and
- Black Cockatoo habitat, Contaminated Sites.

Offsets

- Purchased Property in Chittering on advice from DPaW.

The NorthLink WA team is led by BG&E supported by 7 lead consultants responsible for managing the project. The consultants are listed in the diagram below.

Governance Structure



Community and Stakeholder Engagement

- Project Steering Committee;
- Project Enabling Group;
- Community drop in Events – Morley, Ellenbrook, Bullsbrook & Muchea;
- Community Reference Groups;
- Reference Groups for Drainage, Environment, Freight, Safe Systems;
- Advertising;
- Newsletters;
- Project Website; and
- Toll free contact number.

4. PROJECT PERFORMANCE FRAMEWORK

Anthony Wood, NorthLink WA Project Team, outlined the project performance framework:

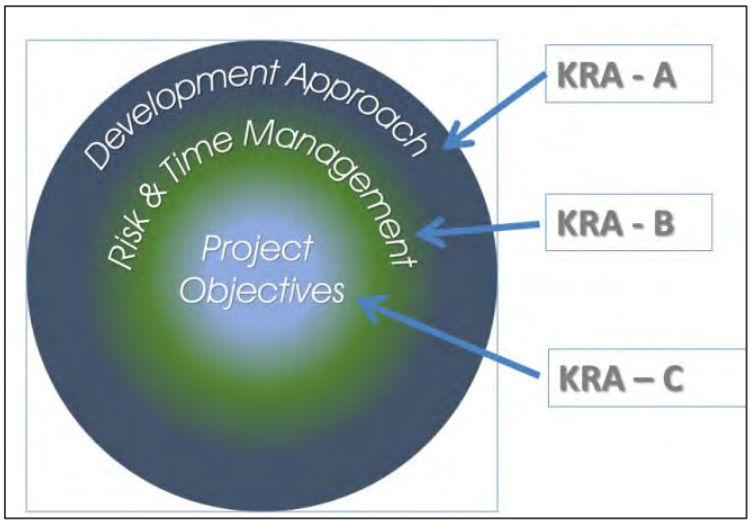
Content

- Background
- Outline of framework structure
- Key Result Areas and Performance Indicators
- How can this group assist?

Performance Framework Purpose

- Monitor progress against team's service objectives
- Assist with decision making process
- Measure success against project objectives

Performance Framework Structure



Project Objectives – KRA – C

1. Improve freight capacity, efficiency and productivity
2. Reduce urban congestion now and into the future
3. Improve road safety through the "Towards Zero" initiative
4. Improve amenity for the community, tourists and road users
5. Maximise Sustainability through economic social and environmental improvement
6. Create value through affordable infrastructure

How can this group assist?

KRA	Description	KPI 1	KPI 2	KPI 3
5	**Maximise Sustainability through economic social and environmental improvement**	Maximising opportunity for environmental enhancements within and outside of the project corridor	Maximising opportunity for environmental enhancements within and outside of the project corridor	Maximising opportunity for environmental enhancements within and outside of the project corridor

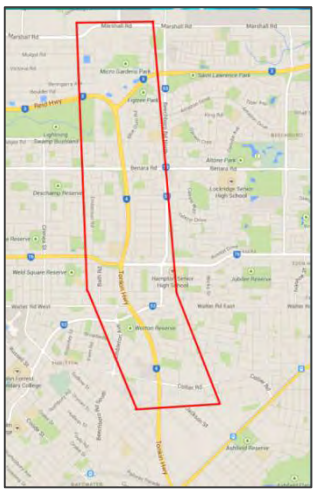
5. DRAINAGE OVERVIEW

Michael Wiezel, NorthLink WA Project Team, provided a drainage overview noting the following.

Drainage Overview

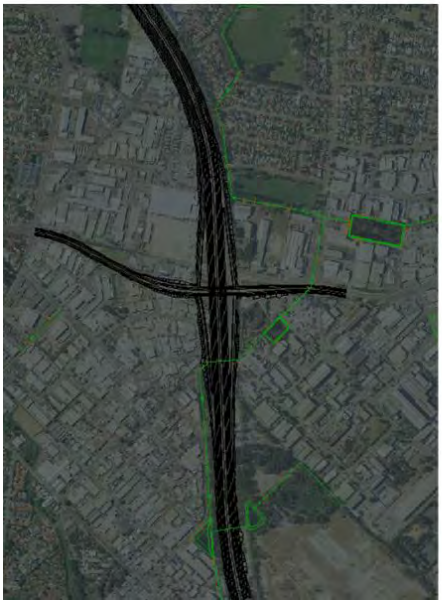
- Geographically large project
- 3 major zones identified:
  - Urban

- UWPC Priority 1 Source Protection Area
- Palusplain



Zone 1 – Urban

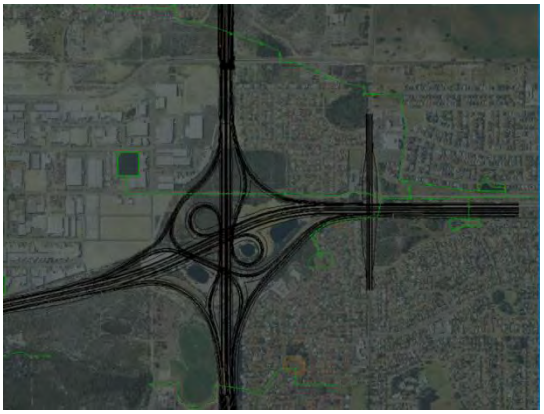
- 4 Grade Separated Interchanges:
  - Tonkin Hwy/Collier Rd
  - Tonkin Hwy/Morley Dve
  - Tonkin Hwy/Benara Rd
  - Tonkin Hwy / Reid Hwy / PDNH



Tonkin Highway / Collier Road

Tonkin Highway / Morley Drive

Tonkin Hwy / Benara Road

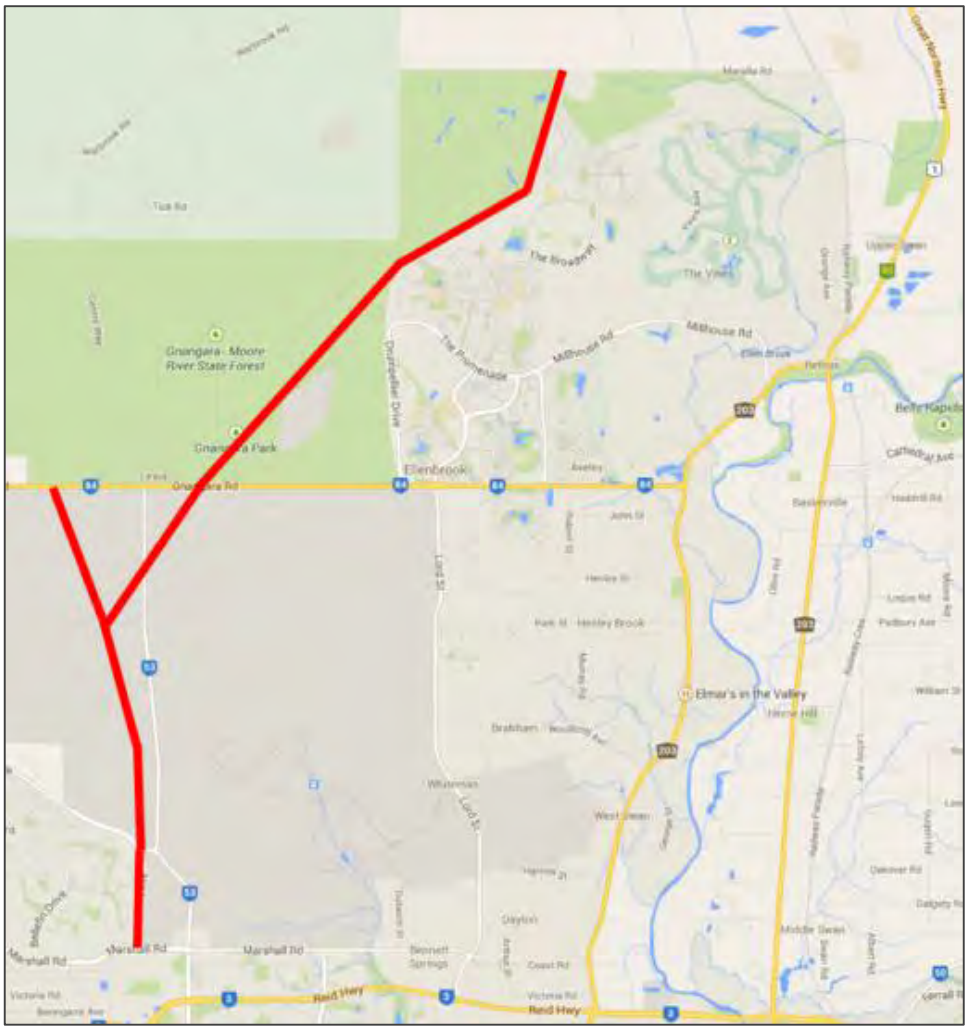


Tonkin Highway / Reid Highway / PDNH

Zone 2 – UWPCA Priority 1 SPA

- Marshall Road to Maralla Road
- Gnangara Mound Underground Water Pollution Control Area Priority 1 Source Protection Area
- Includes Water Corporation production bores and associated Well Head Protection Zones (WHPZ)
- Adjacent Conservation Category and Resource Enhancement wetlands
- Traverses through Whiteman Park and State Forest

Zone 2 Extent



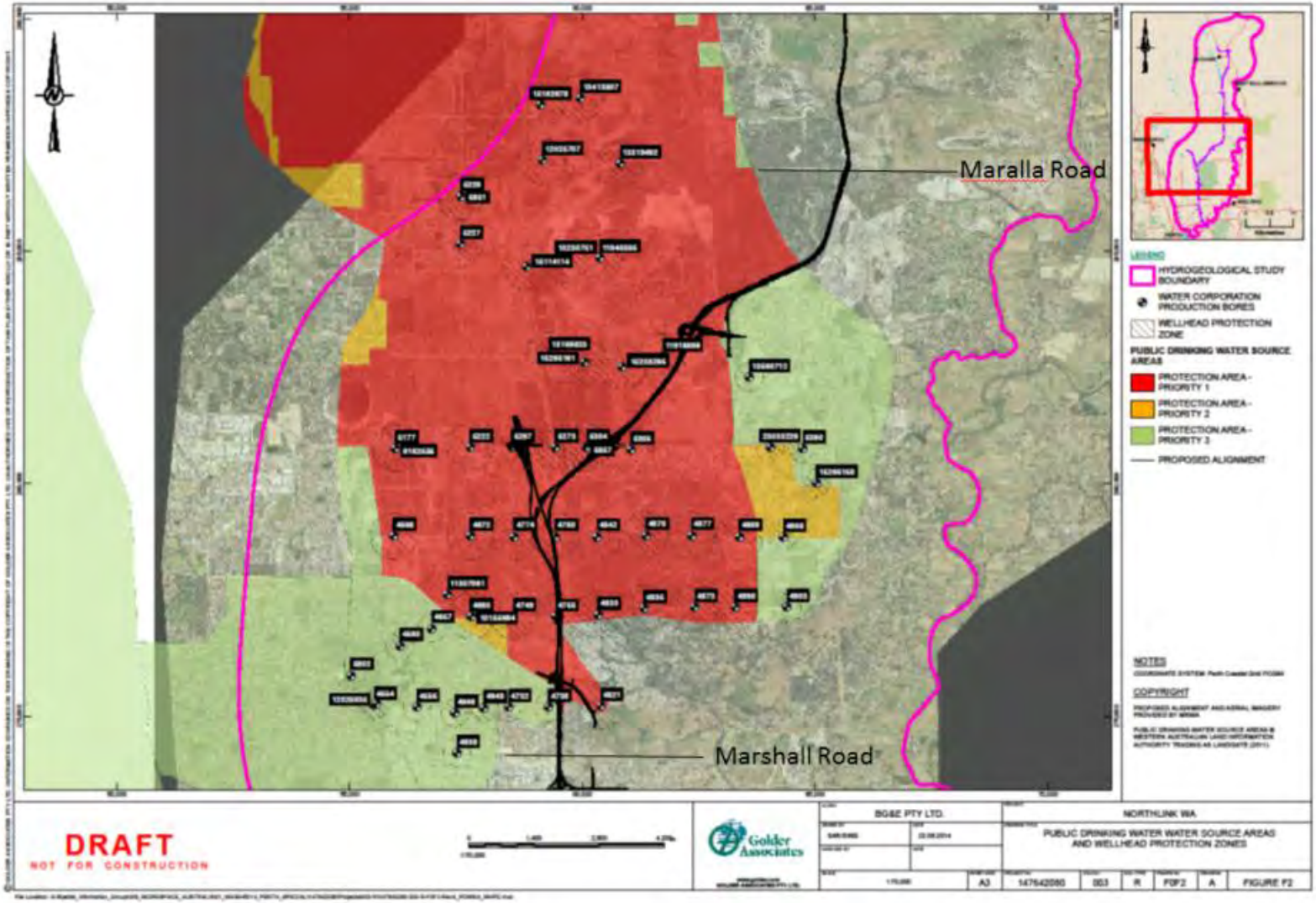

Maralla Road
Marshall Road
LEGEND
HYDROGEOLOGICAL STUDY BOUNDARY
WATER CORPORATION PRODUCTION BORES
WELLHEAD PROTECTION ZONE
PUBLIC DRINKING WATER SOURCE AREAS
PROTECTION AREA - PRIORITY 1
PROTECTION AREA - PRIORITY 2
PROTECTION AREA - PRIORITY 3
PROPOSED ALIGNMENT
NOTES
COPYRIGHT
DRAFT
NOT FOR CONSTRUCTION
Golder Associates
BG&E PTY LTD.
NORTHLINK WA
PUBLIC DRINKING WATER WATER SOURCE AREAS AND WELLHEAD PROTECTION ZONES
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FIGURE F2

WHPZ Hepburn Avenue

WHPZ Gnangara Road

WHPZ Ellenbrook

Zone 3 – Palusplain

- Maralla Road to Muchea
- Actual palusplain conditions start around Warbrook Road
- Numerous minor waterway crossings
- Area is predominately Multiple Use Wetland with isolated Conservation Category Wetland & Resource Enhancement Wetland adjacent the alignment

Maralla Rd to Warbrook Rd

Warbrook Rd to Stock Rd

Stock Rd to Neaves Rd

Neaves Rd to Muchea

QUESTION AND ANSWERS

A question and answer session followed as summarised below.

Q	Where is the Chittering land offset?
A	It is on Iopolla Road and has been purchased by MRWA. It addresses a range of impacts of the project and mostly for Carnaby's Cockatoo habitat. We need to follow due process to ensure it is suitable and used for the purpose. This site won't provide offset for water based impacts. Ellen Brockjman LandCare Group offers its assistance to identify suggested offset land. **ACTION: Mike and Denise**
Q	Is Stock Road interchange included?
A	The remainder of this year will finalise the design concept with provision for an interchange at Stock Road in the ultimate configuration with staging to be developed. It is currently proposed as an at grade intersection initially.
Q	The alignment is close to Priority 1 water bores does it directly impact any?
A	Not directly but we do get close to them - within 100m in some cases. This will change as the design progresses and the detail becomes apparent. It is unlikely that any bore would need to be moved. We need to provide a summary of clear distances and the associated shape files to Water Corporation to inform their planning.
Q	Is Water Corporation included in the consultation?
A	Yes, they are an invited member of the Drainage Reference Group and the Environmental Reference Group. Their existing bores aren't all in active use. Their long term planning is an important input to ensure Perth's potable water supply is assured over time and we need to consider the impacts for their options and plans for the future. Other bores may be drilled within the estate if required as a cost effective solution. We should also seek input and involvement of the water supply area of Water Corporation. We will continue to seek comment from Geoff Hughes as his Water Supply management counterpart. **ACTION: Linton**
Q	What about Department of Health input from a water quality perspective perhaps from Richard Theabald?
A	The Project Team will invite Department of Health to join this group from a water quality perspective. **ACTION: Linton**
Q	City of Swan is currently designing Gnangara Road dual carriageway as a key design input. Has that been considered?
A	Yes, and the relevant design information has been provided by Jim Coten and Mark Bridges of City of Swan.

Q	The DoW design philosophy needs to be similar to protect the aquifer and it may be more economically viable to move the bore than realign the road.
A	That is correct and we will consider options in an informed way.
Q	What about Swan River Trust (SRT) involvement?
A	We will invite SRT to join this group recognising that they will join DPaW soon. Possibly Jennifer Stritzke. **ACTION: Linton**
Q	What happens with regard to containment and spill management generally?
A	It is a consideration in all highway design and the level to which we respond to this needs to be clarified. It will be a risk strategy in response.
Q	Will the highway offer 2 lanes in each direction north of Maralla Road?
A	Yes, in the ultimate configuration but it is initially funded as a single lane each way. Is so, overtaking lanes may be provided as a result. There is a definite need for dual carriageway, the question is when on balance.
Q	Brand Hwy was built without sufficient drainage provision and produces flooding events regularly with sheet flow across flat land. Will the planning and design go to Muchea with a thorough approach?
A	The NPDH is going through this land with sheet flow and suitable culvert provision will be made to maintain current flows. We need to ensure existing flows are maintained and the PER will be based on ultimate design.
Q	Are bridges required for waterway purposes?
A	Yes, with two over Ellen Brook. Earlier hydrology work suggests design flows of 50 cumecs in the 100 year flood. 1 bridge on significant skew has bridge length impacts.
Q	Offset areas may be influenced by LGA desirably with regard to their land use strategies and should be considered.
A	The Offset strategy is critical as an Environmental Reference Group consideration.
Q	How does this brief relate to the subsequent procurement process?
A	We have not yet agreed the procurement strategy but this will take it to design and approval as the basis for tender.

6. DISCUSS AND AGREE TERMS OF REFERENCE

The suggested Terms of Reference for the DRG were presented and briefly discussed.

The Terms of Reference with comment shown are provided at Attachment Three.

Further comment is welcomed from DRG members and should be directed to Linton Pike.

7. DRAINAGE STRATEGY DEVELOPMENT PROCESS

Michael Wiezel briefly explained the drainage strategy development process as follows:

- Data gathering / constraints mapping
- Option identification
- Option development
- Option evaluation
- Drainage Strategy preparation
- Drainage Strategy acceptance (PSC and DoW)

Questions and answers arising from this session are summarised below.

Q	How is the Palusplain soil characterised?
A	Clayey silt and gravelly clay with groundwater to surface level. Relatively high runoff and inundation results. By managing the first 15mm of each rain event we can avoid the need for lots of detention, piping or other mechanisms.

8. DISCUSS AND INFORM PROPOSED STRATEGIC DRAINAGE GOALS, OPPORTUNITIES AND/OR TARGETS

Goals, Opportunities and/or Targets

- Urban;
- UWPCA Priority 1 SPA and WHPZ (Marshall Road to Maralla Road);
- Palusplain – north of Maralla Road; and
- These are discussed in more detail below

Bill Till provided a DoW view noting that:

- Bill leads the process for drainage and water management including criteria;
- There is no enforcement process for the criteria. The Decision Process for Stormwater Management in WA guides designers in drainage management and is published on the DoW webpage. A revision is in the consultation process now;
- The key principles are:
  - Managing the small (rainfall/drainage) event (up to 1 year) as the key. This covers 95% of all rainfall events and equates to managing the first 15mm of rain to fall from a quality and quantity perspective. Flood management then follows this;
  - Managing the extreme event Q100 for flood protection;

- Particularly in the palusplain area, runoff from the project site already enters wetlands so to prevent the highway runoff from entering the wetland would be to change the hydrology. There is little difference in runoff beyond water quality treatment. Whether water ends up in CCW or REW or other area now it should continue in the future and manage the events with appropriate water quality provision in the strategy and design;
- We need smart community infrastructure provisions; and
- We should adopt a risk based approach to selecting the treatments;

Other group discussion identified:

- Long term protection and management of wetlands is critical and a priority to catchment management for the future;
- The placement of infrastructure is critical to ensure appropriate buffers and protection on a risk basis;
- Recognise and manage nutrient management resulting from flows in an effective and efficient way. This may be with infrastructure out of corridor rather than within it potentially;
- Work collaboratively to get vegetation and water quality outcomes optimised;
- We should make wetland protection a priority wherever possible;
- A risk based approach to contamination and spills is needed to contain and allow for intervention in an event;
- The hydrology of the wetlands needs to be understood to ensure they are protected;
- Protect existing bores from spill and other impacts;
- Seek local infiltration solutions generally and manage flows locally without piping it to other areas or main drains;
- Manage flows to avoid direct flow into wetlands unless treated beforehand recognising potential for overflow infiltration;
- Recognise the long term maintenance impacts and costs;
- Adopting the appropriate technologies and treatment options;
- Allow for future replenishment of the bio-infiltration, vegetation, over time as part of the ongoing management task;
- Retain and manage erosion and other impacts eg soil erosion in all cases; and
- Recognise the potential for Acid Sulfate Soils although this should be minimised with little cut proposed.

The following key strategic approaches were agreed for each of the three primary planning contexts.

URBAN SECTION	
Proposed strategic drainage goals	• Avoid introducing more water to the local system than generated by local catchments; • Maintain the current drainage dynamic; • Seek to reduce the net water volume to be managed with local infiltration where possible; • Start with the small regular event and then allow for major events as shown above; • Minimise the use of kerbing to allow for local dispersement and infiltration via drains and swales; • Where kerbing is required with kerb breaks and local piped systems for local infiltration; and • Manage water at source and convey water via overland flow if it is required.
Opportunities	• We should maximise the capacity of the resultant swales, basins and drains to absorb and infiltrate water. • Minimise impacts to the existing drainage network to avoid major capital investment; • Benefit from Water Corporation main drain flood studies north of Benara Road. It is a ground water control system and designed for lowered ground water. There are opportunities within these corridors resulting from a level of over design by retrofitting drains to be better able to provide an environmental function in the broader development context, highway, roads, housing, etc. This has an inherent need to remodel the drainage system to ensure a "best for community" drainage outcome with a better understanding of system performance. This will need to be undertaken by the NorthLink WA team and won't be provided by the drainage asset owner; and • Ensure construction minimises the potential for sand runoff to waterways with effective site management.
Targets	• First 15mm of rain in any event should be managed at source as a rule; • Seek to reduce flows to the existing drainage pipe network with infiltration at source; • Bennet and Bayswater Brook main drain water quality targets have been set - Water Quality Improvement Program. This has impacts for the drains and the management regime. SRT has funded City of Swan and City of Belmont to implement this.

P1 WATER MOUND	
Proposed strategic drainage goals	• Design the swales and table drains to reflect best practice with treatment prior to local infiltration; • Longitudinal design to drain away from bores wherever possible with the best available water quality treatment technologies applied; • Ensure the sensitive high value wetlands are appropriately protected hydrologically; • Ensure connections are made to ensure links, flows and water balance is maintained; and • Protect potable water quality by understanding and diverting stormwater away from production bores – spillage, hydrocarbons, weed management spraying, etc with provision for emergency response to allow for effective clean up.
Opportunities	• First 15mm of rain in any rain event should be managed at source as a rule; • Treat water locally to allow for overtopping to other more sensitive areas and catchments; • The same would apply at a CCW to manage runoff with higher level treatment before water overtops to more sensitive areas. Manage at a response level and risk based assessment. Embed the WSUD in the drainage design process; • Ensure species for revegetation are appropriately selected; • Understand the effects of a staged solution from a hydrology and infiltration perspective with Water Sensitive Urban Design; • Water Quality Protection Note provided by Christa Loos is provided at Attachment Four; • Ensure provision for emergency response in an emergency including clean up; and • Include stormwater monitoring provision to ensure the treatments are achieving their goals at runoff and entry point to ground water at the bottom of the bio retention zone.
Targets	• First 15mm of rain in any rain event should be managed at source as a rule; • Ensure compliance with relevant water quality guidelines and standards and be informed by the Gnangara Water and Land Management Strategy; • Include a process for ensuring we get what we plan to do. Articulate and propose the water quality management compliance processes. This applies as far as “as con” compliance with the design eg fill material quality, thickness, grading, etc; and. • Maintain hydro values and/or improve water quality in CCW and REW and water bores.

PALUSPLAIN	
Proposed strategic drainage goals	• All of the comments shown for the P1 mound apply here; • Ensure suitable water flow options across the road corridor to maintain current flows and/or backwater/inundation and avoid a repeat or compounding of Brand Hwy outcomes. Understand sub-surface flows characteristics in the prevailing soils in the broader wetland scheme; and • Understand and minimise both sub surface and surface flow impediments resulting from the road with suitable culvert and/or other provisions with an appropriate and high level of drainage design interrogation to reflect community values.
Targets	• Manage the first 15mm to fall out of the sky in any one rain event; and • Generate no over ground flows resulting from this structure up to first 15mm.

9. STAKEHOLDER COMMENT – OTHER CRITICAL CONSIDERATIONS

Each stakeholder group was asked to comment on any outstanding matters of importance. The following feedback resulted.

Stakeholder	Comment
Cho Lamb DPaW	• The interface with the ERG is very important. • What is the status of the PER? – It is under development for submission at the end of 2014. ***Facilitator's note*** ***Cho provided supplementary post meeting comment shown below:*** • The impact of drainage on threatened and priority flora and fauna species and threatened and priority ecological communities should be considered. Michael Wiezel noted that: • With regard to the ERG interface the key stakeholders are here and the Project Team is co-located in a single office even though from multiple companies; and • DRG meetings will be held before the ERG as a key input to it.
Grant MacKinnon City of Swan	• Our needs are well covered at this stage.

Stakeholder	Comment
Jim Garrett Shire of Chittering	• The Brand Highway and Great Northern Highway intersection with triple road trains and drop offs at the end of their journey with hot tyres and runoff pollutants. How will drainage manage that over time? We manage the known concentration of contaminants resulting from source – breakdown areas, turning movements, cattle, materials or other loaded material or other.
George Rimpas City of Bayswater	• Nothing further to add.
Marilynn Horgan EMRC	• Circulate minutes from ERG as well please for distribution within EMRC.
Bill Till Department of Water	• Linkages to the ERG are important and we need to progress relevant discussion out of session to ensure consistency with drainage management and option.
Christa Loos Department of Water	• Who it the key point of contact for the DRG? For technical drainage matters it is Mike Wiezel. • Chemical storage provisions during construction need to be well managed with clarification provided by DoW.
Rosanna Hindmarsh Chittering Landcare/Ellen Brockjman Catchment Council	• Consider the ramifications of and for the sub-catchments to Ellen Brook as a result of current and future land use changes eg cattle yards and other changing land uses – Muchea Employment node and others with increased runoff.
Kelly Fulker Perth Region NRM	• Don't over-rely on offsets and look to protect what we can. • Maximise and show-case opportunities with Perth NRM happy to explore opportunities with the team.
Eric Cheung MRWA	• Bridges and culverts are of importance to us. Please raise emerging issues with us for discussion and advice.
Dominic Boyle MRWA	• Thank you for your involvement and open participation.
Anthony Wood NorthLink WA	• Lots of opportunities to do well and apply best practice including beyond the road corridor.
Mike Wiezel NorthLink WA	• Thank you.
Padraic Murphy NorthLink WA	• Please continue to provide input and suggestions.

Stakeholder	Comment
Denise True NorthLink WA	• The interaction and exchange of ideas is great please continue.

10. NEXT STEPS AND CLOSE OUT ACTIONS

The next steps in the process include:

- Finalisation and distribution of this summary;
- Progress with the drainage design strategy;
- Follow up on actions listed above; and
- Circulate contact details for all participants.

Action: Linton

The meeting closed at 12:30pm.

ATTACHMENT ONE – AGENDA

Drainage Reference Group Meeting #1	
Date:	8:45am, Wednesday, 9 July 2014
Location:	City of Swan Operations Centre – Great Northern Highway – See Locality Plan at page 4.

Drainage Reference Group (DRG) Meeting #1 - AGENDA

Workshop Purpose

- Establish the Drainage Reference Group (DRG) for the Northlink WA Projects;
- Provide an overview of the projects;
- Discuss and agree the DRG's Term of Reference;
- Identify and agree an approach to addressing key drainage goals, opportunities and issues; and
- Build project understanding and support to pave the way for successful and timely project outcomes.

Start At:	Item	By:
8:45	**Arrival – tea and coffee provided**	
9:00	Welcome - meeting purpose and process	Linton Pike
9:05	Personal introductions	All
9:10	Project overview and context	Dominic Boyle
9:20	Project Performance Framework	Anthony Wood
9:30	Drainage overview	Michael Wiezel
9:45	Question and answers	All
10:00	Discuss and agree Terms of Reference	All
10:15	Drainage Strategy development process: • Data gathering / constraints mapping; • Option Identification; • Option Development; • Option Evaluation; • Drainage Strategy preparation / acceptance	Michael Wiezel
10:30	**Morning tea**	

Start At	Item	By
10:45	Discuss and inform proposed strategic drainage goals, opportunities and/or targets: • Urban section; • P1 Water Mound - Marshall Road to Maralla Road; and • Palusplain – Maralla road north	All
11:30	Discuss and provide feedback on options for: • Flood mitigation; and • Water quality	All
12:00	Stakeholder comment – Other critical considerations	Each participant
12:20	Next steps and close out actions: • Meeting frequency and timing; • Other	All
12:30	Close	

ATTACHMENT TWO – MEETING PARTICIPANTS

Name	Organisation
Cho Lamb	Department of Parks and Wildlife
Jim Coten	City of Swan
Grant MacKinnon	City of Swan
Jim Garrett	Shire of Chittering
George Rimpas	City of Bayswater
Marilynn Horgan	Eastern Metropolitan Regional Council
Bill Till	Department of Water
Christa Loos	Department of Water
Rosanna Hindmarsh	Chittering Landcare/Ellen Brockjman Catchment Council
Kelly Fulker	Perth Region NRM
Dominic Boyle	Main Roads WA
Christina Jalleh	Main Roads WA
Eric Cheung	Main Roads WA
Anthony Wood	NorthLink WA Project Team
Padraic Murphy	NorthLink WA Project Team
Denise True	NorthLink WA Project Team
Michael Wiezel	NorthLink WA Project Team
Linton Pike	NorthLink WA Project Team

Apologies

Geoff Hughes	Water Corporation
Tim Hillyard	WA Planning Commission
Zahirul Baten	Main Roads WA
Minhdu Nguyen	Main Roads WA
Yoon-kah Wong	City of Swan

NORTHLINK WA DRAINAGE REFERENCE GROUP

Perth Darwin National Highway (Tonkin to Muchea) and Tonkin Grade Separations

TERMS OF REFERENCE

July 2014

11. Objectives

The NorthLink WA Project exists in two parts:

- Perth Darwin National Highway (Tonkin to Muchea); and
- Tonkin Grade Separations.

The NorthLink WA objectives are to:

- Improve freight capacity, efficiency and productivity;
- Reduce urban congestion now and into the future;
- Improve road safety through the “Towards Zero” initiative;
- Maximise sustainability through economic, social and environmental responsibility;
- Improve the amenity for the community, tourists and road users; and
- Create value through affordable infrastructure.

In developing the project NorthLink WA’s Core Service objectives are to:

- Manage all aspects of the NorthLink WA Projects through the development phase to achieve agreed outcomes within time, cost and quality constraints;
- Optimise project outcomes and gain project support through engaging with the community and stakeholders;
- Conduct site investigations and collect data to support both project development and delivery phases (including approvals and detailed design);
- Undertake a Planning Refinement of the ultimate road layout to optimise the long term planning concept within the proposed MRS reservation; and
- Define the NorthLink WA Projects to be built for the current budget so as to maximise the return on investment.

The NorthLink WA Drainage Reference Group (DRG) has been established to inform the drainage design for the NorthLink WA project and to assist in ensuring the needs of key stakeholders are identified early in the process.

12. Role of The Drainage Reference Group

The DRG has been established to:

- Collaboratively inform the Drainage Strategy for NorthLink WA;
- Provide advice and comment on the implementation and fulfilment of the drainage conditions and commitments as part of the compliance reporting process;
- Assist in coordinating the concerns, suggestions and advice of the various agencies and stakeholders to ensure an optimal solution results;
- Adopt innovative outcomes extending beyond compliance to the maximum extent possible in keeping with the NorthLink WA objectives;
- Provide issue-specific liaison in developing the drainage solution; and
- Communicate project matters to, and from, relevant drainage and stakeholder groups.

13. DRG Composition

Participants in the NorthLink WA DRG are:

- Department of Parks and Wildlife;
- Department of Water;
- Water Corporation;
- City of Swan;
- Shire of Chittering;
- City of Bayswater;
- Chittering Landcare / Ellen Brockman Catchment Council;
- WAPC;
- Eastern Metropolitan Regional Council;
- Perth Region NRM;
- NorthLink WA; and
- Main Roads Western Australia.

Other project stakeholders may be invited on an as required basis.

14. Tenure and Meeting Arrangements

Three meetings of the DRG are planned commencing in July 2014 and meeting dates will reflect the project design process. Subsequent meetings are tentatively planned for August and December 2014.

DRG members are appointed for the life of the project with an anticipated project completion date of June 2015. Other meetings of the DRG may occur beyond those proposed to discuss or resolve specific matters.

DRG members unable to attend a meeting may nominate a proxy to attend on their behalf. The Independent Facilitator is to be advised of the nominated proxy prior to the meeting.

The DRG will function as an advisory group with agreed outcomes resolved by consensus and recorded by the Independent Facilitator and copies provided to DRG members and the NorthLink WA Team.

DRG members will not speak on behalf of the group without its prior written consent. This consent can only be given at a meeting of the DRG.

DRG members representing stakeholder groups holding structured meetings are asked to fulfil a liaison, reporting and communication role with the groups they represent.

The NorthLink WA Team will provide appropriate and reasonable support with resources and information as required.

15. Agenda and Minutes

The agenda and documents will be circulated one working week prior to the meeting.

Minutes will be taken and circulated to all members within seven working days of the meeting.

ATTACHMENT FOUR – WATER QUALITY PROTECTION NOTE

WQPN 44, OCTOBER 2006

Roads near sensitive water resources

Purpose

Roadways and their associated drainage and bridge works are vital links in the economic and social life of our communities. They require good site selection, planning and construction, maintenance and incident management during their operational life to limit the risk of harm to water resources. Environmental issues include land clearing, minimising turbidity and petroleum derivatives in stormwater run-off, solvent loss from bitumen preparation, spread of vegetation dieback disease, chemical spills due to transport accidents, pollutants from maintenance and clearing activities, and environmental damage caused by those who access sensitive water resources via the road. Use of effective pollution prevention and risk management measures during the design, construction, operation and maintenance of roadways can help minimise water contamination problems.

The Department of Water is responsible for managing and protecting the State's water resources. It is also a lead agency for water conservation and reuse. This note offers:

- the Department's current views on road siting, construction and management;
- guidance on acceptable practices used to protect the quality of Western Australian water resources; and
- a basis for the development of a multi-agency code or guideline designed to balance the views of industry, government and the community, while sustaining a healthy environment.

This note provides a general guide on issues of environmental concern, and offers potential solutions based on professional judgement and precedent. The recommendations made do not override any statutory obligation or Government policy statement. Alternative practical environmental solutions to suit local conditions may be considered. Regulatory agencies should not use this note's recommendations without a site-specific assessment of any project's environmental risks. Any conditions set should consider the values of the surrounding environment, the safeguards in place, and take a precautionary approach. The note shall not be used as this Department's policy position on a specific matter, unless confirmed in writing.

Scope

This note applies to all new or upgraded roadways (sealed or unsealed) and associated works such as bridges and drainage that could affect sensitive water resources (see description in Appendix C). The note aims to cover all phases of the lifecycle of a roadway, including feasibility studies and planning, construction, operation and maintenance, and potential closure followed by environmental restoration.

The note covers roadways used by motorised vehicles only. Walk-ways, stock routes, cycle paths, and bridle trails are excluded.

Recommendations

Location of roads

Harmony with the local environment

1. Roadways, with any associated drains and bridges should (if practical) blend into the natural landscape and morphology of the site. Waterway and wetland crossings should be avoided or at least minimised. Necessary crossings should create the least practical interference with the natural flow and aquatic habitat of surface waters. Environmental features need careful consideration when planning for roadways, eg, drainage patterns, ecosystems, fauna habitats, local climate, existing land uses, soil types, topography and vegetation cover.

2. Clearing of vegetation and reshaping land should be minimised, and vegetated buffers to sensitive water resources should be preserved. These fringing buffers provide vital water quality benefits (eg filter for sheet stormwater run-off and help maintain water body ecology). Areas susceptible to erosion or sedimentation should be avoided as harm to local water resources may result. Other aspects that need to be addressed include managing plant disease risk eg *Phytophthora cinnamomi* in the southwest of the State, and degradation of remnant native vegetation by weed invasion and human contact.

Buffers to sensitive water resources

3. Perennial indigenous vegetation buffers should be retained or re-established between any roadway and sensitive water resources. Appropriate buffers reduce the immediate contamination risk to water resources by acting as stormwater contaminant filters and allow time for effective remedial action in the event of a chemical spill incident. These buffers may need to be supported by other protective measures eg roadside hollows to capture chemical spills along designated industrial transport routes. The buffers should be wide enough to be self sustaining, and (where practical) fenced to exclude people, vehicles and stock intrusion. For more information, see this Department's Water Quality Protection Note *Vegetation buffers to sensitive water resources* (see Appendix A, Reference 5b).

Protection of waterway and wetland vegetation

4. Where the footprint of roads and bridges may affect waterways or wetland buffer vegetation, they should be relocated or if this is impractical, the impact minimised. Fringing buffers provide significant water quality benefits through their ability to sustain aquatic ecosystems and filter pollutants in stormwater run-off. Roadways should therefore be placed sufficiently high in the landscape to permit retention of waterway or wetland vegetation, and allow for the effective operation of contaminant filter and sediment control functions.

5. Public roads near sensitive water resources should be located on land zoned as a road reserve by the Department for Planning and Infrastructure, the Department of Land Administration or the Local Government Authority (LGA).

Consultation

6. This Department and the community should be consulted when any roadways are proposed through or near any potentially sensitive water resources.

   This ensures that transport corridors are negotiated well in advance of road construction; so they are suitably located, constructed, and can be operated and maintained with an appropriate balance of environmental, as well as social and economic considerations. Any road-works proposed within 200 metres of a sensitive water resource should be referred to this Department's regional office for assessment, with supporting information addressing how the environmental risks will be managed.

Within Public Drinking Water Source Areas (PDWSA)

These are areas declared for the management and protection of water sources used for public drinking water supply. They are proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*. PDWSA include Underground Water Pollution Control Areas, Water Reserves and Catchment Areas.

7. Within Priority 1 (P1) areas, well-head and reservoir protection zones defined in Drinking water source protection plans, this Department normally opposes new roads, as they are incompatible with the risk avoidance strategy used to protect water sources. Roads may occasionally be approved with conditions, where the proponent shows that the road is needed to either lessen problems posed by present local transport routes or is vital to the State's interests.

8. Within Priority 2 (P2) areas, this Department normally gives conditional approval to road developments, provided the proponent demonstrates the road will not cause an increased risk to water resource values. The conditions of approval should be designed to minimise the water contamination risks. Road-works in P2 areas should provide for both optimum traffic safety and minimal risk of environmental impacts eg from chemical spillage due to transport accidents.

9. Within Priority 3 (P3) areas, roads are compatible with this Department's source protection strategy provided best industry design and construction practice is followed. These notes propose best environmental practice options for roadways.

10. Road developers should use scientific investigation and potential contaminant movement modelling to define protective buffers to water source reservoirs, bores and wells. The model should take the following into account:
    a. the properties of any likely water contaminant (including its initial concentration, solubility and degradation potential);
    b. method of contaminant movement and probable duration between its release point and the water supply source under a variety of weather scenarios;
    c. local meteorological data;
    d. potential for vegetation and soil filtering, bio-chemical attenuation processes along the contaminant travel pathway, and any synergistic effects in the environment; and
    e. the receiving water quality regime and requirements to sustain its present usage and a suitable factor of safety so that the model is conservative.

Such modelling does not override any statutory controls or Departmental policy position related to protection of public water supplies.

11. Under some circumstances it may be impractical to carry out the scientific studies recommended above eg for small-scale developments or for severely disturbed buffer zones. In such cases the default separation distance from road-works (where conditional or compatible) should be at least 100 metres to drinking water source bores, the full supply level of storage reservoirs and their feeder streams.

Near conservation valued wetlands

12. Roadways and associated facilities, eg parking bays, should not be constructed through or within natural wetlands with recognised or probable conservation values, or their fringing vegetation buffer.

13. Any proposed road development that is likely to have a significant effect on the values of a wetland or its vegetation buffer should be referred to the Environmental Protection Authority (EPA) in accordance with Section 38 of the *Environmental Protection Act 1986* for possible environmental impact assessment. Where passage through a wetland is unavoidable, a target of no change in its function should be achieved through offsets eg enhanced protection of a nearby equivalent wetland or a constructed extension to the affected wetland to provide the same values and area (see Appendix A, Reference 3 for details of related EPA documents). For additional information on wetland management categories, boundaries and buffer determination, see Appendix A, Reference 4a and Appendix C.

14. A wetland buffer helps to maintain vital ecological processes and functions, and protect the wetland from potential harm. To sustain the wetland it is important to determine, safeguard and effectively manage these buffers. The local regional office of the Department of Environment and Conservation can provide detailed information on defining and protecting wetlands.

Near Environmental Protection Policy wetlands

15. The *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* and *Environmental Protection (South West Agriculture Zone Wetlands) Policy 1998* prohibit the unauthorised filling, mining, drainage change, and effluent discharge into lakes, under Part III of the *Environmental Protection Act 1986*. Roadways must not be constructed through, or otherwise harm such wetlands, unless approved either by the Minister for the Environment on the advice of the EPA or the Department of Environment and Conservation.

Near conservation valued waterways

Five Waterways Management Areas have been declared under the *Waterways Conservation Act 1976* to protect specific estuaries and their associated waterways that are considered especially vulnerable to degradation. These are the Albany Waterways, Avon River, Leschenault Inlet, Peel–Harvey, and Wilson Inlet Management Areas.

Many other waterways while not protected by the *Waterways Conservation Act,* have valuable ecological and social values that should be retained or are being restored with the guidance of Natural Resource Management regional groups where degraded (see www.nrm.org.au).

16. If a road development is located within a Waterways Management Area, or may have an effect on any natural waterway or its fringing vegetation, the proponent should consult with this Department's regional office on appropriate measures to minimise ecological damage and water contamination risks during the construction and subsequent operation of the road.

17. Apart from essential waterway crossings, roads and their engineered drainage system should be positioned (if practical) outside the bounds of waterways and associated fringing vegetation.

18. To protect waterways and their associated riparian area, a foreshore area or waterway buffer should be determined based on an assessment of the biological and physical features associated with the waterway, its values and pressures, as outlined in the Department of Water's *Foreshore Policy 1 - Identifying the Foreshore Area* (WRC, 2002). The features to be used in the assessment are known as *bio-physical criteria* (see Appendix A, Reference 5c).

    This approach to buffer setting allows flexibility and site-specific decision-making by considering a range of criteria and allows for negotiated outcomes, rather than using a standard buffer distance that may not match the local conditions. This is considered a sustainable approach to waterway management that does not restrict the social and economic opportunities for waterways, and protects their ecological values.

19. Details of how to use biophysical criteria to determine the size or width of a foreshore area or waterway buffer, including the underlying rationale, can be found in the Department's Water Note 23 *Determining Foreshore Reserves* (WRC, 2001), see Appendix A, Reference 5c. The onus is on the development proponent to demonstrate and justify the process and outcome of defining an appropriate 'foreshore area' on a site-specific basis.

Within the Swan River Trust management area

20. The Swan-Canning estuary and abutting reserves are managed by the Swan River Trust using the *Swan River Trust Act 1988*. Written approval from the Trust is necessary for any land or water-based development that may have an effect on the estuary.

Other location constraints

21. A minimum vertical separation distance of two metres from the road sub-base to the high (wet-season) water table should be retained for free-draining soils, to avoid waterlogging and allow for soil filtration of potential contaminants and aerobic microbial action.

Native vegetation

22. The clearing of native vegetation is regulated under the *Environmental Protection Act* 1986 and *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. The Department of Environment and Conservation is responsible for administering this legislation, which prohibits clearing of native vegetation, unless for an exempt purpose or where a clearing permit has been granted. Exemptions under the regulations do not apply in gazetted environmental sensitive areas (see Appendix A, Reference 4c and Appendix B).

Approval for development or upgrade of roads

23. For summary details of approvals; relevant statutes and managing agencies, see Appendix B.

Road design

24. Roads (where practical and in accord with safe design standards) should closely follow the land contour to minimise the extent of cut and fill that may alter natural water movement patterns or require extensive artificial drainage works. The design should avoid impact on waterways and wetlands, especially those with recognised conservation values.

25. Road-works that must cross waterways and wetlands should:

    a. not change natural hydrological regimes or cause storm event flooding of upstream land. For sites with semi-perennial water, bridges are preferred to fords, pipe-work or box culverts due to less interference with flow regimes and aquatic habitat;

    b. replicate where practical the natural cross-sectional area and shape of the waterway or wetland so that flows are not concentrated or flooding risk increased. Summary information on the road crossing hydraulic calculations and backwater impacts should be provided to this Department with any development submission;

    c. avoid creating barriers or impediments to migration of aquatic fauna. The number, size, shape and location of any necessary culverts should be selected to minimise the impacts on aquatic habitats.

       Techniques, such as ensuring sufficient light entry in crossings and fitting rock baffles or other flow velocity controls along the base of culverts, may be used to facilitate fish passage. Fish-ways or fish ladders should also be installed to allow migrating fish to overcome constructed barriers in their path. Several types of fish-ways can be built to provide passage along the length of the river. For more information see the Department's Water Note 26 *Simple fish-ways* (WRC, 2002), see Appendix A, Reference 5c or contact our nearest regional office;

    d. avoid (where practical) alteration to natural waterway and wetland geomorphology (including beds and banks) and ensure unnatural sedimentation is prevented;

    e. incorporate measures to prevent significant erosion of waterway or wetland banks;

    f. avoid crossings at channel bends or at angles much less than 90 degrees to the main flow channel; and

    g. avoid meandering or dynamic waterways where the channel change process is active and is likely to continue in the future. Crossings interfere with this natural process of meander progression and structural damage to bridges may occur, as well as increased channel erosion.

    See Appendix D for a diagram illustrating environmental protection measures at waterway and wetland crossings.

26. The following measures should be used (where practical) near sensitive water resources to limit the risks and effects of transport accidents, especially where traffic densities may be high:

    a. sight distances (horizontal and vertical visibility) should be suited to the intended road use, seasonal weather patterns and designated vehicle speed limits;

    b. slow vehicle passing lanes installed on major transport routes;

    c. advisory and hazard warning signs installed and maintained, however erection of distracting advertising signs should be avoided;

d. broad road shoulders installed to allow an emergency stopping place for vehicles;

e. provide suitable carriage-way buffers to trees and service poles, especially on bends;

f. intersections minimised, with turnout lanes, median strips and roundabouts used;

g. reflective road markers and vibration strips used to define lanes and indicate deviations on tourist and transport routes; and

h. where gradients are steep, install and maintain robust perimeter guard rails and heavy transport arrester beds.

Unpaved roadways

27. These should be avoided where practical, as they require regular maintenance to limit the risk of traffic accidents and often generate turbid stormwater run-off. Where a paved surface is uneconomic, roads should run parallel to the land contour, avoiding slopes exceeding one in ten to minimise erosion. Where roads in steep terrain are unavoidable, erosion prevention measures and drainage structures should be employed to limit environmental harm.

Road drainage

28. Drainage systems should incorporate the principles of water-sensitive design, see Appendix A Reference 5d. Appropriate techniques include kerb-less roads in flat terrain, vegetated roadside soakage swales, contaminant bio-filters and local stormwater disposal in built-up areas. Drains direct to natural waterways and wetlands with social and ecological values should be avoided. Otherwise effective measures should be in place to control litter and chemical discharge resulting from any transport accidents.

Parking bays, stopping places and picnic areas

29. Where practical, parking facilities or amenities should not be placed close to sensitive water resources (particularly where uncontrolled tourism access to these waters is likely to harm their values). Where unavoidable, they should be provided with managed landscape viewing facilities, toilet and litter disposal facilities, signage and barrier fencing to deter general access to the water body and its fringes. In public drinking water source catchments, such proposals should be referred to this Department for assessment and response prior to their implementation.

Road construction

Erosion and sediment control

30. Road designers or contractors should develop site-specific erosion and sediment control plans to minimise environmental impacts of stormwater run-off during construction activities. The following sediment control measures should be included in the plans:

a. clearing and exposed soil working surfaces kept to a minimum, and protected from stormwater erosion;

b. during wet seasons, silt fences and sediment traps should be optimally placed to prevent soil export to waterways and wetlands;

c. vehicle wash-down facilities should be available to remove excess soil when leaving construction sites. Wash-down facilities for mechanical plant or vehicles should be constructed and operated as recommended in this Department's Water Quality Protection Note *Wash-down of mechanical equipment,* see Appendix A, Reference 6;

d. temporary entry or exit roads to construction sites should be provided with a coarse rock surface to prevent the transfer of soil off-site, where it may affect nearby drainage channels or spread weeds and vegetation dieback disease.

Construction depots

31. These should be located as far as practical from sensitive water resources. They should be located on previously cleared gently-sloping (ie less than one in ten), well-drained land.

32. Environmental protection measures at depot should include:

    a. raw material storage located where it will not be flooded or eroded. Where stormwater run-off may occur, settling ponds should intercept flows and provide sufficient detention or other effective means to effectively control turbidity; and

    b. fuelling facilities for vehicles and construction plant should follow the recommendations given in this Department's Water Quality Protection Note *Tanks for above ground chemical storage near sensitive water resources*, see Appendix A, Reference 5b.

Water supply

33. The availability of scheme or local water supply should be carefully considered when planning road-works. Waters taken from surface or groundwater sources generally require a licence under the *Rights in Water and Irrigation Act 1914*. Information on regulated waters and licensing requirements should be obtained from this Department's regional offices.

Waste disposal

34. All wastes from employee amenities (eg toilets, showers and crib rooms) and portable sewage units should be either discharged to sewer or managed in accordance with the *Health Act 1911*, and the requirements of the Local Government Authority (LGA). Buffers of at least 100 metres from any on-site wastewater management and disposal facilities to surface waters should be maintained.

35. Any solid putrescible, hazardous or intractable waste generated on the site should be disposed of at a site acceptable to the LGA which conforms to the Department of Health and the Department of Environment and Conservation administered regulations (see Appendix A, Reference 4b), *Guidelines for acceptance of solid waste to landfill.*

Chemical use and management

36. Waste or spilt construction site chemicals (eg fertilisers, fuel, herbicides, insecticides, oils, degreasers, anti-freeze, solvents for asphalt products, sealers and paints) and wash-water associated with these materials should be stored, handled and contained to minimise their soakage or run-off to the environment. An option is to provide temporary containment compounds where these products are frequently used, such as at fuelling areas and equipment washing areas.

37. Secondary containment should be used to prevent harmful chemicals from entering ground or surface water resources. For more information, see this Department's Water Quality Protection Note *Toxic and hazardous substances - storage and use;* see Appendix A, Reference 5b.

Mechanical servicing

38. Routine plant and vehicle servicing involving liquids such as coolants, hydraulic oils, brake fluid or lubricants should take place within weather-proof structures designed to contain fluid spills. The operator should install effective systems for the capture and export of waste liquids for recycle or approved disposal.

39. All facilities and operations should be compatible with this Department's Water Quality Protection Notes *Mechanical servicing and workshops* and *Mobile mechanical servicing and cleaning*. This activity requires this Department's written approval within public drinking water source areas that are designated as *Underground Water Pollution Control Areas*.

Workforce environmental awareness

40. Awareness programs for contractors and construction crews should be prepared and implemented, covering environmental protection (including water resource protection).

Operational management practices

41. An Environmental management practice (EMP) manual should be prepared and utilised to protect the local environment and water resources. Typical examples of recommended practice can be found in the document *Stormwater Management Manual for Western Australia*, see Appendix A, Reference 5d. The EMP should cover maintenance depots, operation and maintenance of roadways, drainage management and site restoration.

42. The EMP should address temporary control of waste, chemical spills, erosion and polluted run-off. Examples of practices for protecting disturbed erosive soils include brush or mulch cover, straw bale barriers, silt fences, slurry filled pillows and sedimentation basins.

43. Provision should be made for routine inspection and maintenance of drainage, erosion and sediment control facilities after construction has been completed. Aspects include programmed inspections, temporary cereal crop cover and follow-up permanent vegetation restoration. Land stabilisation practices help to intercept polluted run-off from the operation of roadways or from erosion and sedimentation generated at small construction sites.

44. The EMP may also be used for permanent or long-term stormwater control. Controls may be both structural and non-structural. Examples include erosion and sediment management using grassed swales, filter strips and stormwater infiltration areas. Post and mesh fencing of protective barriers along road reserves should help in separating road users from sensitive areas and reduce fauna access to the road, resulting in a lowered risk of accidents.

Operation and maintenance of roadways

45. Road, highway and bridge operation and maintenance programs involve inspection, routine and season-specific maintenance, and repairs including the rights-of-way where drainage control facilities are located. An infrastructure safety program should be developed in conjunction with general inspection and maintenance programs.

46. Roadway operators should develop and implement a routine inspection and maintenance schedule, with practical measures to minimise contamination of waters. Options include:
    a. mechanically swept or vacuum-cleaned urban streets and associated parking bays;
    b. collection and removal of dead animals and road litter; and
    c. litter abatement programs eg via way-stop litter bins, verge clean-up campaigns and drainage litter traps.

47. The roadway owner or operator should undertake the following roadway measures to minimise transport accidents and contaminated run-off, as part of a regular program:
    a. inspect barriers, fences, erosion and sediment control devices;
    b. maintain retaining walls and pavements to minimise cracks and water damage;
    c. repair pot-holes and shoulder erosion to minimise risk of vehicle accidents;
    d. maintain stormwater energy dissipaters and velocity controls on open drains to lower run-off velocity and control soil erosion;
    e. dispose of accumulated sediment collected from detention ponds, drainage systems, and pollution control structures, and any wastes generated during maintenance operations in accordance with appropriate local government and State agency requirements;
    f. use techniques during bridge maintenance such as suspended tarpaulins, vacuum collection or booms to prevent paint spills, solvents and scrapings from becoming waterborne pollutants;
    g. take care when re-contouring or smoothing unpaved roads to maintain a structurally sound surface, while providing an adequate crown and drainage so that erosion or scattering of base materials is avoided; and
    h. keep drainage ditches and water diversion turnouts free from accumulated debris.

Maintenance of verges

48. The following measures to prevent verge erosion and water contamination should be used:
    a. local native plants in roadside revegetation projects. Avoid planting deciduous or exotic plants, as their leaf litter contributes significant nutrient loads to water bodies, while exotics may spread via seed movement along waterways, disrupting the natural ecology;
    b. mulch, seed and sparingly fertilise, or apply topsoil and perennial plants to damaged vegetated areas and employ gabions or terracing on steep slopes;
    c. establish environmentally safe programs for pesticide use and nutrient management;
    d. restrict herbicide and pesticide application in highway rights-of-way to accredited operators, to ensure safe and effective application;
    e. follow supplier's recommendations on optimum application rates for chemicals such as soil stabilisers, dust palliatives, herbicides, pesticides and plant growth inhibitors. Try to avoid frequent use and consequent intrusion of such chemicals into surface stormwater run-off. Within drinking water source areas, use of pesticides is limited by requirements of the Department of Health and this Department's policy *Pesticide use in Public Drinking Water Source Areas*, see Appendix A, Reference 5a;

f. regularly inspect, clean, regrade earth drains, and manage debris and vegetation growth in drains, ditches and swales to ensure they perform as effective drainage and contaminant filter systems. Keep ditch slopes covered with vegetation or other durable, non erosive material; and

g. maintain road shoulders, slopes and swales to assure their effective function and operation in protecting the road asset and the local environment.

Maintenance of bridges

49. Where practical, pest control for timber structures should include the following measures:

a. pest-specific pesticides should be used so as to minimise the impact on other terrestrial or aquatic invertebrates;

b. where pesticide use cannot be avoided, use targeted methods such as shrouded spraying;

c. conform to the chemical registration conditions (normally shown as label directions);

d. avoid application of water soluble or mobile chemicals when rain is predicted within 48 hours;

e. spillage control and capture measures should be in place prior to pesticide application to prevent residue entry into any waterway or wetland;

f. pesticide operators should be qualified and experienced, and have received instruction on managing the local environmental risks; and

g. all waste materials should be removed from the area for safe disposal at a local government approved site.

Nutrient use and control

50. Disturbed land should be revegetated using native plant species endemic to the area, as these plants will need little fertiliser, only initial watering and will enhance habitat for native fauna. Fertilisers, where use is necessary to promote the growth of vegetation on disturbed earth, should not contribute excessive nitrates and phosphates to surface waters.

51. Personnel qualified and experienced in soil testing and nutrient application should be used to determine the least amount of fertiliser to apply in a given situation. Slow release fertiliser should be used and timed to maximise nutrient delivery to growing plants, and minimise nutrient leaching or entry into stormwater run-off.

52. For fertiliser application rates near sensitive waters, see this Department's Water Quality Protection Note *Irrigation with nutrient-rich wastewater* (Appendix A, Reference 5b).

Performance audit

53. The road should be periodically inspected by government officers to audit the site operator's compliance with environmental and planning approval requirements.

Accidents and emergency response

The risk of contamination to sensitive water resources increases with human access and the type of traffic using the road. Higher risks are considered to apply where roads provide for goods haulage and access to tourist destinations.

54. The risks and potential consequences to sensitive waters should be defined at the road planning stage. Assessment should involve consultation with government agencies who manage the natural resources that could be affected by the roadway and its users.

55. Roads may require location-specific management plans to cope with accidental fuel or other chemical spillage. When a road is located near a sensitive water resource in a remote location, an effective response to a chemical spillage may be delayed due to the long travel distances from works depots. The design of the road therefore should include measures for interim spillage control and containment. These measures should ensure the spill is contained while the response personnel are being mobilised.

56. Absorbent matter such as sand or inert litter should be readily available to assist clean-up of any waste spill. Any materials used for clean-up should be disposed of at an approved facility.

Road closure and environmental restoration

57. Should a roadway no longer be required, its reserve should be de-proclaimed, the road closed and the roadway restored to a condition compatible with the adjoining or planned land usage. This should include removal of the paved surface and redundant drainage structures, deep ripping of compacted road base, replanting of native vegetation and restoration of natural water-courses. Soil stabilisation, import of topsoil, limited fertiliser addition and early establishment watering may be needed to ensure survival of the replanted vegetation.

More Information

We welcome your views on this note. Feedback provided on this topic is held on our file **12144.**

This note will be updated periodically as new information is received or industry/ activity standards change. Updates are placed on the Department's internet site www.water.wa.gov.au, select *Drinking water* > *Publications* > *Water Quality Protection Notes.*

To comment on this note or for more information, please contact the Water Source Protection Branch at this Department's offices in Perth, phone (08) 6364 7600 (business hours), fax 6364 7601 or use *Contact us* at the Department's internet site, citing the note number and version.

Where a conflict arises between the Department of Water's recommendations and any proposed activity that may affect a sensitive water resource, this note may be used to assist negotiations with stakeholders. The negotiated outcome should not result in a greater risk to water quality than if the Department's recommended protection measures were used.

In October 2005, the State Government announced the formation of the Department of Water. From January 2006, the Department of Water has assumed primary responsibility for managing the State's water resources. Once the Department of Water is legally established, it will replace many of the present functions of the present Water and Rivers Commission and operate in parallel (with separate powers) to the Department of Environment and Conservation.

Department of **Water**

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Appendices

Appendix A - References and further reading

1. Australian Government - National Water Quality Management Strategy
   a. *Australian and New Zealand Guidelines For Fresh and Marine Water Quality* 2000;
   b. *Australian Guidelines for Water Quality Monitoring and Reporting* 2000;
      see web page www.deh.gov.au/water/quality/nwqms/index.html.
   c. *Australian Drinking Water Guidelines* 2004

   See web page www.nhmrc.gov.au/publications/synopses/eh19syn.htm
2. Australian Department of the Environment and Heritage
   Conservation guidelines for the management of wild river values 1998;
   see web page www.heritage.gov.au/anlr/code/arc.html; or
   contact this Department's Drainage and Waterways Branch for local information.
3. Environmental Protection Authority (WA)
   a. *Draft Guidance statement 33 Environmental guidance for planning and Development 2005;*
   b. *Position statement No 9 Environmental offsets June 2005;*
   c. *Environmental Protection (Swan Coastal Plain Lakes) Policy* 1992;
   d. *Environmental Protection (South West Agriculture Zone Wetlands) Policy 1998;*
   e. *Environmental impact assessment (EIA) – Referral of proposals;*
   f. *Position statement No 4 Environmental Protection of Wetlands 2004.*

   see internet site www.epa.wa.gov.au, select *Guidance statements, Policies* or *EIA.*
4. Department of Environment and Conservation (WA)
   a. Wetlands policy and publications
      - *Position statement: Wetlands,* WRC 2001;
      - *Wetlands of the Swan Coastal Plain,* WRC and DEP 1996;

      see internet page www.dec.wa.gov.au, select *Department of Environment > Water > Wetlands > Publications.*
   b. Waste management
      - *Guidelines for acceptance of solid waste to landfill* 2001;
      - *drumMUSTER program, see* www.drummuster.com.au ;
      - *Landfill Waste Classification and Waste Definitions 2001;*
      - *Draft Strategy for the management of green and solid organic waste in WA 1997;*
      - *Western Australian Waste Reduction and Recycling Policy 1997;*

see internet page www.dec.wa.gov.au, select *Department of Environment* > *Land* > *Waste management* > *Publications*.

c. Vegetation Protection
   - *A Guide for Local Government Clearing Native Vegetation under the Environmental Protection Act 1986*, 2005;
   - *A Guide to Clearing Permits under the Environmental Protection Act 1986*, 2005;
   - *A Guide to the Exemptions and Regulation for Clearing Native Vegetation*, 2005;

   see internet site www.dec.wa.gov.au , select *Department of Environment* > *Land* > *Native Vegetation Protection* > *Legislation*

5. Department of Water (WA)
   a. Drinking water source policy
      Pesticide Use in Public Drinking Water Source Areas, 2000
   b. Water Quality Protection Notes
      - *Dewatering of soils at construction sites;*
      - *Extractive industries within Public Drinking water Source Areas;*
      - *Irrigation with nutrient rich wastewater;*
      - *Land use compatibility in Public Drinking Water Source Areas;*
      - *Liners for containing pollutants, using engineered soils;*
      - *Liners for containing pollutants, using synthetic membranes;*
      - *Mechanical equipment wash-down;*
      - *Mechanical servicing and workshops;*
      - *Mobile mechanical servicing and cleaning;*
      - *Nutrient and irrigation management plans;*
      - *Soil filling in public drinking water source areas;*
      - *Stormwater management at industrial sites;*
      - *Tanks for above ground chemical storage;* and
      - *Toxic and hazardous substances- storage and use.*

      see web page http://drinkingwater.water.wa.gov.au, select *Publications* > *Water Quality Protection Notes*.
   c. Waterways policy and guidelines
      - Foreshore Policy 1 - *Identifying the Foreshore Area*, WRC 2002;
      - Water Note 11 - *Identifying the riparian zone;*
      - Water Note 23 - *Determining foreshore reserves;*
      - Water Note 26 - *Simple fish-ways;*

      see internet page http://waterways.water.wa.gov.au, select *Policy* or *Water Notes*.
   d. Stormwater
      Stormwater Management Manual for Western Australia;
      see internet page http://stormwater.water.wa.gov.au, select *Publications*.

6. Main Roads Western Australia
   a. Design standards;
   b. Environmental policy statement;

      see web page www.mainroads.wa.gov.au, select *Environment* > *Environmental Policy Statement* or *Standards* > *Drawings*, or *Road and Traffic Engineering* or *Structures Engineering*.

Appendix B - Statutory requirements include:

What's regulated	Statute	Regulatory office
Subdivision of land Land zoning and development approval	*Planning and Development Act 2005*	West Australian Planning Commission Department for Planning and Infrastructure Local Government Authority (Council)
Impact on the values and ecology of land or natural waters	*Environmental Protection Act 1986* *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*	Minister for the Environment advised by the EPA Department of Environment and Conservation – regional office
Approval for developments that affect the Swan–Canning estuary	*Swan River Trust Act 1988*	Swan River Trust
Licence to take surface water and groundwater (section 5c) For proclaimed waterways, a permit is required to obstruct or interfere with the bed and banks (section 17) Bore construction (section 26 D)	*Rights in Water and Irrigation Act 1914*	Department of Water – regional office
Industrial sites in existing public drinking water source areas	*Metropolitan Water Supply, Sewerage and Drainage Act 1909* *Country Areas Water Supply Act 1947*	
Licence to discharge waters into managed waterways	*Waterways Conservation Act 1976*	
Storage of fuels, solvent, explosive and dangerous goods	*Explosive and Dangerous Goods Act 1961*	Department of Consumer and Employment Protection

APPENDIX C - Sensitive water resources

Clean water resources used for drinking, sustaining aquatic and terrestrial ecology, industry and aesthetic values, along with breathable air, rank as the most fundamental and important needs for viable communities. Water resources should remain within specific quality limits to retain their values, and therefore require stringent and conservative protection measures. Guidance on water quality parameters necessary to maintain water values are published in the Australian Government's *National Water Quality Management Strategy Guidelines* (see web page www.deh.gov.au/water/quality/nwqms/index.html).

The Department of Water strives to improve community awareness of catchment protection measures for both surface water and groundwater as part of a multi-barrier protection approach to maintain the quality of water resources.

To be considered sensitive, water resources must support one or more of the environmental values described below. Human activity and land uses pose a risk to water quality if contaminants could be washed or leached into sensitive water resources in discernible quantities. These water resources include shallow groundwater accessed by water supply wells, waterways, wetlands and estuaries. Community support for these values, setting of practical management objectives and implementation of sustainable protection strategies are seen as key elements in protecting and restoring the values of these water resources.

Sensitive water resource values include:

a. Public Drinking Water Source Areas (ie Water Reserves, Catchment Areas or Underground Water Pollution Control Areas) proclaimed or assigned under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909*, the *Country Areas Water Supply Act 1947* or the *Health Act 1911*.

b. Private water supply sources, including the following uses:
   - human or stock consumption;
   - commercial or industrial water supplies (with specific qualities that support the activities eg aquaculture, cooling, food or mineral processing or crop irrigation); and
   - garden or municipal water supplies (which can affect people's health or wellbeing).

c. Groundwater aquifers that sustain important ecological functions eg cave ecology.

d. Waterways (excluding engineered drains or constructed features) with ecological and / or social values such as aesthetic appeal, boating, fishing, tourism, and swimming, including:
   - waterways of High Conservation Significance as described in the Environmental Protection Authority's Draft Guidance Statement 33 *Environmental Guidance for Planning and Development* (Section B5.2.2) see www.epa.wa.gov.au , select EIA > *Guidance statements*;
   - waterways managed under the *Waterways Conservation Act 1976*, ie the Avon, Peel-Harvey, Leschenault, Wilson Inlet and Albany Waterways Management Areas; and
   - waterways managed under the *Swan and Canning Rivers Management Act, 2006*.

Note: many waterways in the State remain to be scientifically evaluated and their value classified. Any such waterways that are substantially undisturbed by human activity, should be considered to have high conservation value unless proven otherwise.

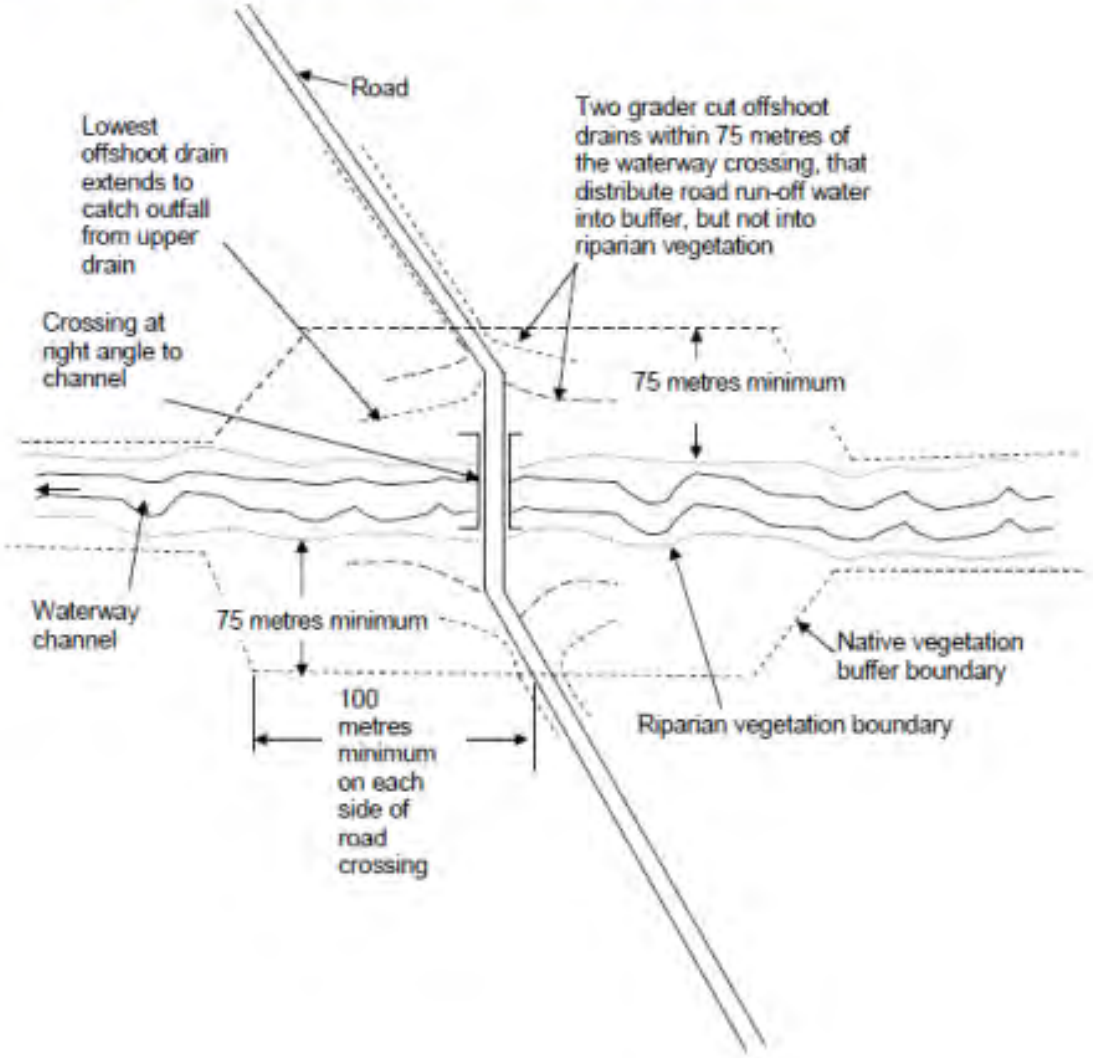
e. Wetlands possessing recognised or probable conservation values (generally excluding those highly disturbed, unless subject to active management to restore specified environmental values), and including:

- RAMSAR wetlands (see internet site www.ramsar.org);
- Wetlands of High Conservation Significance as described in the Environmental Protection Authority's Draft Guidance Statement 33 *Environmental Guidance for Planning and Development* (Section B4.2.2), see www.epa.wa.gov.au , select EIA > *Guidance statements*;
- Wetlands described by Department of the Environment and Heritage (Australia) in *A Directory of important wetlands in Australia,* (see web page www.deh.gov.au/water/wetlands/databases.html, or the Department of Environment and Conservation web page www.naturebase.net/national_parks/wetlands/wa_wetlands.html);
- Conservation and Resource Enhancement category wetlands identified in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset, all wetlands identified in the *South Coast Significant Wetlands* dataset and high value wetlands identified in the *Geomorphic Wetlands Augusta to Walpole* dataset.

  Note: many wetlands in the State remain to be scientifically evaluated and classified. Any such wetlands that are generally undisturbed by human activity, should be considered to have high conservation value, unless proven otherwise. The Augusta to Walpole wetland dataset to date has not been subject to a detailed evaluation process.

  The Department of Conservation and Environment is the custodian of wetland datasets and is responsible for maintaining and updating the information within them. The datasets ban be viewed or downloaded from the internet site www.dec.wa.gov.au, select *Department of Environment > Tools, systems and data > Geographic Data Atlas > Inland waters > Wetlands*. Guidance on viewing the wetlands is provided on the same website at *Water > Wetlands > Data > Wetland mapping > How to view wetland mapping* or phone the Department on 6364 6500.

Appendix D - Protection measures for road crossing of waterways



ATTACHMENT FIVE – CONTACT DETAILS

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Grant MacKinnon	grant.mackinnon@swan.wa.gov.au
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Minhdu Nguyen	minhdu.nguyen@mainroads.wa.gov.au
Yoon-kah Wong	yoon-kah.wong@swan.wa.gov.au
Mark Cugley	Mark.cugley@swanrivertrust.wa.gov.au

NorthLink WA
Drainage Reference Group #2
Venue: Old Council Chambers,
City of Swan Operations Centre – Great Northern Highway
9:00am, Thursday 28 August 2014

MEETING MINUTES

1. WELCOME, MEETING PURPOSE AND PROCESS

Linton pike (workshop facilitator) explained that the purpose of the workshop was to:

- Present a drainage design update; and
- Present and discuss possible drainage solutions and options as the basis for further development

Linton encouraged all participants to participate openly and present their views to inform the developmental drainage work now underway.

The Meeting Agenda is provided at Attachment One.

A list of meeting participants and apologies are provided at Attachment Two.

2. Previous Meeting Summary

Comment was invited on the previous meeting summary.

- No changes were requested.

Comment and an update on actions arising from the previous minutes is provided below.

Action agreed at DRG Meeting of 9th July 2014	Action reported at this meeting
The proposed offset land addresses a range of impacts of the project and mostly for Carnaby's Cockatoo habitat. We need to follow due process to ensure it is suitable and used for the purpose. This site won't provide offset for water based impacts. Ellen Brockman LandCare Group offers its assistance to identify suggested offset land.	Further investigation is required first. Mike to contact Rosanna in due course for further discussion. **ACTION: Mike**
Water Corporation is an invited member of the Drainage Reference Group and the Environmental Reference Group. Their existing bores aren't all in active use. Their long term planning is an important input to ensure Perth's potable water supply is assured over time and we need to consider the impacts for their options and plans for the future. Other bores may be drilled within the estate if required as a cost effective solution. We should also seek input and involvement of the water supply area of Water Corporation. We will continue to seek comment and the participation of Geoff Hughes as well.	Geoff Hughes confirmed his intention to attend this meeting in reply to the meeting invitation. Linton will also invite Stacey Rudd of Aroona Alliance – Water Corp seeking her involvement. **ACTION: Linton**

Action agreed at DRG Meeting of 9th July 2014	Action reported at this meeting
Department of Health input is needed from a water quality perspective perhaps from Richard Theobald? The Project Team will invite Department of Health to join this group from a water quality perspective.	Done - Dept of Health is represented by Richard today.
NorthLinkWA will invite Swan River Trust (SRT) to join this group recognising that they will join DPaW soon.	Done - Swan River Trust is represented by Kate Bushby.

3. Project Geo-Hydrological Update

Michael Wiezel provided a Project Geo-Hydrological Update noting the following:

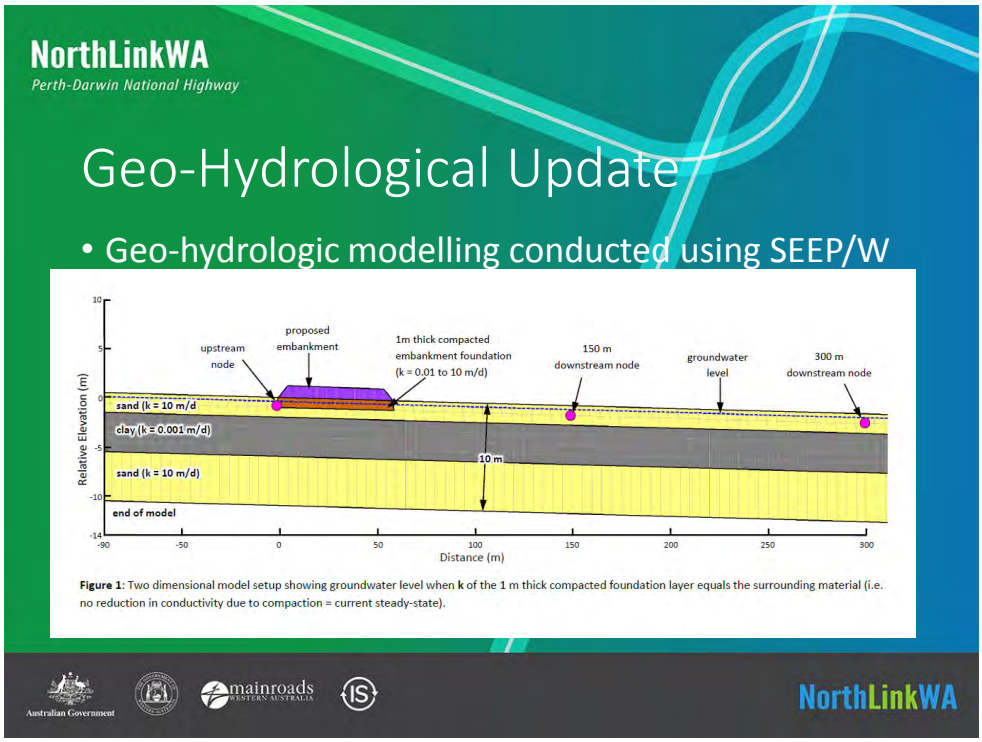
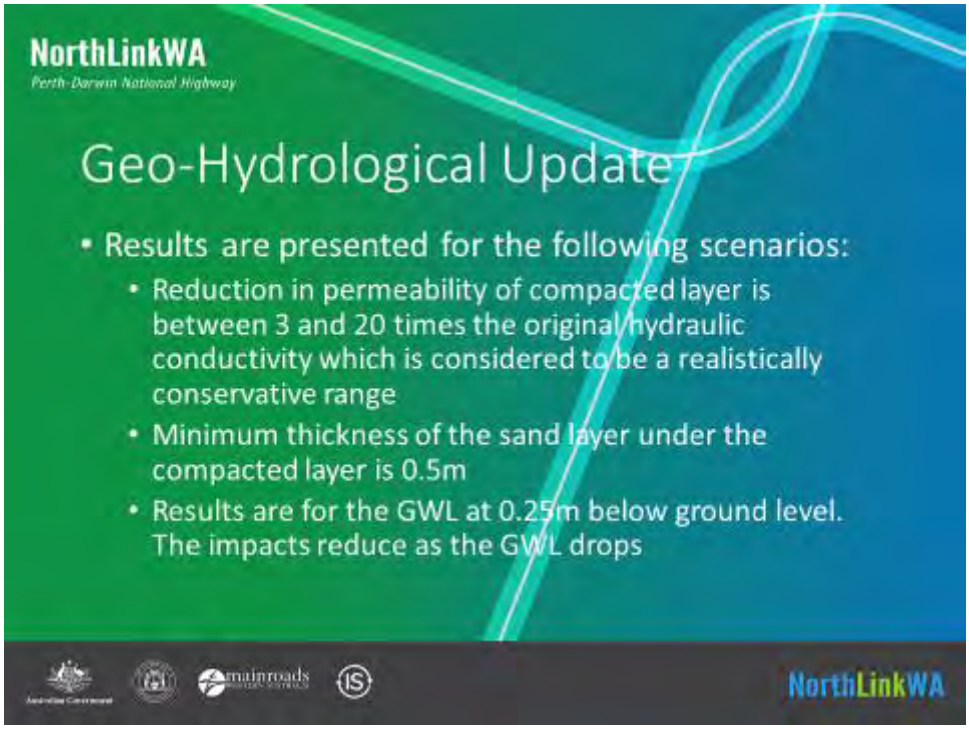
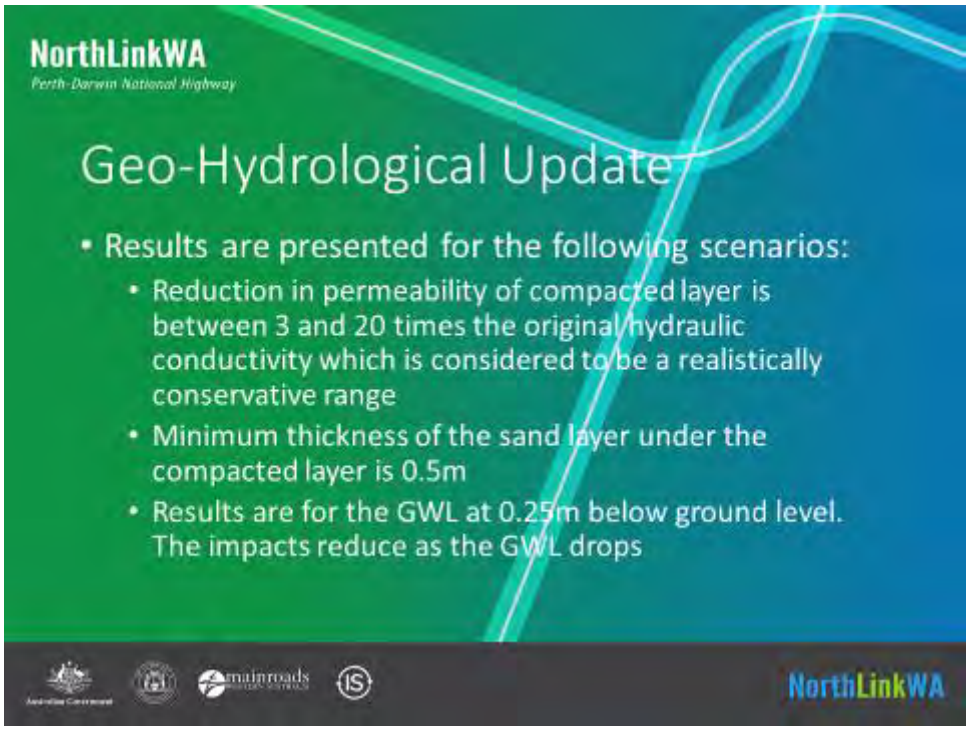


Figure 1: Two dimensional model setup showing groundwater level when **k** of the **1** m thick compacted foundation layer equals the surrounding material (i.e. no reduction in conductivity due to compaction = current steady-state).


NorthLinkWA
Perth-Darwin National Highway
Geo-Hydrological Update
• Results are presented for the following scenarios:
• Reduction in permeability of compacted layer is between 3 and 20 times the original hydraulic conductivity which is considered to be a realistically conservative range
• Minimum thickness of the sand layer under the compacted layer is 0.5m
• Results are for the GWL at 0.25m below ground level. The impacts reduce as the GWL drops
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Geo-Hydrological Update
• Results are presented for the following scenarios:
• Reduction in permeability of compacted layer is between 3 and 20 times the original hydraulic conductivity which is considered to be a realistically conservative range
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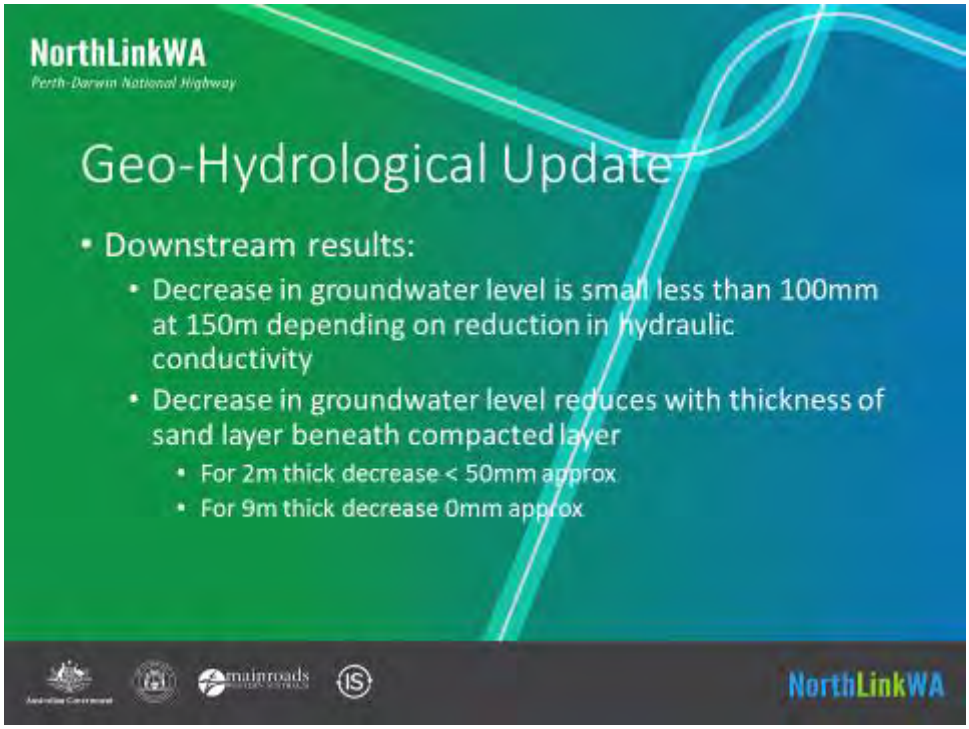
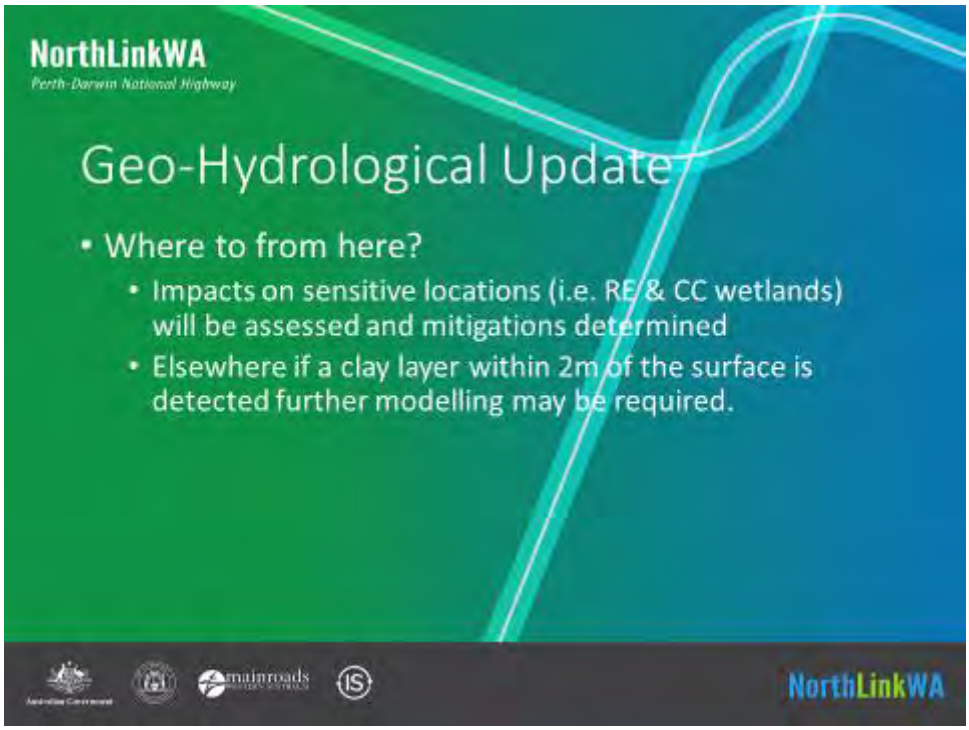
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Geo-Hydrological Update
• Downstream results:
• Decrease in groundwater level is small less than 100mm at 150m depending on reduction in hydraulic conductivity
• Decrease in groundwater level reduces with thickness of sand layer beneath compacted layer
• For 2m thick decrease < 50mm approx
• For 9m thick decrease 0mm approx
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Geo-Hydrological Update
• Where to from here?
• Impacts on sensitive locations (i.e. RE & CC wetlands) will be assessed and mitigations determined
• Elsewhere if a clay layer within 2m of the surface is detected further modelling may be required.
mainroads
NorthLinkWA

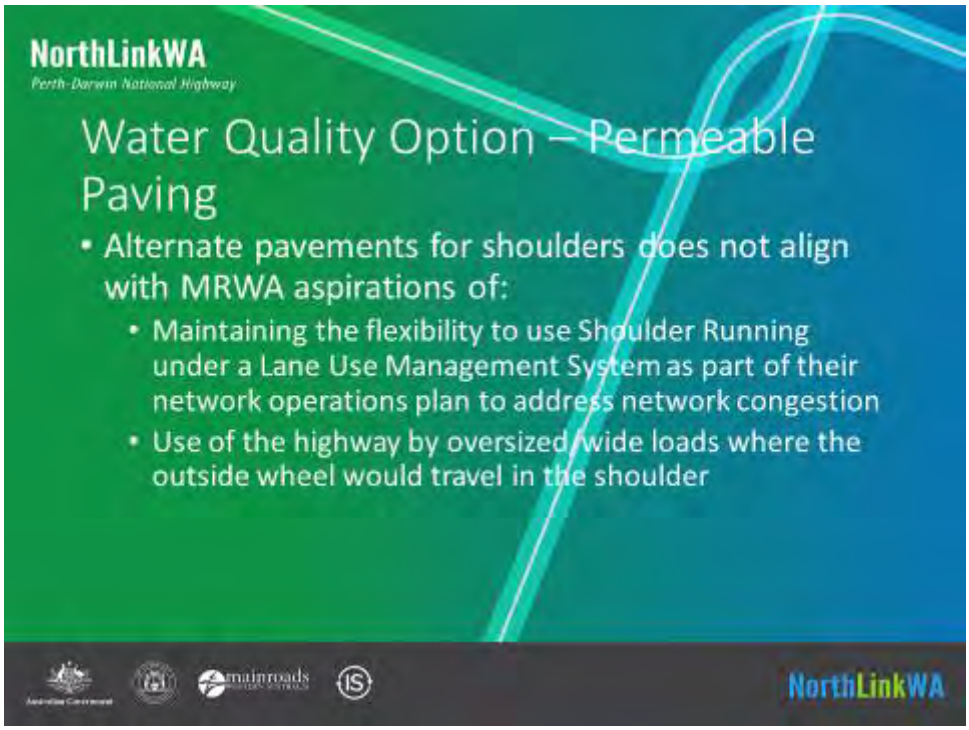
A question and answer session resulted as shown below.

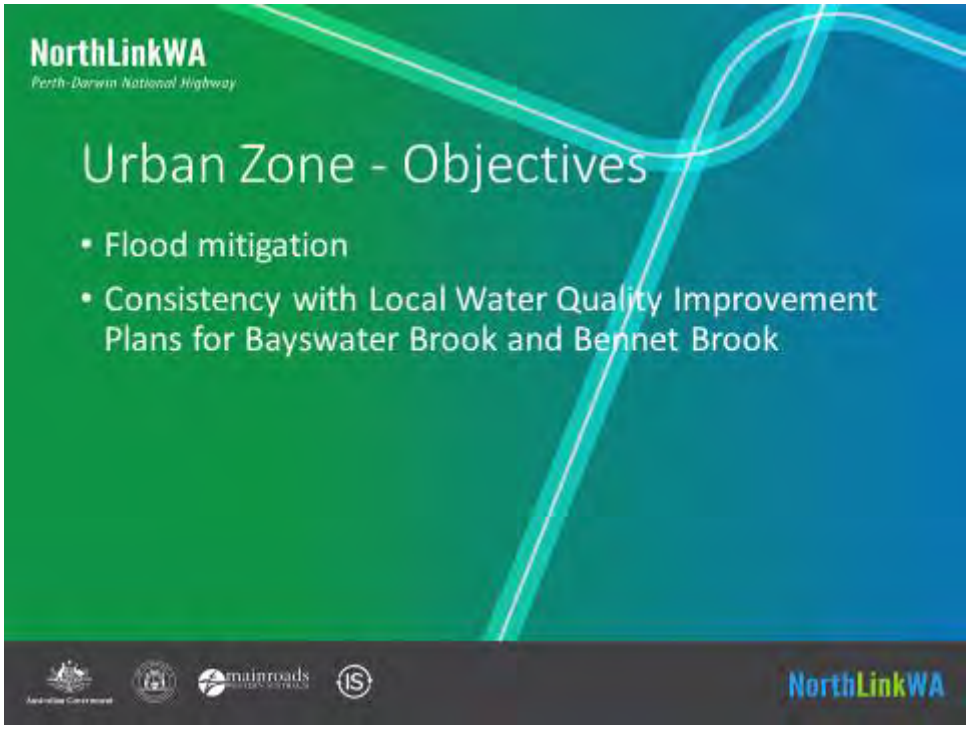
Q	The modelling is based upon a number of assumptions that are made for a number of different sites and conditions? Will it be ground "trothed" in time?
A	It is a conceptual model of what we expect to encounter. The source information is provided by geo-technical investigation and the experience and lessons learnt from similar sites previously. The geo-technical investigation has been underway for several months and includes 12 bore holes, 38 Cone Penetration Tests and 40 trial pits noting that we have worked within land access constraints.
Q	We have seen the impacts of climate change over time with similar volumes of rain now falling in a shorter period of time with greater intensity and short bursts. Is that factored in to the modelling?
A	Our focus has been on the ground water modelling with surface water runoff considered separately. If ground water changes result from climate change we will need to consider its potential impacts for the model. The Australian Rainfall and Runoff Review Project has been running for several years across Australia and is available on the Australian Rainfall and Runoff website. We are using this for our base data and design criteria. A further update of the runoff models will follow but has not yet been done. We will add a suitable mitigation factor to provide an appropriate level of confidence in the results. We will formulate a Climate Change Position Paper for this purpose and overlay it to the model for the project as a whole. The environmental impacts are often greater than the flooding impacts with short duration high intensity rainfall subject to system performance under that scenario. We are confident that this is an appropriate and valid response to this issue.
Q	The changes in runoff and catchment for the first 100mm or 150mm will impact upon adjoining land use and/or vegetation. Will that be cross referenced to these impacts?
A	We will look at local area impacts at wetlands. We are talking about peak ground water levels with seasonal variation occurring anyway. We won't do much more work in farming areas with topography the key factor. The prevalence of clay is a greatest sensitivity and in particular the depth of sand over it is the key factor. Further investigation will follow where potential issues are identified.
Q	How are land use impacts factored in?
A	We will focus on the road impacts and future development will need to be addressed separately by others. Any proposed land development will require the preparation and submission of their own drainage strategies. This matter is one for the WA Planning Commission with processes in place to do so. This project will focus on associated NorthLinkWA impacts only.
Q	Is this matter worth raising with the Department of Planning?
A	We work with Department of Planning on an ongoing basis and this and other relevant matters are considered in the relevant forums.

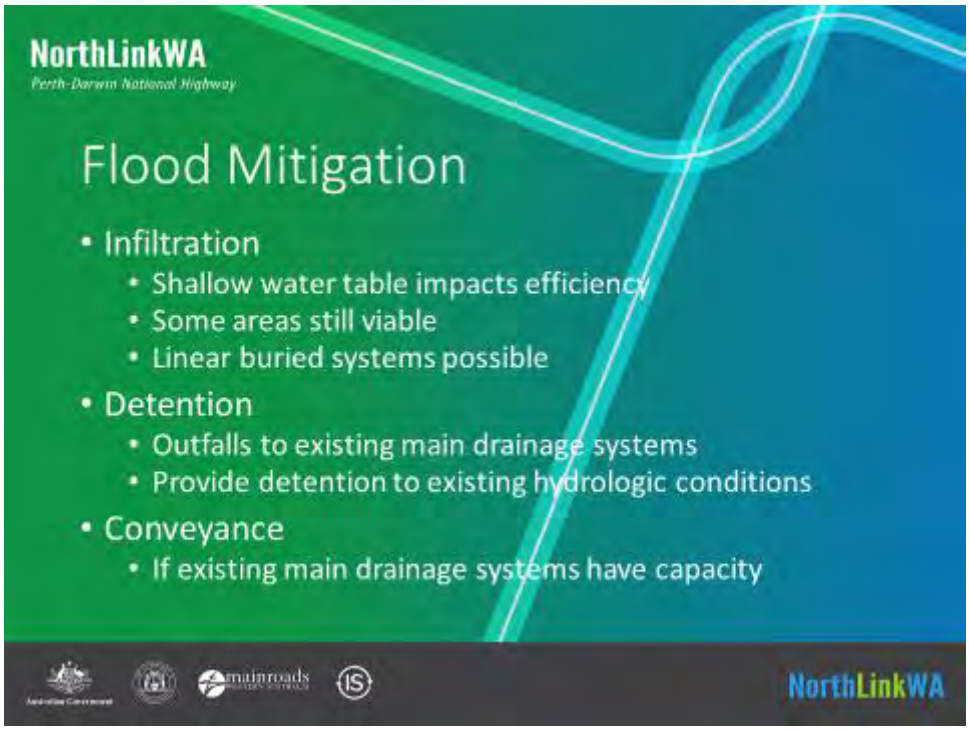
Q	Once development occurs the Local Government Authority is responsible for water management at the regional and/or district level with the road a potential impediment to existing flows.
A	This is noted and needs to be addressed in the surface drainage discussion to follow.

4. Drainage Option Development Update – URBAN SECTION

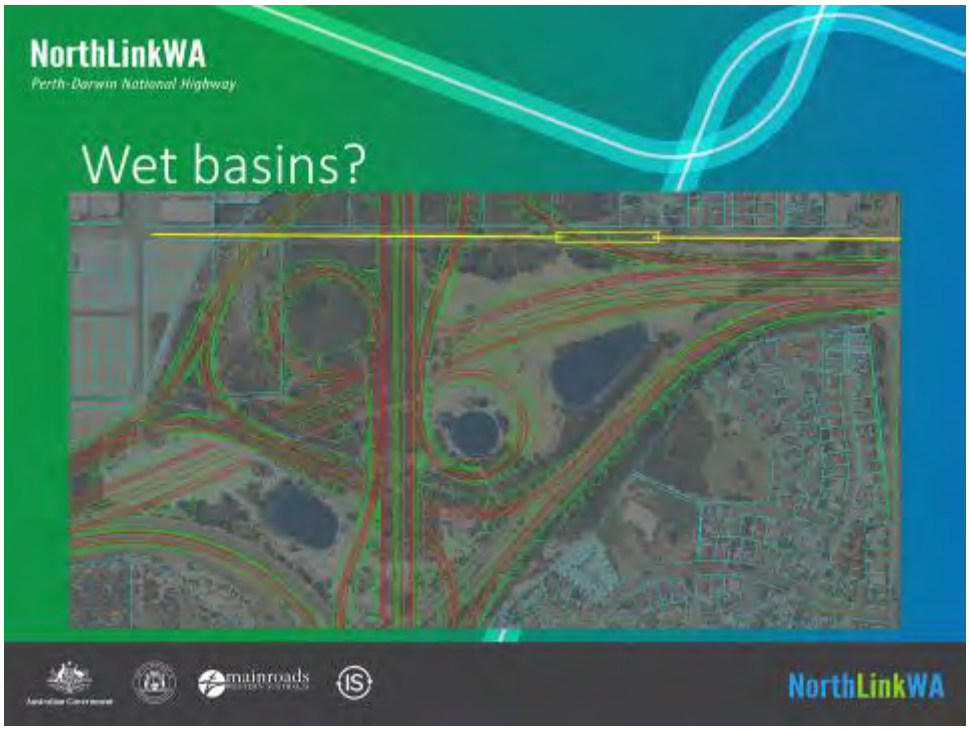
Michael Wiezel provided a drainage option update for the **URBAN SECTION** of the project noting the following:

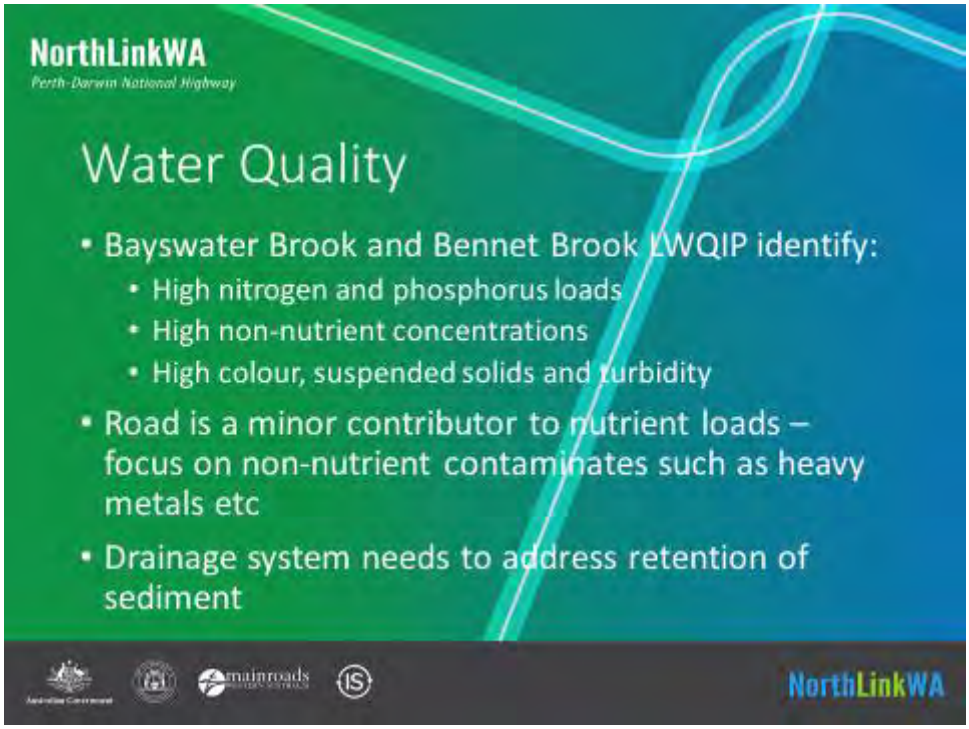



NorthLinkWA
Perth-Darwin National Highway
Urban Zone - Objectives
• Flood mitigation
• Consistency with Local Water Quality Improvement Plans for Bayswater Brook and Bennet Brook
mainroads
NorthLinkWA

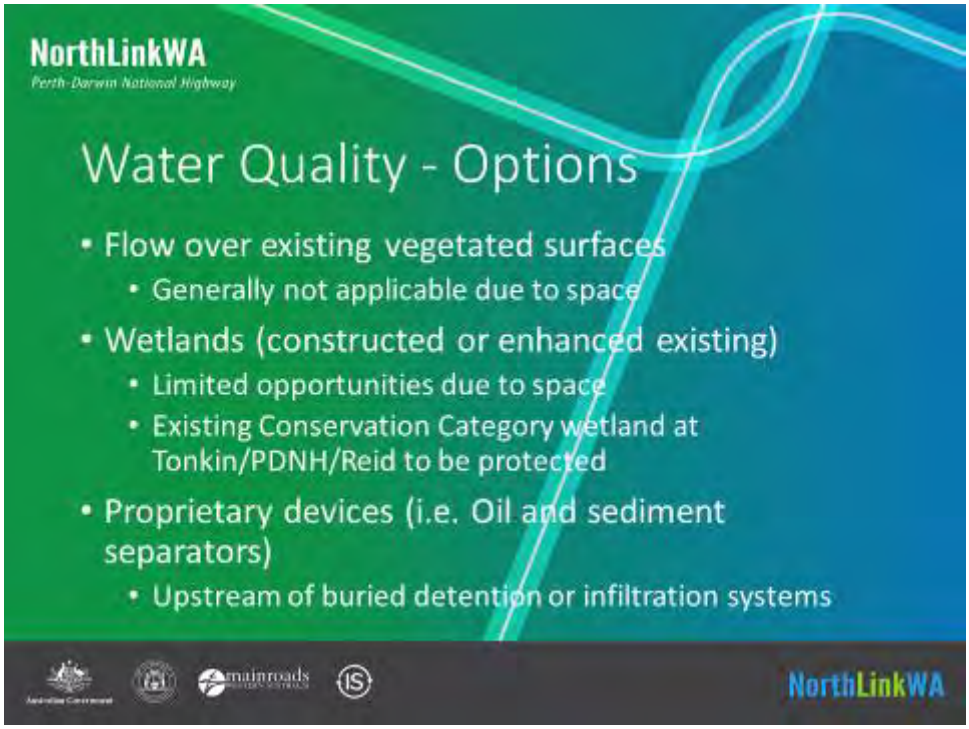

NorthLinkWA
Perth-Darwin National Highway
Flood Mitigation
• Infiltration
• Shallow water table impacts efficiency
• Some areas still viable
• Linear buried systems possible
• Detention
• Outfalls to existing main drainage systems
• Provide detention to existing hydrologic conditions
• Conveyance
• If existing main drainage systems have capacity
mainroads
NorthLinkWA


Tonkin Hwy / Reid Hwy / PDNH


NorthLinkWA
Perth-Darwin National Highway
Wet basins?
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality
• Bayswater Brook and Bennet Brook LWQIP identify:
• High nitrogen and phosphorus loads
• High non-nutrient concentrations
• High colour, suspended solids and turbidity
• Road is a minor contributor to nutrient loads – focus on non-nutrient contaminates such as heavy metals etc
• Drainage system needs to address retention of sediment
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Infiltration at source
• 'Leaky' pits where pit and pipe drainage provided
• Bioretention
• Higher cost and maintenance
• Alignment through Urban zone is generally constrained for space
• Objectives can be reached through other options
• Grassed/vegetated swales
• Generally constrained for space but preferred to piped drainage
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Flow over existing vegetated surfaces
• Generally not applicable due to space
• Wetlands (constructed or enhanced existing)
• Limited opportunities due to space
• Existing Conservation Category wetland at Tonkin/PDNH/Reid to be protected
• Proprietary devices (i.e. Oil and sediment separators)
• Upstream of buried detention or infiltration systems
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Strategy Summary
• Flood Mitigation
• Infiltration
• Detention
• Water Quality
• Infiltration of common rainfall event
• Proprietary devices upstream of buried systems that are not easily maintainable
mainroads
NorthLinkWA

A question and answer session resulted as shown below.

Q	Will this link be used by high and/or wide loads?
A	Our current thinking is that vehicles greater than 5.5m wide or 5.5m high will stay on Great Northern Highway. Other significant loads (up to 5.5m x 5.5m vehicle envelope) will still potentially travel along this link.
Q	Do we fill the basins and then look for another solution to manage the result flow impacts for adjoining land, flora, fauna and other impacts?
A	We need to manage the first 15mm as a priority. If fauna and flora is then likely to be impacted by overtopping suitable water quality treatments will be needed. If water bodies and ground water exposure is proposed we will generally seek to make them as large as is practically possible. In the urban section we will look at what resource we have and only change it where we need to. The normal rule is to not provide wet basins but where they already exist, they can be left. Department of Water will treat them as flow receival basins as an opportunity to avoid the use of Water Corporation drains. The ongoing maintenance task is also important and impacts potentially upon multiple government stakeholders including Main Roads WA, Local Government Authorities and Water Corporation. Community based environmental groups would probably want to see existing basins and wetland areas retained and enhanced e.g. Friends of Lightning Swamp – Melinda McAndrew knows this area well and can be contacted here through the offices of Perth Regional NRM. **ACTION: Michael**
Q	Is this around classified as P1 to P3 water catchment?
A	Not as far we are aware. Michael to confirm. **ACTION: Michael**
Q	Is this corridor Perth airport flight path risk for bird strike?
A	No.
Q	There are no community issues currently recognised by this group with a suggestion to retain the existing topographical and wetland form as much as possible please.
A	There is a ground water control in the area and we would seek to link to the Water Corporation system as well as use their drainage assets for short term water retention.
Q	What is the extent of the earthwork spill at the Reid and Tonkin interchange?
A	Our current thinking is that Reid Highway will pass over Tonkin Highway to minimise the project footprint by benefitting from the existing topography. Other measures can be adopted to minimise the footprint if needed.
Q	Are all drainage pits proposed as “leaky” pits with an associated risk that the pavement will be wet?
A	Yes, “leaky” pits are proposed other than where it is unsuitable to do so e.g. below the maximum ground water level. The base is 1m below road pavement and avoids the potential. Forest Highway is largely “leaky” pit construction as a case study if issues are emerging in similar conditions.

Q	**Could we seek to store runoff water for reuse for summer time irrigation?**
A	Probably not, we explored this approach for the Gateway WA project but found it difficult to achieve in long linear catchments like a road reserve. Our rainfall patterns mean long duration artificial storage and retention periods at high cost. The superficial aquifer is a better, low cost storage option and needs further assessment of allocation processes. Usage of the superficial aquifer needs to be understood with little availability for irrigation or other purposes currently. The Local Government Authority view is generally that an artificial tank is not required as the aquifer fulfils the same purpose naturally provided it is managed in a balanced way. There are losses in winter rainfall in the aquifer as it moves through the system and makes its way to the river or other outfall points. There are various strategic water management processes in place to manage this in the future. The North East Corridor Strategy is about to commence with clay and other factors adding complexity with high variability in water level and availability often limiting potential yield.
Q	Did Gateway WA look at the quality of water possibly available for re-use?
A	Yes, and recognised the need for a level of water quality treatment. The cost of storage is the prohibitive factor.
Q	What are the potential impacts for Bennett Brook as a result of additional runoff from the impervious surfaces?
A	It is unlikely there will be additional runoff from the road making its way to Bennett Brook with flow beyond local infiltration going to Water Corporation drains. This may be a different matter for future localised land development.

The following additional comment and/or follow up actions were agreed:

- Incorporate existing water bodies at Reid Highway and Tonkin Highway interchange as a receiving water body or water storage body and maintain the existing water body if possible;

ACTION: Michael

- The proposed approach seems suitable from a Department of Water perspective. Detention volume calculations rely on the K value assumed by the designer. Designers, reviewers and others must adopt realistic rather than unachievable K values to ensure valid assumptions result.

ACTION: Michael

- City of Bayswater would like to see the resultant pavement areas with opportunities to get even more emphasis on local infiltration as a primary strategy for this section.

ACTION: Michael

- Edele will seek and provide further comment from within the various interest groups of the City of Swan.

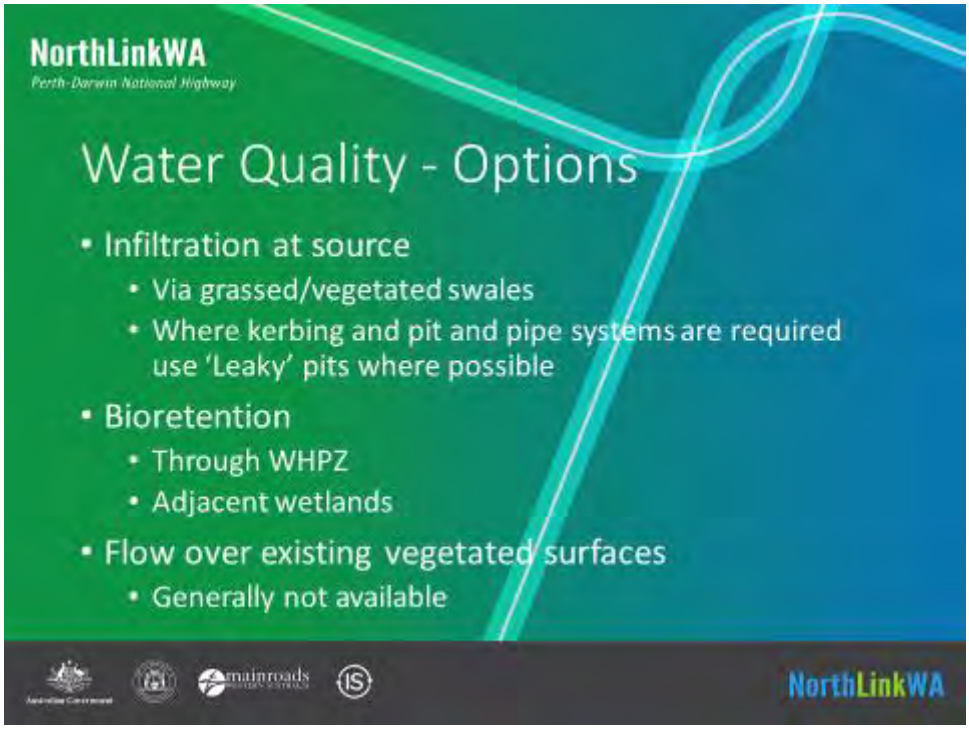
ACTION: Edele

5. Drainage Option Development Update – P1 GROUNDWATER SECTION

Michael Wiezel provided a drainage option update for the **P1 GROUNDWATER SECTION** of the project noting the following:


NorthLinkWA
Perth-Darwin National Highway
P1 Zone - Objectives
• Protection of Gnangara Groundwater Mound
• Protection of Well Head Protection Zones
• Maintain recharge on Gnangara Mound
• Flood mitigation
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Flood Mitigation
• Infiltration
• Shallow water table impacts efficiency
• Detention
• Only possible at southern end as there are no water courses north of Hepburn Interchange
• Conveyance
• As above
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Infiltration at source
• Via grassed/vegetated swales
• Where kerbing and pit and pipe systems are required use 'Leaky' pits where possible
• Bioretention
• Through WHPZ
• Adjacent wetlands
• Flow over existing vegetated surfaces
• Generally not available
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Wetlands (constructed or enhanced existing)
• Potential opportunity to design infiltration basins as ephemeral wetlands
• Proprietary devices (i.e. Oil and sediment separators)
• Used for pit and pipe drainage where there is insufficient space or other constraints limiting the application of the other water quality options
• Non-Structural controls
• Ensure Emergency Spill Response plan exists and is known within relevant Authorities
• Signage through P1 zone to raise awareness of Zone with motorists and encourage reporting of spills
mainroads
NorthLinkWA

A question and answer session resulted as shown below.

Q	What is the depth of the Water Corporation bores and what is the associated infiltration time to the main water body with potential for the ingress of MTBE (Methyl tertiary-butyl ether) fuels a major health concern?
A	The bores are generally around 20m or 30m in mostly sandy ground. Fairly rapid infiltration occurs with not all bores in use. Any changes or impacts to the bores will be managed with Water Corporation input. A risk based approach is needed with Water Corporation and Department of Water involvement critical to ensure appropriate mitigations result including signage or to consider other bore solutions in proximity.
Q	Is there any intention to provide other land use and bicycle and pedestrian facilities?
A	No land use changes are proposed and cycling and pedestrian facilities are included in the scope of work.
Q	Will picnic areas, truck bays and toilets be proposed in this area?
A	Probably not and there is no demonstrable need for them to date.

The following additional comment and/or follow up actions were agreed:

- A serious spill will require more than just signage and an Emergency Response Plan is needed including contacts for different spills or other event for hazardous materials;

ACTION: Michael

- An unconfined bore at 20m depth means very little if any time to intervene with a reliance on dilution or closure of bores the best solution subject to rapid response time;

ACTION: Michael

- We should consider limiting hazardous goods to Great Northern Highway to avoid potential spill of hazardous material into water catchment areas;

ACTION: Padraic

- Swales should be vegetated with native vegetation to avoid the potential need for weed spraying as part of the maintenance regime to avoid the potential for water pollution;

ACTION: Padraic

- Avoid the inclusion of public spaces for recreation picnics, toilets or other in this area. Main Roads is looking at the best location for a service centre and would be a factor to consider for consideration in Service Centre Assessment process; and

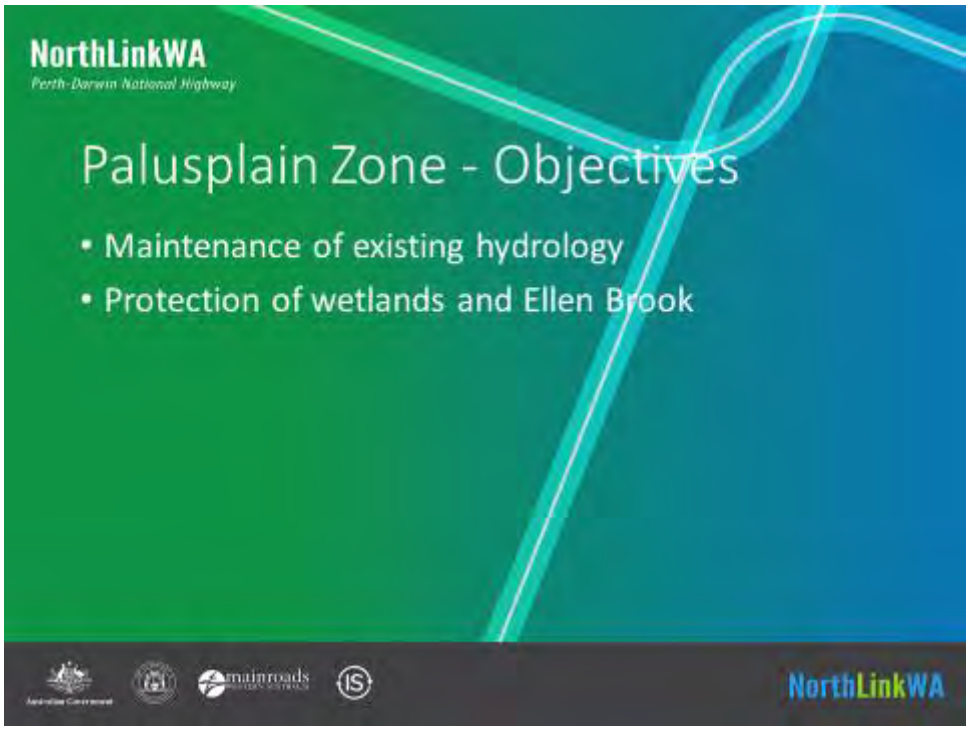
ACTION: Anthony

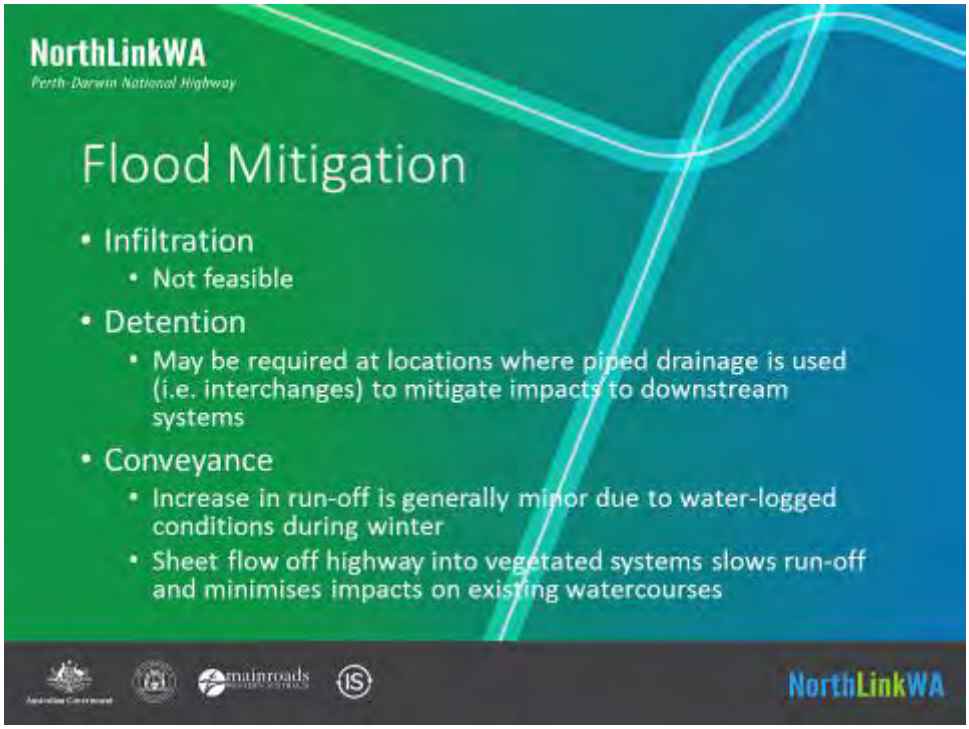
- DoW Policy 13 Water Resource areas for Crown Land needs to be considered to understand its potential implications if any.

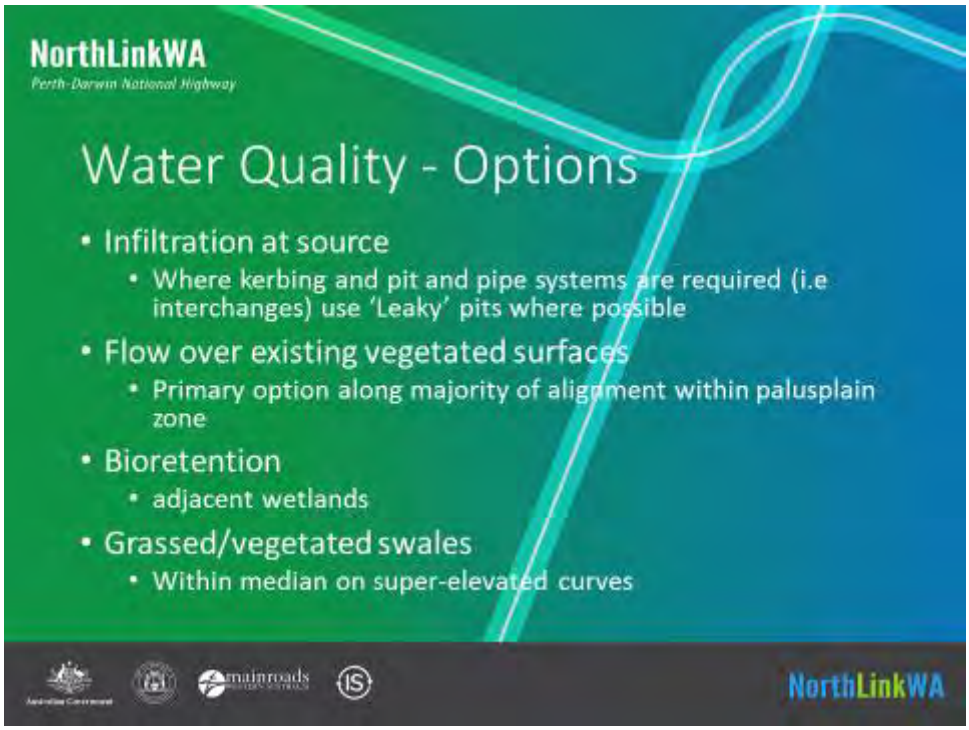
ACTION: Christa

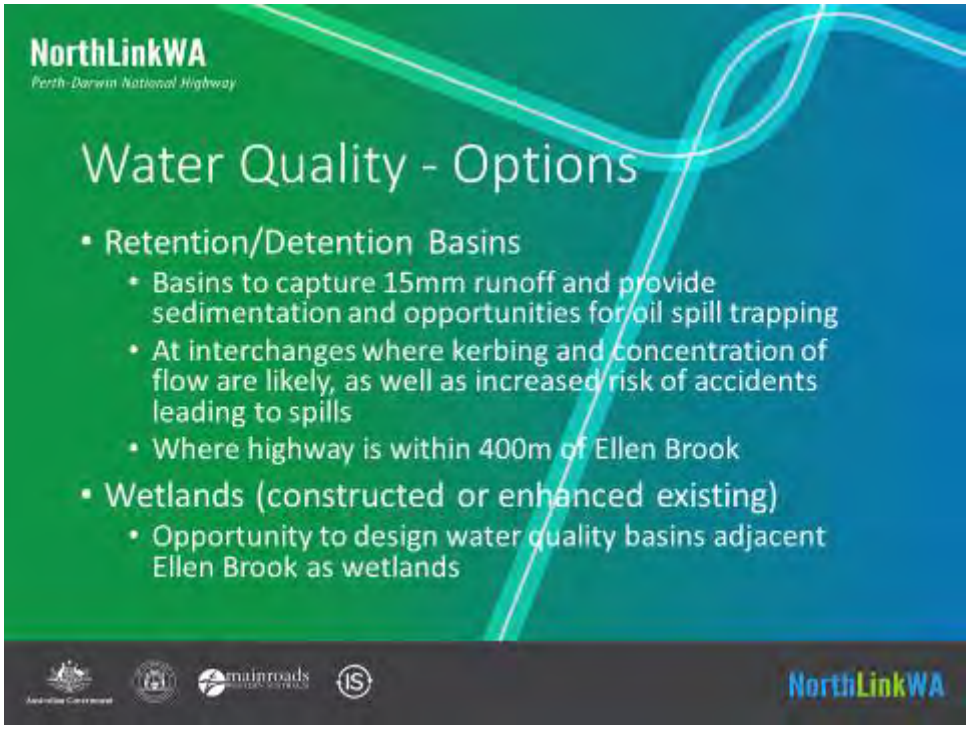
6. Drainage Option Development Update - PALUSPLAIN SECTION

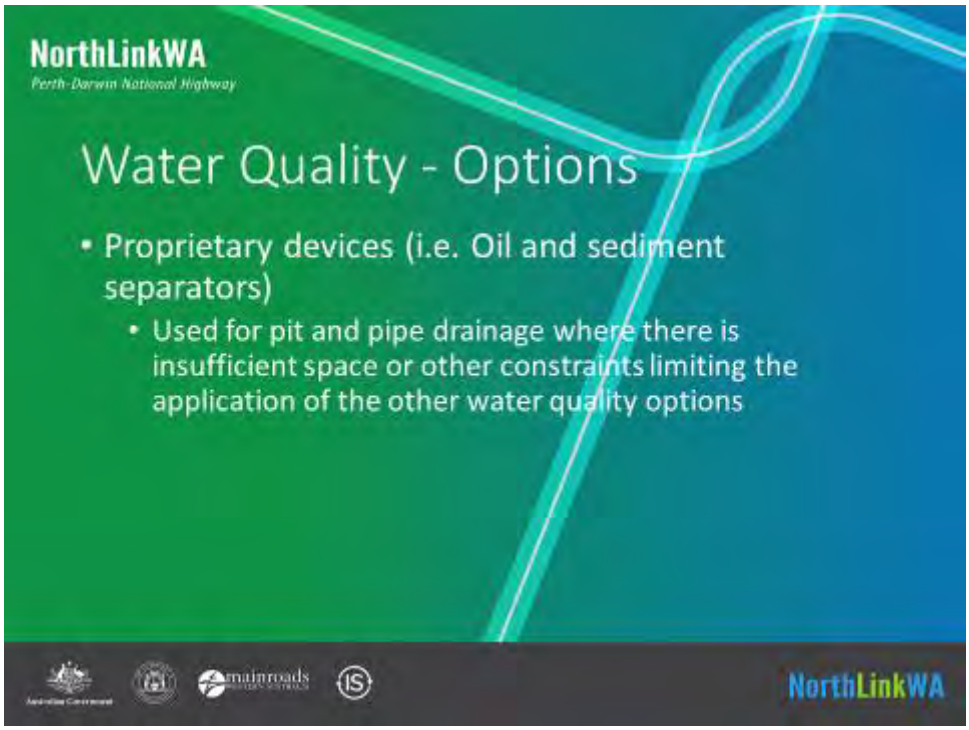
Michael Wiezel provided a drainage option update for the **PALUSPLAIN SECTION** of the project noting the following:

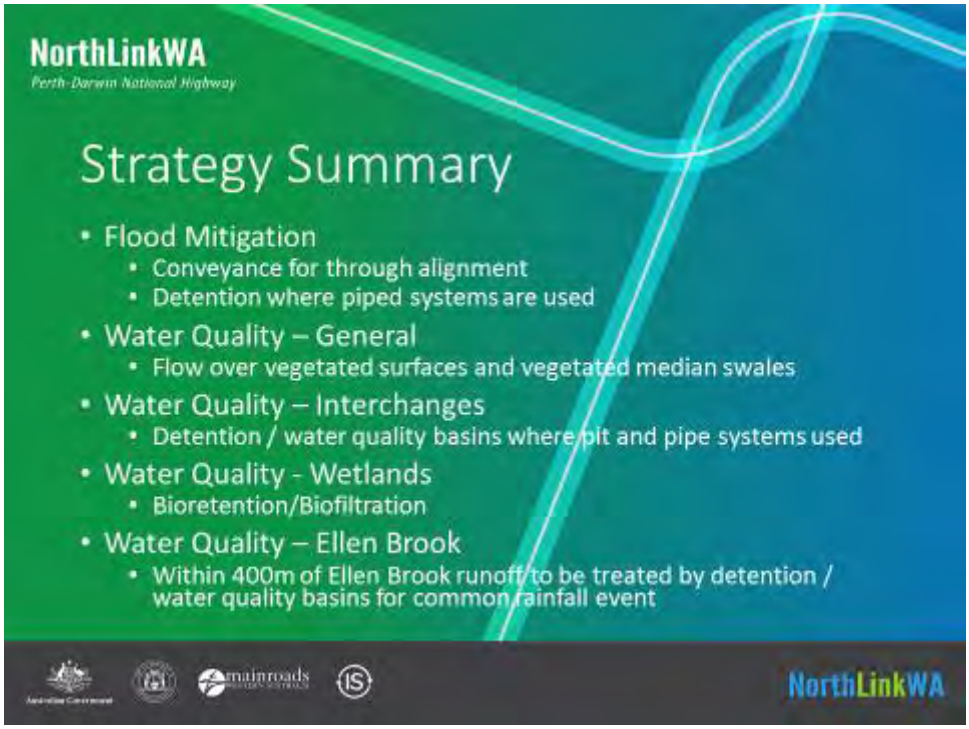



NorthLinkWA
Perth-Darwin National Highway
Flood Mitigation
• Infiltration
• Not feasible
• Detention
• May be required at locations where piped drainage is used (i.e. interchanges) to mitigate impacts to downstream systems
• Conveyance
• Increase in run-off is generally minor due to water-logged conditions during winter
• Sheet flow off highway into vegetated systems slows run-off and minimises impacts on existing watercourses
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Infiltration at source
• Where kerbing and pit and pipe systems are required (i.e interchanges) use 'Leaky' pits where possible
• Flow over existing vegetated surfaces
• Primary option along majority of alignment within palusplain zone
• Bioretention
• adjacent wetlands
• Grassed/vegetated swales
• Within median on super-elevated curves
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Retention/Detention Basins
• Basins to capture 15mm runoff and provide sedimentation and opportunities for oil spill trapping
• At interchanges where kerbing and concentration of flow are likely, as well as increased risk of accidents leading to spills
• Where highway is within 400m of Ellen Brook
• Wetlands (constructed or enhanced existing)
• Opportunity to design water quality basins adjacent Ellen Brook as wetlands
mainroads
NorthLinkWA


NorthLinkWA
Perth-Darwin National Highway
Water Quality - Options
• Proprietary devices (i.e. Oil and sediment separators)
• Used for pit and pipe drainage where there is insufficient space or other constraints limiting the application of the other water quality options
mainroads
NorthLinkWA



A question and answer session resulted as shown below.

Q	What is the role of the emergency services in the response to spills at wetland locations with a suitable response needed?
A	We need to consider how best to do this and provide control measures within bio retention areas. **ACTION: Mike**
Q	What impacts are anticipated for federal government bores on Department of Defence land?
A	Where impacted they will be moved to a suitable alternative location. The same sensitivities apply to Muchea potable water supply but the project is some distance to bore locations.

The following additional comment and/or follow up actions were agreed:

- The proposed strategy seems appropriate with more detail to follow to better understand the implications in the broader land use context;
- We must avoid the experience of Brand Highway with poor provision for sheet flow resulting in significant inundation in inappropriate areas;
- Consider using Saw Pit Gully as a possible outlet flow for flood over topping event; and

ACTION: Michael

- Northern end road design must make provision for the future Shire of Chittering drainage solutions for planned future development.

ACTION: Michael

7. Stakeholder Comment

Each participant was invited to provide further comment on the information provided at the meeting. The following feedback was received:

Name	Comment
Edele O'Brien	Nothing to add but will seek further comment within City of Swan.
Tom Findlay	Nothing to add but will seek further comment within Shire of Chittering. Please provide the Reference Design shape files to allow Shire of Chittering to better understand the implications recognising that it still could change. **ACTION: Mike**
George Rimpas	Nothing to add at this time.
Bill Till	Nothing to add at this time.
Christa Loos	Provide the Reference Design shape files to allow Department of Water to better understand the implications recognising that it still could change. **ACTION: Mike**
Rosanna Hindmarsh	Provide the Reference Design shape files to allow Ellen Brockman Integrated Catchment Group to better understand the implications recognising that it still could change. **ACTION: Mike** Has any change resulted at the proposed bridge crossing point at Ellen Brook? Further investigation and hydraulic modelling was done and a skewed bridge at this location will work but will require further assessment with relief culverts possibly required.
Zahirul Baten	Will protection be provided to flood retention facilities? Flood mitigation measures for swales in P1 section will be protected by barriers to limit run off road crashes and will be influenced by the Safe System Group.
Kate Bushby	Nothing to add but will seek further comment within Swan River Trust. **ACTION: Kate**
Richard Theobald	We need to confirm that the ground water monitoring is appropriate. Easements will be required to protect the future options. Fauna crossing points must also be provided.
Padraic Murphy	We will go to preliminary drainage design to inform the project case as an input to the tender with the ultimate configuration required by the end of 2014 and the drainage design by March/April 2015. When done we will bring it to this group for comment. **ACTION: Mike** Thanks again for your involvement and input.
Michael Wiezel	Thanks for your time and input - it is appreciated.
Sophie Wallis	Great to hear your views and ensure sustainable and innovative solutions are sought and acted upon.

8. Next Steps and Follow Up Actions

Michael Wiezel explained that the next steps in the process include:

- The next DRG meeting will be held toward the end of 2014;
- A subsequent final meeting will be held in the new year to reflect the preliminary design milestone; and
- We may split the projects given the scale of the total works.

The meeting closed at 11.50pm.

ATTACHMENT ONE – AGENDA

Start At	Item	By
8:45	**Arrival – tea and coffee provided**	
9:00	Welcome - meeting purpose and process	Linton Pike
9:05	Previous meeting summary and actions arising	All
9:15	Project geo-hydrological update	Michael Wiezel All
9:30	Drainage option development update: • **Urban section**;	Michael Wiezel All
10:00	**Morning tea**	
10:15	Drainage option development update: • **P1 Groundwater Section**;	Michael Wiezel All
10:45	Drainage option development update: • **Palusplain Section;**	Michael Wiezel All
11:15	Other considerations	All
11:30	Stakeholder comment	Each participant
11:50	Next steps and follow out actions	All
12:00	**Close**	

ATTACHMENT TWO – MEETING PARTICIPANTS

Name	Organisation
Edele O'Brien	City of Swan
Thomas Findlay	Shire of Chittering
George Rimpas	City of Bayswater
Bill Till	Department of Water
Christa Loos	Department of Water
Rosanna Hindmarsh	Chittering Landcare / Ellen Brockman Catchment Council
Kelly Fulker	Perth Region NRM
Dominic Boyle	Main Roads WA
Zahirul Baten	Main Roads WA
Kate Bushby	Swan River Trust
Richard Theobald	Department of Health
Padraic Murphy	NorthLink WA Project Team
Michael Wiezel	NorthLink WA Project Team
Linton Pike	NorthLink WA Project Team
Sophie Wallis	NorthLink WA Project Team

Apologies:

Name	Organisation
Eric Cheung	Main Roads WA
Marilynn Horgan	EMRC
Yoon-kah Wong	City of Swan
Denise True	NorthLink WA Project Team
Grant MacKinnon	City of Swan
Michael Roberts	Department of Parks and Wildlife
Jim Coten	City of Swan
Jim Garrett	Shire of Chittering
Tim Hillyard	WA Planning Commission
Geoff Hughes	Water Corporation
Kelly Fulker	Perth Region NRM
Dominic Boyle	Main Roads WA
Mindhu Nguyen	Main Roads WA
Anthony Wood	NorthLink WA Project Team

APPENDIX C

Drainage Options

C. DRAINAGE OPTIONS

C1.1 General

Initial development of the drainage strategy involved researching and collating typical options for mitigating flooding risks and managing water quality. These options were presented to the DRG at the first meeting with open discussion over their use. Following the initial meeting and taking into consideration feedback received, the various options and management practices were assessed for appropriateness against the objectives for each zone. This assessment process culminated in the selection of preferred treatments for each zone. The preferred options were then presented at the second DRG meeting where again open discussion and comment on their suitability to each zone was invited.

All strategies covering management of water quality and flood mitigation that were discussed within the DRG meetings are detailed below.

C1.2 Small Event and Water Quality Management

The options for water quality control focus on the control of runoff from the *small frequent rainfall event,* defined as 15mm falling over one hour or more. Small frequent rainfall events account for over 95% of the annual rainfall in an average year. The small frequent rainfall event requires water quality treatment if discharged to a receiving surface or groundwater body.

The options investigated to address water quality are in line with the best management practices presented in the Department of Water's *Stormwater Management Manual for WA* and are discussed below.

C1.2.1 Leaky pits and Infiltration systems

This option is applicable to locations where pit and pipe systems are needed. Leaky pits refer to drainage pits (inlets and manholes) with a hole in the base slab to allow some infiltration of water entering the pits. The quantification of how much infiltration is possible in a leaky pit is difficult, however the provision of leaky pit bases is not expensive and may even be cost neutral as the standard base from some manufacturers incorporates a hole for infiltration. Therefore the provision of leaky pit bases on pit and pipe drainage systems where the system is not below the maximum groundwater level is recommended.

To extend the effectiveness of the leaky pit concept the pit and pipe drainage network can be discharged to infiltration swales, basins or tanks (where space is limited) to capture and infiltrate the common rainfall event. This can be incorporated with infiltration for flood mitigation, however should be provided as close to where the rainfall originally fell as possible.

Infiltration systems are effective at removing litter, total suspended solids, coarse sediment and heavy metals (depending on state). Infiltration systems are typically less effective at removing nutrients from runoff due to the low phosphorus retention index of most naturally occurring sands in WA. The nutrient removal efficiency can be increased by soil amendment (refer to Bioretention) and landscaping the system with appropriate vegetation.

Urban Zone

In the Urban zone the SCWQIPs list nutrient concentrations, sediment and heavy metals as the major concerns for the Bayswater Brook and Bennett Brook catchments. The use of pit and pipe drainage is more

likely in the Urban zone due to space constraints associated with the ultimate plan for Tonkin Highway to be 8 lanes. As the highway is not a significant contributor of nutrients, the use of infiltration systems is considered appropriate as it is effective at removing sediment (or total suspended solids) and to a lesser extent, heavy metals which are the likely pollutants off the road.

P1 Zone

Within the P1 zone the intention will be to limit the use of kerbing and/or pit and pipe systems where possible. Therefore the application of leaky pits and infiltration systems will be limited, however where pit and pipe drainage are required outside the WHPZs, leaky pits should be provided. Within WHPZs the pit and pipe systems should be discharged to the bioretention systems to ensure the runoff passes through the bioretention prior to infiltration.

Palusplain Zone

Infiltration systems are generally not appropriate for the Palusplain zone due to the seasonally waterlogged/inundated nature of the zone, however the use of leaky pits in large fill embankments associated with grade separated interchanges and crossings should be considered.

C1.2.2 Permeable/Pervious Pavement

The use of permeable pavement on the road shoulders to provide for infiltration at source was raised in the ERG. Limiting the use to the shoulders was in recognition that Main Roads have previously rejected the use of permeable pavement in the carriageways. The use of permeable pavement for the shoulders has also been ruled out for the NorthLink project as alternate pavements (such as permeable pavement or reduced thickness pavement) for shoulders does not align with MRWA aspirations of:

- Maintaining the flexibility to use Shoulder Running under a Lane Use Management System as part of their network operations plan to address network congestion; and
- Use of the highway by oversized/over mass vehicles where the outside wheel would travel in the shoulder.

C1.2.3 Grassed/vegetated swales

Grassed/vegetated swales, herein referred to as vegetated swales, are broad, shallow channels with vegetation covering the sides and base. The swales are used in place of other conveyance systems such as piped drainage and promote infiltration thereby reducing stormwater peak runoff, velocity and volume. Swales remove coarse and medium sediments, including suspended solids and trace metals.

Urban Zone

There is likely to be limited scope for the application of vegetated swales in the Urban zone due to the confined corridor and ultimate planning for 8 lanes. There may be scope to utilise vegetated swales at the Tonkin Highway / Reid Highway / PDNH interchange to transfer runoff towards the existing basins that are proposed for use as part of the flood mitigation system.

P1 Zone

The use of vegetated swales is applicable in the P1 zone, outside the WHPZs, to infiltrate common rainfall events and direct excess runoff to suitable infiltration areas.

Palusplain Zone

In the Palusplain zone the use of swales along the alignment, which is generally transverse to the direction of overland flow, may serve to 'drain' the areas between streamlines and therefore it is preferable to utilise the existing ground slopes where possible. In the southern part of the zone where it is still transitioning from interdunal to palusplain and some cut may result, it is preferable to use a vegetated swale to a traditional table drain.

C1.2.4 Bioretention

A bioretention system consists of an excavated basin or trench that is filled with porous media and planted with vegetation. Bioretention systems operate by filtering runoff through the surface vegetation, followed by the stormwater percolating into the porous media, where filtration, extended detention treatment, denitrification and some biological uptake occurs. The porous filter media in the bioretention system can be drained either by direct infiltration into the surrounding soil (where highly permeable soils are present) or by a subsoil or base drain.

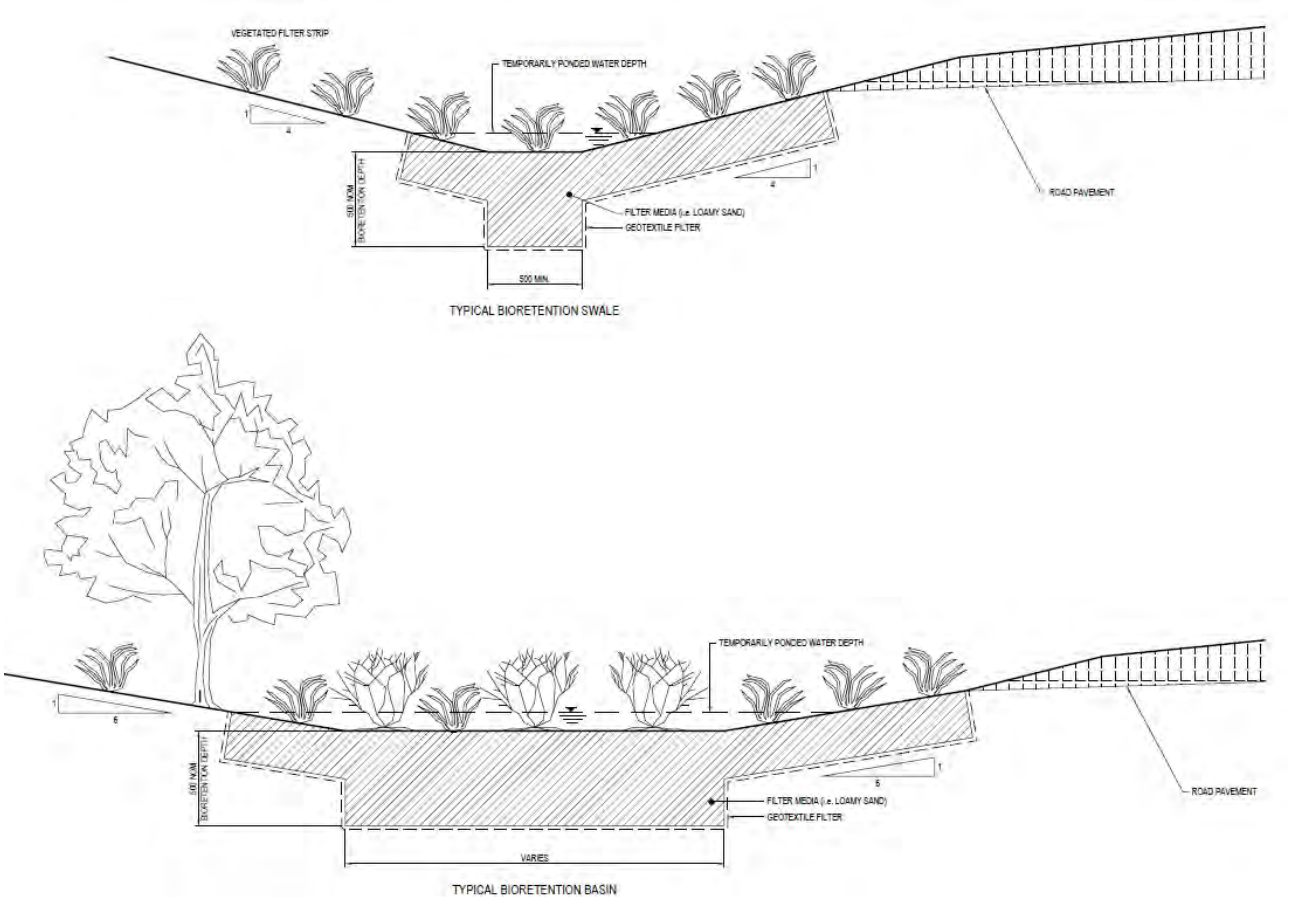


Figure C1: Typical bioretention swale and basin

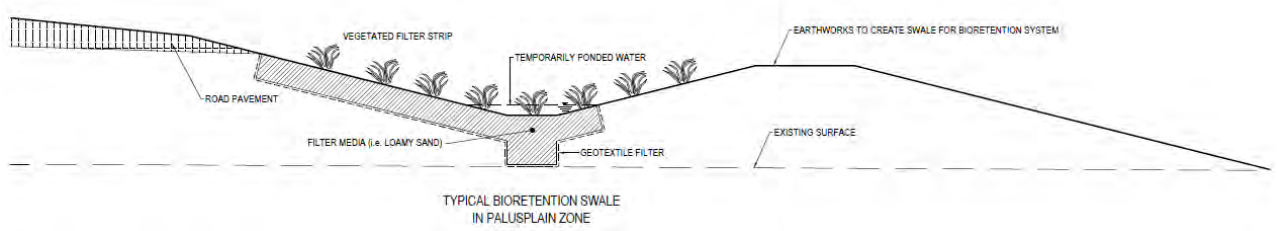


Figure C2: Example bioretention swale in Palusplain Zone

Bioretention systems remove fine sediment, trace metals, nutrients, bacteria and organics. They are generally more effective than vegetated swales, particularly in WA where the native sands are not very effective at removing nutrients.

The cost of bioretention systems is higher than for vegetated swales as the existing soil needs to be replaced or augmented to provide a suitable filtration media. Bioretention systems also require a higher level of maintenance than other more basic infiltration systems.

Within the project, the WHPZs in the P1 zone and the Conservation Category / Resource Enhancement Category wetlands adjacent to the alignment are areas of significant water quality concern and are therefore locations where the use of bioretention is appropriate.

C1.2.5 Flow over vegetated surfaces

The use of flow over vegetated surfaces to provide water quality treatment involves the passing of runoff as a sheet flow through a vegetated surface (either existing or planted). The vegetation acts to slow the flow of the runoff and thereby encourage deposition of sediments within the flow. It is best used where a uniformly distributed flow comes of the road, i.e. where the road is unkerbed.

The use of flow over vegetated surfaces is best used where it is important or desirable to maintain sheet flow conditions in the road runoff, such as in the Palusplain zone. It may also be suitable in the P1 zone where the existing ground falls away from the highway and away from the Water Corporations bores to a location that will not cause flooding issues in major events.

C1.2.6 Wetlands

In considering wetlands for water quality treatment of road runoff, both constructed wetlands and enhanced existing wetlands have been considered.

Constructed wetlands are vegetated detention areas designed and built specifically to remove pollutants from stormwater runoff. In particular constructed wetlands are more effective at treating runoff with high concentrations of soluble pollutants than other treatment methods. The constructed wetlands typically require relatively large areas however and are therefore not suitable in space constrained areas, such as the Urban zone. In the P1 zone and Palusplain zone there are less space constraints, however in these areas the desired level of water quality protection can be achieved through other methods.

In the discussion around wetlands at the ERG, many of the stakeholders expressed the view that the hydrology of the wetland needed to be maintained in its existing condition; and that runoff from the road entering the wetland needed to be treated prior to entering the wetland. Therefore to use an enhanced existing wetland for runoff treatment would effectively require the enhancement to be to a severely

degraded lower category (Multiple Use) wetland, which would in effect be the same as creating a constructed wetland.

The construction of specialised wetlands for runoff treatment is not considered applicable for the drainage strategy but the construction of and/or enhancement of wetlands along the alignment for social and environmental benefit is supported. In particular the landscaping of other drainage treatments, such as infiltration or detention areas, as ephemeral wetlands is encouraged.

C1.2.7 Proprietary devices (i.e. Oil and sediment separators, filter systems)

Proprietary devices, such as oil and sediment separators, are usually associated with and utilised at the end of pipe systems where either space or groundwater constraints make the use of other water quality systems unacceptable. They can also be useful upstream of confined systems such as infiltration or detention tanks to trap sediments and floating pollutants in a more easily accessed device for maintenance. However such devices has a comparatively high cost to implement and reduced overall benefit as they do not encourage infiltration of the common rainfall event.

The use of proprietary devices should be considered for protection of the receiving waters in those situations where other systems are deemed unviable.

C1.2.8 Spill Management

Spill management is an important issue across the project and can be addressed through both structural controls and non-structural controls.

Structural controls are physical devices used to intercept spills and are appropriate for consideration where a piped or lined drainage system is used. Where the piped/lined system discharges immediately upstream of a sensitive receiving water, an oil spill trap should be provided. Where the piped/lined system discharges to a disconnected system (i.e. main drainage system including basins) where there are opportunities to trap spills prior to reaching a sensitive receiving water an oil spill trap may not be needed. These locations should be assessed on a case by case basis.

The promotion of a disconnected drainage system (where flow over vegetated surfaces rather than in impervious pipes) provides opportunities to intercept spills and treat them nearer the source.

Non structural controls are measures other than physical controls, such as legislation or education. In this instance the main non structural control to be considered is appropriate emergency spill response planning for the Priority 1 Source Protection Area of the Gnangara Mound.

C1.3 Flood Event Management

Management of stormwater runoff through infiltration to the superficial aquifer is a common approach to stormwater management in Perth, and is the primary mechanism for the management of the majority of rainfall events as outlined in Section C1.2, however when the runoff (from major storm events) exceeds the capacity of the small event system, the excess runoff needs to be managed to ensure that there is no damage to property/infrastructure and no adverse effects downstream.

The options identified and investigated for flood event management, being events greater than the small/minor event system and up to 1% AEP (100 year ARI), are discussed below.

C1.3.1 Infiltration

The management of runoff excess from the small/minor event system, for major events by infiltration, involves the identification of existing and/or provision of shallow storage areas to retain the runoff excess until it is infiltrated.

It is recognised that this is most effective where there is sufficient separation between the infiltration surface and the superficial aquifer. The project site is characterised by a high water table which will limit the effectiveness of infiltration as a means of managing flood events.

Urban Zone

Within the Urban zone there is generally limited clearance to groundwater, which will reduce the effectiveness of infiltration for flood event management. However with minimal existing formal connections to the district/regional drainage networks, managed by Water Corporation or local governments; infiltration for flood event management will best match the existing drainage regime of the site. Where overflow outlets are required into the district/regional drainage networks, these will need to be negotiated with Water Corporation or the relevant local governments in liaison with the Department of Water, as the overall administrator of the Perth Arterial Drainage Scheme.

P1 Zone

Although the clearance to groundwater in the P1 zone is limited, with the exception of the Water Corporation's Emu Swamp Main Drain and a tributary of Mussel Brook in the southern portion, there are generally no water courses to discharge into. As such, whilst infiltration efficiency is reduced, it is the preferred option for flood event management.

Given the limited extent of development across most of this zone, there is potential to allow runoff from flood events to flow to natural low points outside the site to infiltrate (pending an assessment of potential flood damage to properties and that the infrastructure is not compromised). Where major event runoff needs to be controlled within the site, the use of formalised infiltration basins for flood event management is most likely.

Palusplain Zone

The Palusplain zone, being predominately palusplain, is seasonally inundated or waterlogged making infiltration for major event management not appropriate.

C1.3.2 Conveyance

Conveyance refers to the use of existing water courses and/or district/regional drainage systems to manage the excess runoff resulting from major events to receiving waters safely.

Urban Zone

The Urban zone features many Water Corporation 'main' drains. It is a requirement of the Water Corporation that new connections or major developments that connect to their drains do not change the hydraulic grade line in their drainage system for the 10 year ARI and 100 year ARI events. Where the discharge point is near the outlet of the Water Corporation system, straight conveyance may be achievable; however the NorthLink Project is generally higher up in the system where detention is likely to be required if connected to Water Corporation drains. If a connection to a Water Corporation asset is required this should be negotiated in liaison with the Department of Water, as the overall administrator of the Perth Arterial Drainage Scheme.

P1 Zone

Within the P1 zone there are two opportunities where conveyance might be considered. These are at Marshall Road, where the PDNH crosses the Water Corporation's Emu Swamp Main Drain and just north of the PDNH / Hepburn Ave interchange where PDNH crosses a tributary of Mussel Brook.

If conveyance of major event flows to the Emu Swamp Main Drain is required at the detailed design stage this should be negotiated with the Water Corporation in liaison with the Department of Water, as the overall administrator of the Perth Arterial Drainage Scheme.

Conveyance of major event flows to the tributary of Mussel Brook would have to consider any potential impact on the Conservation category wetlands downstream of the crossing.

Palusplain Zone

For the Palusplain zone the difference between the pre and post development flows will be minor as the highway represents a minor increase to the imperviousness of the overall catchment and therefore conveyance is the recommended method for flood management.

C1.3.3 Detention

Detention, beyond that required to achieve design criteria for small and minor event management, should only be required if existing peak flood heights and flow rates cannot be managed by the downstream channels and overland flow paths.

Urban Zone

The Urban zone features Water Corporation 'main' drainage systems throughout, however there are few existing formal connections from the Tonkin Highway alignment to this network. Where the use of detention for flood event management is required due to limited local infiltration capability, connection to these drains and detention requirements will need to be negotiated with Water Corporation or the relevant local governments in liaison with the Department of Water, as the overall administrator of the Perth Arterial Drainage Scheme.

P1 Zone

As discussed in the previous section, there are two drainage systems/waterways in the P1 Zone that might be utilised for flood event management, being the Water Corporations Emu Swamp Main Drain and a tributary of Mussel Brook.

If it is established that the Emu Swamp Main Drain does not have the capacity to accommodate the flood event management flows from the project then detention of flows into the Emu Swamp Main Drain may be an option and the size of the required detention storage would need to be determined during detailed design.

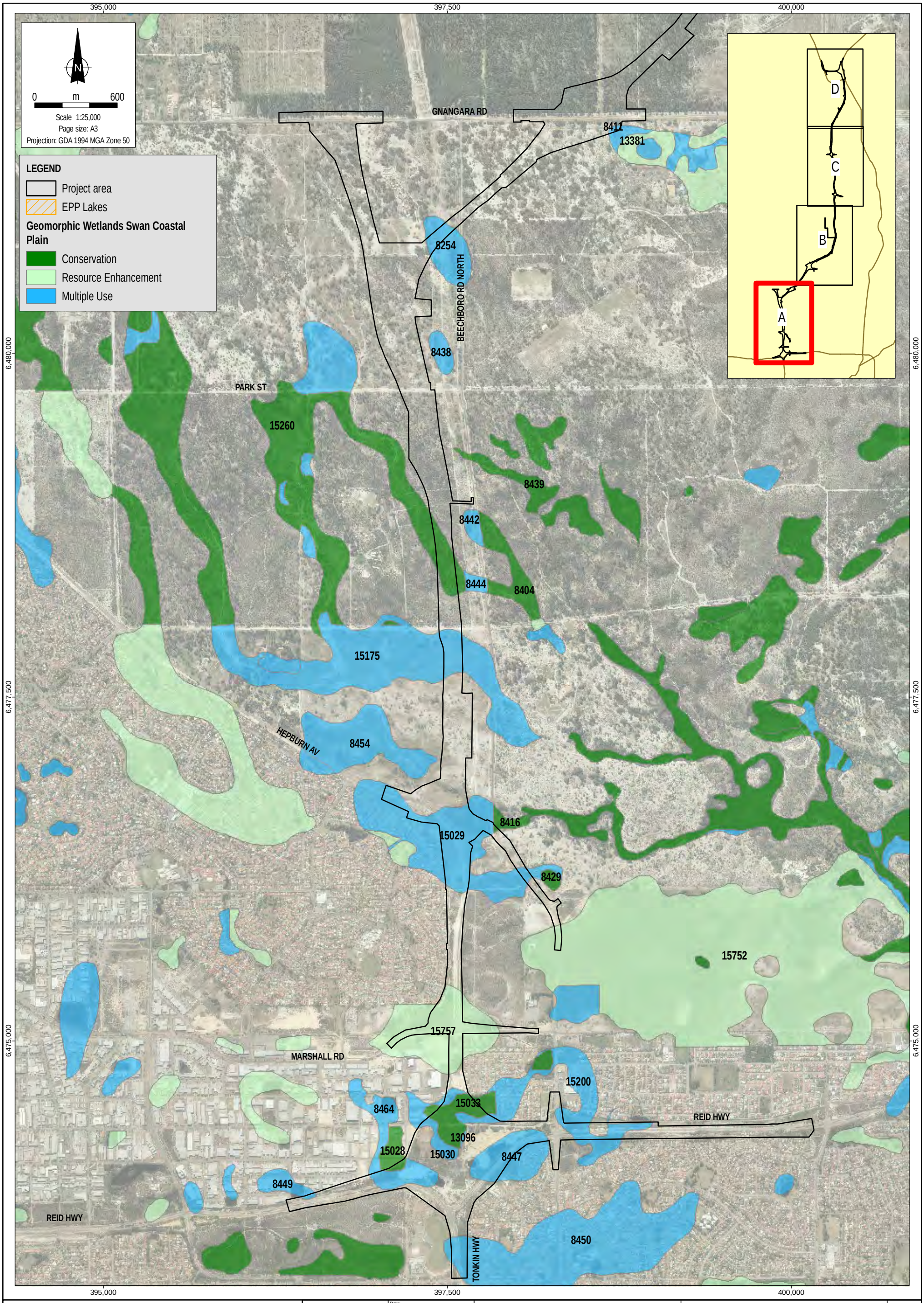
Similarly if it is established that the tributary of Mussel Brook cannot accommodate flood event management flows from the project then detention of flows to a level that satisfies the downstream constraints may be an option. As for the conveyance option, the use of detention of flows into the tributary would have to consider any potential impact on the Conservation category wetlands downstream of the crossing.

Palusplain Zone

As discussed previously the difference between the pre and post development flows will be minor and to utilise detention basins would require the flow to be concentrated at a location, which can be more problematic than allowing the runoff to enter the catchment in a distributed nature. Therefore detention for flood mitigation is generally not proposed for the Palusplain zone.

APPENDIX D

Wetlands



Source & Notes
Project area from NorthLinkWA (January 2015).
Geomorphic wetlands from DPAW (January 2015).
EPP lakes from EPA.
Aerial imagery from Landgate (August 2014)

NorthLinkWA

coffey

Date: 10.02.2015
MXT: 4483AA_03_GIS037_1
File Name:

Main Roads WA

Perth to Darwin National Highway

Geomorphic wetlands and EPP lakes

Figure No: A
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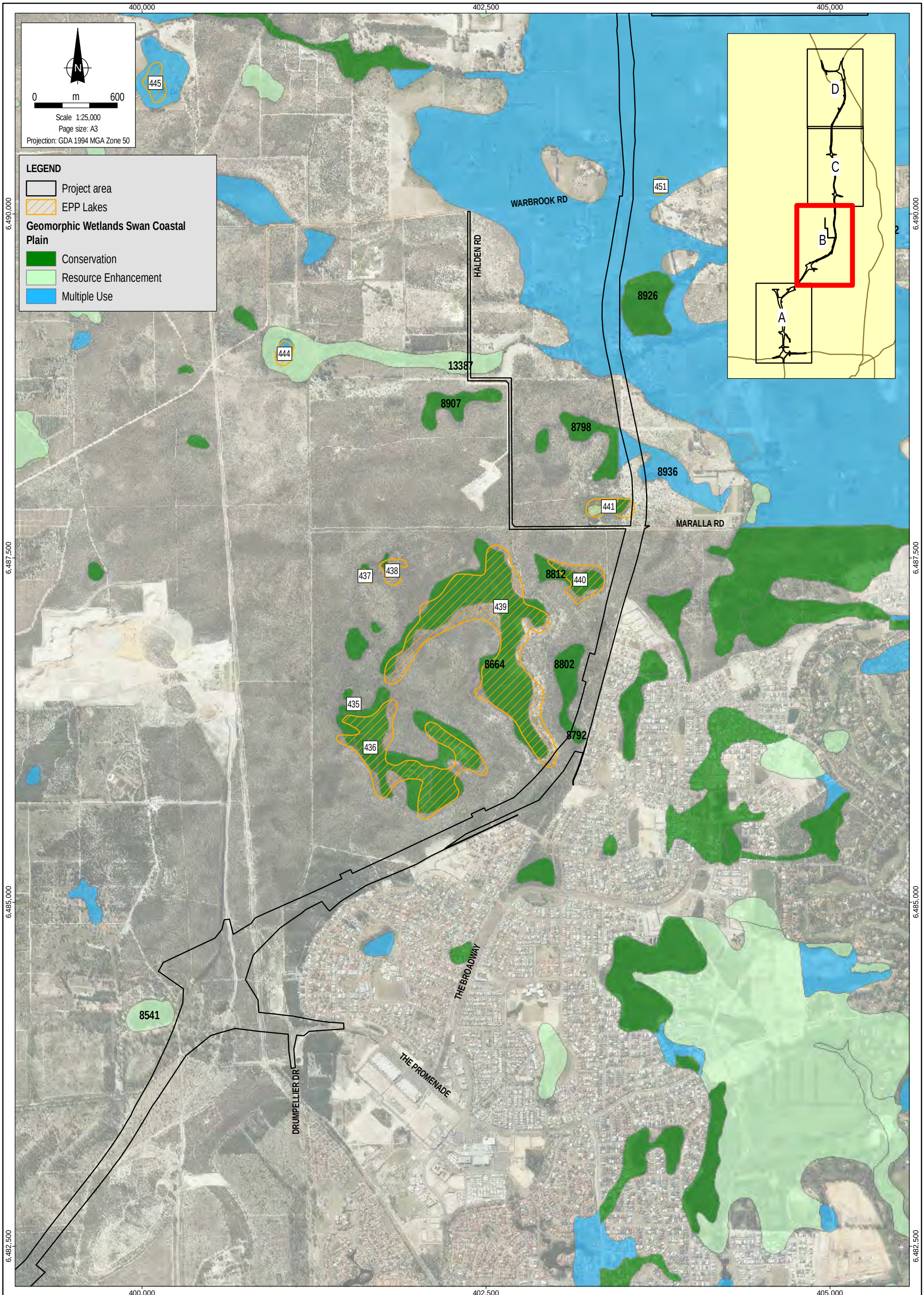

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NorthLinkWA

coffey

Date: 10.02.2015
MXT: 4483AA_03_GIS037_1
File Name:

Main Roads WA

Perth to Darwin National Highway

Geomorphic wetlands and EPP lakes

Figure No: B
DRAFT

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LEGEND

- Project area
- EPP Lakes

Geomorphic Wetlands Swan Coastal Plain

- Conservation
- Resource Enhancement
- Multiple Use

402,500 405,000

6,500,000 6,497,500 6,495,000 6,492,500

8779 13402 15732 8773 8909 8910 8911 8914 8916 8783 8919 8784 8785 8927

405 465 464 462 456 457 455 458 453 454 449 450 452 447 448 446

NEAVES RD MUCHEA SOUTH RD RAILWAY PDE STOCK RD

A B C D

Source & Notes
Project area from NorthLinkWA (January 2015).
Geomorphic wetlands from DPAW (January 2015).
EPP lakes from EPA.
Aerial imagery from Landgate (August 2014)

NorthLinkWA

coffey

Date: 10.02.2015
MXT: 4483AA_03_GIS037_1
File Name:

Main Roads WA

Perth to Darwin National Highway

Geomorphic wetlands and EPP lakes

Figure No: C
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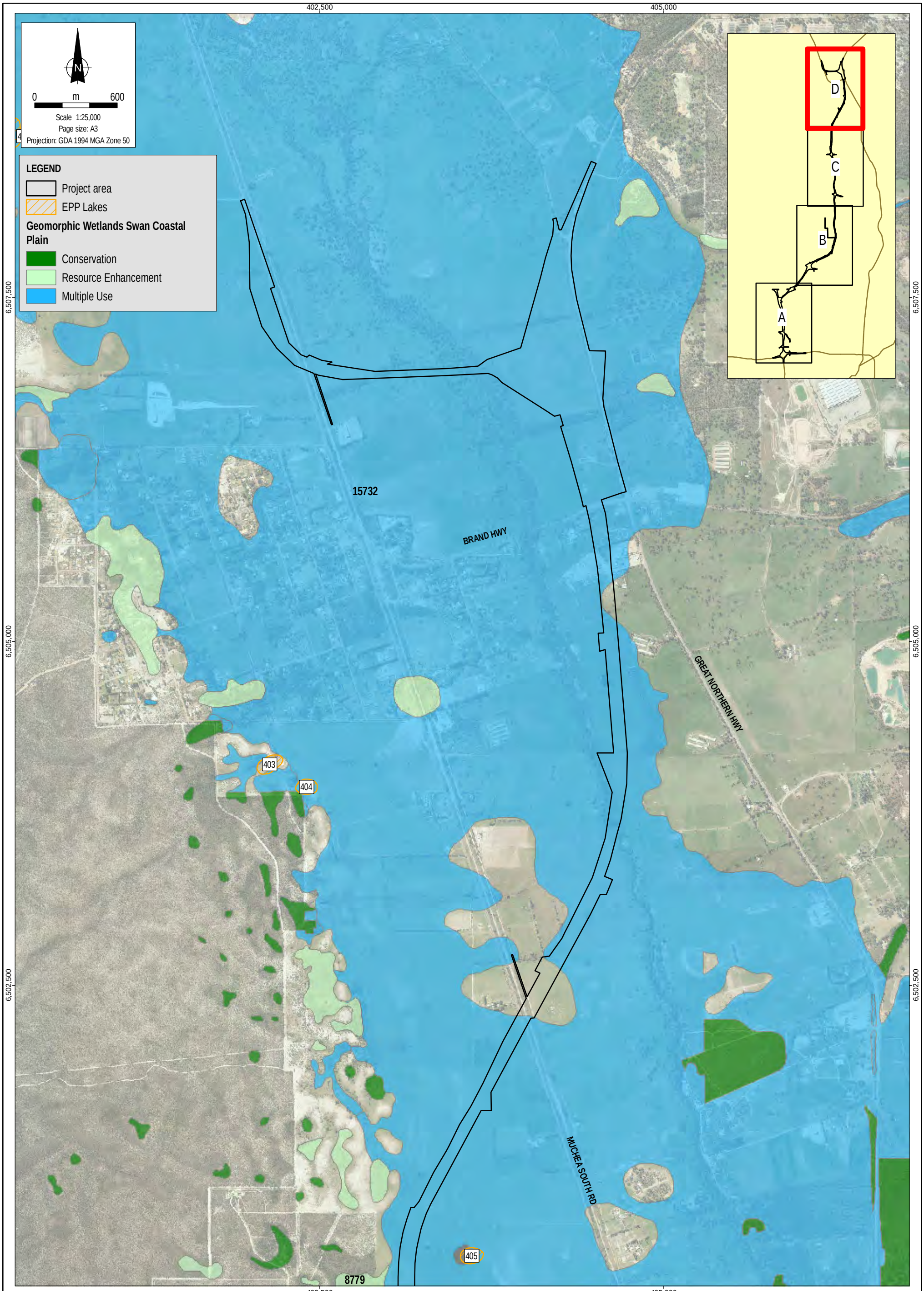

Source & Notes Project area from NorthLinkWA (January 2015). Geomorphic wetlands from DPAW (January 2015). EPP lakes from EPA. Aerial imagery from Landgate (August 2014)	NorthLinkWA	coffey	Main Roads WA Perth to Darwin National Highway	Geomorphic wetlands and EPP lakes

Date: 10.02.2015
MXT: 4483AA_03_GIS037_1
File Name:

Figure No: D
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BG&E NorthLinkWA
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Australian Government

mainroads WESTERN AUSTRALIA

NorthLinkWA