6.5.8 NSW Integrated Water Cycle Management Guidelines

Integrated Water Cycle Management (IWCM) is a way for local water utilities to better manage their water systems to maximise benefits to the community and environment. It also achieves improved communication and sharing with other water users and managers. It is a key component of the Department of Water and Energy's(now DECCW) Best Practice Management of Water Supply and Sewerage Guidelines.

Whilst preparation of an IWCM is not compulsory for utilities, it is required for eligibility for Country Towns Water Supply and Sewerage Program funding towards any capital works. NSC has recently initiated a Draft IWCM Strategy for the LGA. Details of which are addressed in Section 1.8.1.

6.6 Local Government Policy

6.6.1 Draft IWCM Strategy

Nambucca Shire's water supply, sewerage and stormwater infrastructure requires upgrading to meet population growth, legislative and best practice standards. Therefore to address the current and emerging issues within a catchment context, it was decided to holistically review and evaluate how the urban water cycle in Nambucca Shire could be improved. Thus this draft strategy is to be used to demonstrate that improved management of the 'urban footprint' can help achieve NSC's strategic business objectives, State resource policy objectives and community expectations for natural resource management. Importantly, the draft IWCM Strategy is:

- Driven by the local community and has whole of government support;
- Holistic and comprehensive;
- Long term in its horizon, (30 years), but would be reviewed every 6 years;
- Flexible to accommodate future uncertainties;
- Economically, environmentally and socially responsible.

A copy of the draft IWCM Strategy is available on NSC's website. The Proposal is an integral component of the draft IWCM Strategy in securing a sustainable water supply to meet population growth, legislative and best practice standards.

6.7 Commonwealth Government Policy

6.7.1 National Water Initiative

The National Water Initiative (NWI) follows on from the Commonwealth Organisation of Australian Governments (COAG) agreement and provides a blueprint for national water reform, which takes effect through an Intergovernmental Agreement signed by the States, Territories and Australian Governments in June 2005 (with WA and Tasmania signing in April 2006).

The objective of the NWI is to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes.

Full implementation of the NWI is expected to achieve:

- Clear and nationally compatible characteristics for secure water access entitlements;
- Transparent, statutory-based water planning;
- Statutory provision for environmental and other public benefit outcomes, and improved environmental management practices;
- The return of all currently over allocated or overused systems to environmentally sustainable levels of extraction;
- The progressive removal of barriers to trade in water and the meeting of other requirements to facilitate the broadening and deepening of the water market to achieve an open trading market;
- A clear assignment of the risk arising from future changes in the availability of water for consumption;
- Water accounting to meet the information needs of different water systems in terms of planning, monitoring, trading, environmental management and on-farm management;
- Policy settings that facilitate water use efficiency and innovation in urban and rural areas;
- Responses to future adjustment issues that may have an impact on water users and communities; and
- Recognition of the connectivity between surface and groundwater resources with connected systems managed as a single resource.

The NWI includes objectives, outcomes and agreed actions to be undertaken by governments across eight inter-related elements of water management which relevantly include:

Integrated management of water for environmental and other public benefit outcomes:

- Identify within water resource planning frameworks the environmental and other public benefit outcomes sought for water systems and develop and implement management practices and institutional arrangements that would achieve those outcomes.
- Urban water reform: Ensure healthy, safe and reliable water supplies; increase water use efficiency in domestic and commercial settings; encourage the re-use and recycling of wastewater; facilitate water trading between and within the urban and rural sectors; encourage innovation in water supply sourcing, treatment, storage and discharge; and achieve improved pricing for metropolitan water.

In relation to urban water reform, the NWI provides that Proposals for investment in new or refurbished water infrastructure continue to be assessed as economically viable and ecologically sustainable prior to the investment occurring.

Schedule D of the Agreement states agreed principles for regulatory approvals for water use and works. It requires, among other things that approvals be consistent with relevant water legislation and water plans and takes into account environmental, social and economic impacts of use, including on downstream users.

This EIS addresses the principles espoused in the Agreement, and in particular Schedule D by providing an assessment of the environmental, social and economic impacts of the Proposal in accordance with the NWI.

6.8 Summary of approval process and legislation requirements

The Proposal is permissible without development consent in accordance with the provisions of the SEPP Infrastructure and the EP&A MP. The Proposal has been assessed under Part 5 of the EP&A Act. NSC is the proponent for the activity and also a determining authority.

Table 6-1 summarises the approvals and notification requirements of the Proposal.

Table 6-1 Summary of approvals and notification requirements

Act	Approval / requirements	Authority
Environmental Planning and Assessment Act 1979	◗ Part 5 'Activity' Approval.	NSC and others
Heritage Act 1977	◗ Notification of intention to impact the forestry stump, site NWSH1, in writing to the Director of the NSW Heritage Office.	NSW Heritage NSC
National Parks and Wildlife Act 1974	◗ Section 87 permit to carry out sub-surface investigations within the identified PAD. ◗ Should any items of significance be identified as part of the sub-surface investigations, a Section 90 consent to destroy would be required.	NSW Department of Environment, Climate Change and Water (formerly DECC)
Protection of the Environment Operations Act 1997	◗ Environment Protection Licence for the excavation of material from on-site borrow areas. ◗ Environment Protection Licence for water releases from the storage that may pollute the environment.	NSW Department of Environment, Climate Change and Water (formerly DECC)
Water Act 1912	◗ Licence to construct bores under Section 112. ◗ Section 167 flood control work approval.	NSW Department of Environment, Climate Change and Water (formerly DWE)
Water Management Act 2000	◗ A controlled activity approval would be required for the Proposal for water access.	NSW Department of Environment, Climate Change and Water (formerly DWE)

Act	Approval / requirements	Authority
Fisheries Management Act 1994	◗ Section 200 approval for dredging and reclamation ◗ Section 218(5) notification to Minister ◗ Section 219 permit in relation to the construction of fish passage at existing pipeline crossing of Nambucca River.	NSW Department of Industry and Investment (formerly DPI)
Forestry Act 1916	◗ The acquisition approval process required under the *Forestry Act* but would not take place until it is known whether the Proposal has been approved and NSC begins land acquisition prior to commencement of construction.	NSW Department of Industry and Investment (formerly DPI)
Local Government Act 1993	◗ Approval under s60 of the Local Government Act 1993 to construct the off-river storage.	NSW Department of Environment, Climate Change and Water (formerly DWE)

7 Air Quality and Climate

7.1 Introduction

This Chapter identifies the potential air quality impacts associated with the Proposal and the management measures to reduce any impacts. Table 7-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 7-1 EIS Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Likelihood of air, noise or water pollution arising from the development or activity. ◗ Analysis of construction impacts including: pollution controls.	Section 7.3
Department of Environment, Climate Change and Water (DECCW)	◗ *Air:* baseline conditions, assess impacts and describe management and mitigation measures.	Section 7.2 ,7.3, and 7.4

7.2 Existing Climate Conditions

7.2.1 Temperature and Rainfall

The climate in the location of the Proposal is generally described as subtropical with warm, wet summers and dry, mild winters. The Bureau of Meteorology (BOM) weather station that was considered to be most representative of the location of the Proposal in terms of distance from the coast, elevation and most up to date data was Kempsey. Kempsey is located approximately 60 km south of Bowraville. As shown in Table 7-2, based on mean temperature records, the warmest month is January and the coolest month is July. February receives the greatest rainfall and September the least.

Table 7-3 provides some additional climate characteristics that have been provided by CSIRO (2007) for various locations on the North Coast of NSW. The current average of these characteristics also reflects the relatively mild climate experienced on the North Coast of NSW.

Table 7-2 Climate Statistics from Kempsey BOM Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Max Temp (°C)	29.2	28.8	27.8	25.5	22.6	20.0	19.7	21.3	24.0	25.6	27.1	28.6
Mean Min Temp (°C)	17.6	17.9	16.5	13.2	9.7	7.0	5.6	6.2	8.9	11.8	14.3	16.5
Mean Rainfall (mm)	134.0	155.7	152.2	115.0	92.3	95.4	67.1	62.5	56.6	78.4	93.5	109.0

Table 7-3 Climate Statistics for Locations on the North Coast of NSW (CSIRO, 2007)

Statistic	Current Average
Days below 0°C at Yamba	0
Days above 35°C at Yamba	1
Droughts per Decade	2
Fire Days at Coffs Harbour	4

7.2.2 Local Wind Climate

The nearest known source of suitable hourly or better, wind data is the Coffs Harbour Meteorological Office (MO) Automatic Weather Station (AWS) operated by the BoM. The AWS site is about 43 km northeast of the Proposal. The wind patterns are likely to be slightly different at Bowraville, but the prevailing wind patterns are considered to be sufficiently representative for the purposes of this assessment.

Figure 7-1 shows the annual wind rose for Coffs Harbour. The annual wind climate in the area is dominated by flows from the north, northeast and southwest. Winds from the east have the lowest frequency of occurrence. Low wind speeds are most common from the east to south-east, while higher wind speeds, which can be associated with dust lift-off, are from the north, northeast, south and southwest.

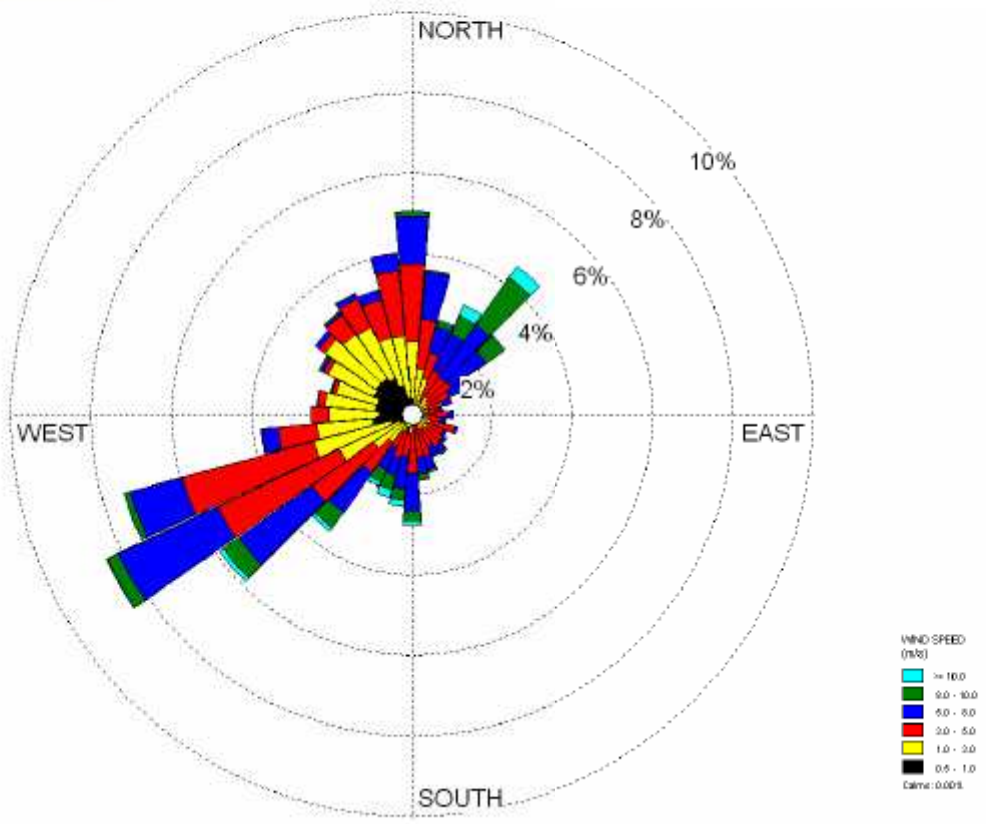


Figure 7-1 Annual Wind Rose – Coffs Harbour

7.2.3 Sensitive Receptors

Figure 7-2 shows sensitive receptors that have been included in this air quality impact assessment. During construction of the Proposal, specifically the pipeline, residential receptors may be located within close proximity (i.e. less than 50m) to construction activities. Typically, the potential for air quality impact is greatest at receptors located nearest to the Proposal, with the level of impact decreasing with distance from the construction area. In general, sensitive land uses located less than approximately 500 metres would be considered, with particular attention given to receptors located within approximately 300 metres of the Proposal.

7.3 Impact Assessment

7.3.1 Construction

Construction Emissions Inventory

The main components of the construction phase of the Proposal would be the preparation of the off-river storage area and construction of the storage embankment as well as trenching activities associated with pipe-laying.

The types of emissions to air during the construction process would primarily consist of:

- Dust emissions from both the mechanical disturbance and wind erosion of soil;

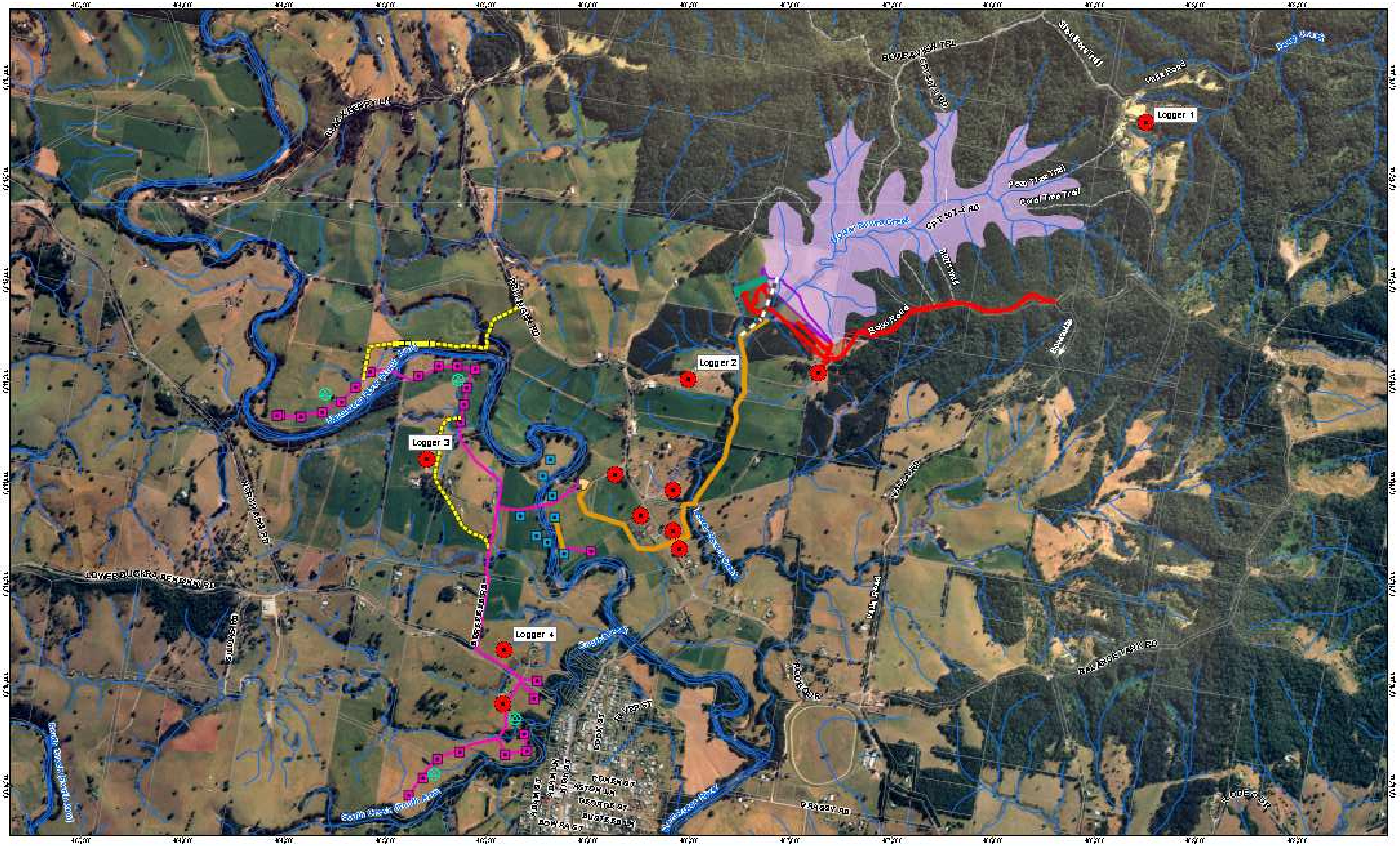
- Smoke emissions as a result of any burning off of cleared vegetation; and
- Exhaust emissions from the range of motor vehicle and mobile plant required for the Proposal.

Activities that have been identified as possible sources of dust emissions are:

- Clearance of vegetation, rock and soil material;
- Material handling e.g. excavation, bulldozer;
- Vehicle induced dust emissions on haul routes; and
- Pneumatic rock-breaking, where required;
- Loading and dumping of cleared material;
- Levelling and grading of disturbed soil surfaces;
- Passage of construction and administrative vehicles over unsealed sections of road or localised unconsolidated soil surfaces; and
- Wind erosion of all unstable/uncovered stockpiles and other unconsolidated surfaces.

Whilst most vegetation would be harvested or mulched as part of the Proposal, some burning of cleared vegetation may be required and would have the potential to impact on local air quality. Should burning activities be required, they would be of a short-term nature and would be undertaken within the proposed storage area via high temperature pits to limit smoke emissions.

Vehicle exhaust emissions during the construction phase of the Proposal also have the potential to impact on local air quality. However the impact is likely to be negligible given the relative isolation of the Proposal, limited number of sensitive receivers within close proximity to the Proposal and the implementation of identified mitigation measures.



1:17,000 (at A3)

0 87.5 175 350 525 700

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Fire Trail
- Creeks
- Cadastre
- Outlet Pipe
- Spillway
- Preliminary Road Design
- Proposed Pipeline Option 7
- Proposed Borefield Collection Pipeline
- Existing Borefield Locations
- Proposed Borefield Locations
- Proposed Borefield Transformers
- Proposed Borefield Access Roads
- Stage 1 Dam Wall
- Stage 1 Inundation Area
- Existing Headworks Area
- Residential Receptors

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Identified Sensitive Receivers Figure 7-2

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Dust Emissions

The dominant sources of dust emissions during the construction works are likely to be from machinery such as dozers, graders, excavators and haul trucks. If not managed appropriately, construction dust emissions have the potential to cause loss of amenity and health impacts, particularly to nearby receivers.

Storage

The greatest potential for dust-generation is likely to occur within the proposed storage area due to the large quantities of material to be excavated. At this location, the nearest sensitive receivers are between 200 and 440 metres respectively. It is considered that a high proportion of the coarse particulate matter emissions are likely to be deposited within 300 to 500 metres of the construction activity, reducing the potential impact at sensitive receivers when construction activity is at further distances. The natural topography and native vegetation to be retained around the storage would also act to reduce the impact on sensitive receivers.

Borefield and Transfer Pipeline

Limited dust is expected to be generated as a result of the borefield and transfer pipeline construction as trenching and installation of infrastructure would occur almost simultaneously thereby minimising the time disturbed soil is exposed. The closest receivers to the borefield collection system are between 200 and 250 metres respectively. Given that these works are lineal, there would only be a short period of time when construction activities would be in close proximity to the receivers.

Haul Roads

Haul roads have the potential to generate a significant amount of dust during construction. A substantial part of the materials required to construct the storage embankment are expected to be sourced from site. It has been estimated that approximately 32,000 m^3 of materials are expected to be imported to the site from supply quarries for the construction works. The access facilities required for the construction phases of the Proposal are expected to be satisfied by Valla Road and Bobo Road. Only a short section at the southern end of Valla Road is sealed whilst the northern portion and Bobo Road is unsealed. As a result, there is potential for adverse dust impact at receptors located along Valla Road, caused by dust generated from haul trucks passing over the unconsolidated road surface. Given that only several receivers are located in close proximity to the road, dust suppression can be targeted at these locations.

Measures for dust mitigation are outlined in Section 7.4 of this assessment.

Smoke Emissions

The type of emissions during burning of vegetation have been sourced from the DECCW's Air quality guidance note *Agricultural Stubble Burning* and from the DECCW Regulation of open burning in NSW, *An environmental guideline for NSCs, fire management authorities and landowners*.

The area of vegetation burned, meteorological conditions, soil moisture content and the type of vegetation burned would influence the composition and intensity of smoke produced from the burning vegetation. This smoke generally contains a range of chemical constituents as the

result of both the complete and the incomplete combustion of the biomass, including carbon monoxide and respirable fine particulates of varying composition.

The impact of the smoke emissions are heightened if the burning is conducted during periods when the prevailing weather is conducive to poor dispersion (and hence dilution) of the smoke. Poor dispersion typically occurs during the night time, with low wind speeds and stable atmospheric conditions. However, these conditions can also occur during the daytime for certain combinations of meteorological conditions in combination with certain terrain types (such as flat plains, valleys, undulating ranges, etc).

Smoke from burning of vegetation has the potential to cause adverse air quality impacts on nearby receivers. In light of these impacts, any burning would be undertaken in high temperature pits under supervision and in consultation with the NSW Rural Fire Service to reduce smoke emissions. Measures for control and minimisation of smoke impacts are outlined in Section 7.4.

7.3.2 Operation

It is not anticipated that a significant amount of traffic would be generated by the proposed storage following construction. Bobo Road would however be sealed during the construction phase of the Proposal and would be maintained upon completion of the storage. As such, dust emissions from vehicles travelling over this road would be significantly reduced.

Air emissions during the operation phase of the Proposal are therefore anticipated to be negligible and are not expected to have adverse impacts on sensitive receptors.

7.4 Mitigation Measures

Managing air pollution at the source through management practices and mitigation measures would be as follows:

7.4.1 Dust Emissions from Construction

- Bobo Road, as the primary access road to the main storage area, be sealed prior to the construction phase to minimise dust generation from haul trucks.
- Water trucks be used on Valla Road during heavy use to minimise dust generation from haul trucks.
- Pre-water construction areas and stockpiles before they are disturbed and continue watering during any activities where fugitive dust may be produced;
- Where practicable, storage piles would be located in areas away from traffic areas, protected from the wind and away from public vantage points;
- Soil surfaces exposed for long periods of time would be covered with mulches or covers to stabilise soil;
- Limit cleared areas of land and clear only when necessary;
- With the exception of the inundation area, retain existing vegetation where possible and re-vegetate cleared areas and stockpiles with fast growing species for rapid coverage to temporarily or permanently stabilise soil;
- Control on-site traffic by designating specific routes for haulage and access;

- All trucks hauling dirt, sand, soil or other loose materials along public roads would be covered;
- Material spillage on roads and pathways would be cleaned up at regular intervals;
- Wheel washers would be installed where vehicles enter and exit unpaved roads onto paved roads, or wash off trucks and any equipment leaving the site each trip to remove dirt, mud or debris from tyres; and
- Establish real-time dust (PM_{10}) monitoring at receptor to the southwest of the storage site.

7.4.2 Smoke Emissions from Burning

Considerations for smoke control measures have been sourced from the DECCW's Air quality guidance note *Agricultural Stubble Burning* and from the DECCW Regulation of open burning in NSW, *An environmental guideline for NSCs, fire management authorities and landowners.*

Control technologies and methods for managing smoke emissions from vegetation burning are provided below:

- High temperature pit burning would be used over at-ground or stockpiled fires;
- Burning vegetation would be extinguished to stop or control impacts due to emissions;
- The use of fuels or fire accelerants is not proposed;
- The area to be lit and supervision is one way of managing or controlling the potential extent of impacts, by limiting the volumes of smoke produced and the dimensions of the ensuing smoke plume;
- Burning would only occur when prevailing wind direction is blowing away from town and nearby residents. Burning would not be conducted when prevailing winds are in the direction of nearby residences or when meteorological conditions do not allow proper dispersal of smoke;
- Burning would not be scheduled after rain;
- A communication strategy for keeping the community informed about when vegetation burning is scheduled would be implemented;
- Prior to any burning, the NSW Rural Fire Service would be consulted; and
- All burning operations would be supervised.

8 Soils, Landform Stability and Erosion Hazard

8.1 Introduction

This Chapter considers the impacts of the Proposal on soil erosion and sedimentation and river bed and bank stability. It discusses existing baseline conditions at the study area, assesses the impacts and describes management and mitigation measures.

Table 8-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 8-1 EIS Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Assessment of the impacts of the activity (both construction and operation) on geomorphology. ◗ Details of impacts of proposed works on soil erosion and sedimentation, including mitigation measures during construction through to permanent site stabilisation and any revegetation. ◗ Assessment of soil quality, in particular potential disturbance and subsequent management of Acid Sulfate Soils (ASS) or potential ASS during construction. ◗ The effect of the development or activity on soil erosion and the silting up of rivers or lakes.	Sections 8.4.2 Section 8.3.1 Section 8.3.1
NSW Department of Industry and Investment (DI&I) (formerly DPI)	◗ As the project involves clearing of a considerable area of land, the EIS would need to address methods to be employed to contain sediment, nutrients, and other materials associated with the works and prevent them affecting Bowra Creek.	Section 8.5.1.
Department of Environment, Climate Change and Water (DECCW) (formerly DECC)	◗ *Soils and Contamination*; baseline conditions, assess impacts and describe management and mitigation measures.	Sections 8.2.2, 8.4.3, 8.5.4.

8.2 Methodology

8.2.1 Geomorphology

Site assessments were undertaken at a number of key locations within the study area. Sites were chosen to provide a good overview of the character and condition of the different reach

types evident within the study area from aerial imagery. Two geomorphologists completed the site investigations and took note of the following factors:

- Channel confinement and planform;
- Channel geometry;
- Instream deposits;
- Bank shape;
- Channel stability;
- Vegetation associations; and
- Land use.

8.2.2 Contaminated Land

The following scope of work was undertaken by GHD as part of the EIS. The scope of this Preliminary Site Investigation (PSI) did not include soil or groundwater sampling or analysis.

Desk-top Study and Site Inspection

- A review of aerial photographs from 1956, 1967, 1980, 1991, 1997 and 2003;
- Review of Department of Industry and Investment (DI&I) records, DECCW Significant Risk of Harm register and NSC records;
- Review of geology, DECCW groundwater bore database, hydrology and topography information for the site;
- An inspection of the sites of concern identified and surrounding land-uses documenting site features; confirming features documented in the desktop review and inspecting for signs of contamination or potential contamination activities; and
- Preparation of a report summarising the results of the site investigation and provision of recommendations for further investigations (if required) during detailed design.

The PSI was carried out in general accordance with:

- National Environment Protection Measure (Assessment of Site Contamination) (NEPC, 1999);
- Contaminated Sites: Guidelines for Assessing Service Station Sites (NSW EPA, 1994);
- Contaminated Sites: Sampling Design Guidelines (NSW EPA, 1995); and
- Guidelines for Consultants Reporting on Contaminated Sites (NSW EPA, 1997).

8.3 Existing Conditions

8.3.1 General Study Area

Geology and Landforms

The Dorrigo-Coffs Harbour 1:250,000 Geological Series Sheet SH56-11, shows that the study area is underlain by the Lower Permian aged metasediments of the Nambucca Beds, typically

comprising of slate, phyllite, schistose sandstone, schistose conglomerate and basic volcanics. The observed soil cover includes recent alluvium in the valley floodplain areas and colluvium and residual soil on the valley side slopes and ridges.

Topography

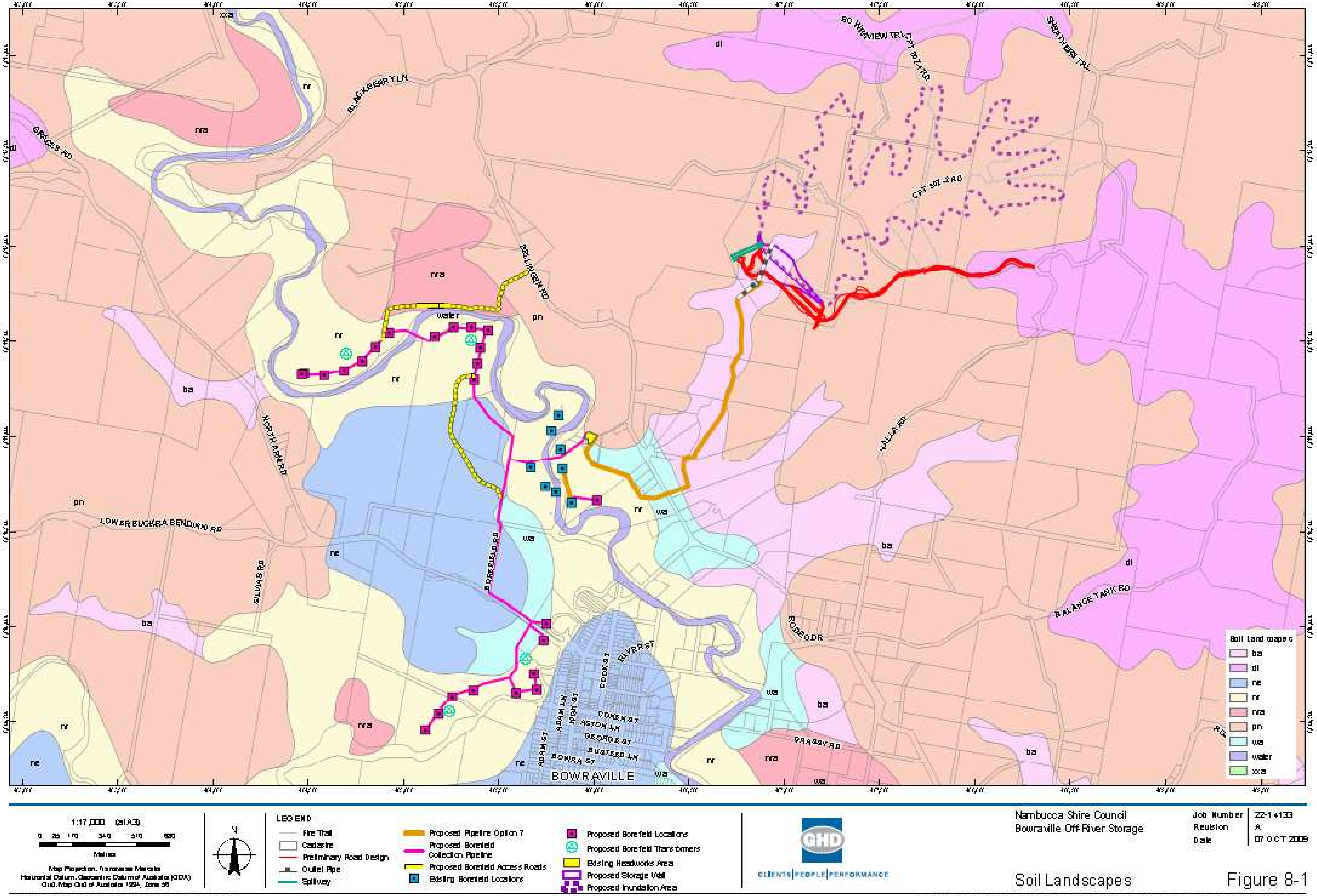
The broader catchment area rises abruptly from 50 to 150 m Australian Height Datum (AHD), with especially steep slopes to the west of the study area. The majority of the Bowra Creek catchment ranges from 20 to 60 m AHD with numerous moderately steep gullies and slopes in the upstream catchment. The area between Bowra Creek and the Nambucca River is undulating with average elevations of 10 – 20 m AHD. The Nambucca River floodplain and South Creek are low lying with elevations in the order of 10 m AHD.

Soil Types

Based on Eddie (2000), six (6) soil landscapes occur across the study area. These are mapped in Figure 8-1 and their characteristics are summarised in Table 8-2.

Table 8-2 Soil Landscapes in the Study Area

Soil Landscape	Description	Erosion Risk
Nambucca River	Low relief alluvial floodplain and terrace surfaces (slopes <5%) consisting of unconsolidated sandy loams and gravels.	◗ Low to moderate risk of sheet erosion on terraces; ◗ High risk of rill erosion on exposed banks; and ◗ High risk of gully erosion on unstable surfaces.
Warrell Creek	Gently undulating alluvial terraces (slopes 3 – 15%) consisting of red ferrosols.	◗ Low to moderate erosion risk due to moderate erodibilty and low slopes; and ◗ Low susceptibility to gully erosion.
Bowra Creek	Low relief alluvial fans and footslopes (slopes 1 – 5%) consisting of alluvial soils derived from upslope erosional metasediment landscapes.	◗ Low surface relief and high organic matter content results in low erosion risk for surface soils; ◗ Dispersible subsoils have a moderate to high erodibility when exposed.
Die Happy	Steep, dissected hills landscape with slopes of 33 – 50%, consisting of stony kurosols developed on metasediments.	◗ Severe sheet erosion risks due to high erodibility and steep slopes; ◗ High risk of gully erosion where drainage is concentrated.
Pine Creek	Rolling hills with slopes of 20-33%, consisting of stony kurosols developed on metasediments.	◗ Moderate to high sheet erosion risk of top soils when ground cover has been removed due to steep gradients and friable soils; ◗ Moderate to high risk of gully erosion where drainage is concentrated.
Newry	Undulating rises and hills (slopes 5 – 10%), with brown kurosols developed on metasediments.	◗ Moderate to high rill erosion risk of top soils when ground cover has been removed; ◗ High risk of gully erosion where drainage is concentrated.



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Soil Landscapes

Figure 8-1

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Acid Sulfate Soils

Given the general elevation and the soil types within the study area, no acid sulfate soils were identified within the study area (refer to Figure 8-2 Contaminated Land and Acid Sulfate Soil). No further assessment has therefore been undertaken in relation to cid sulphate soils.

Contaminated Land

Figure 8-2 Contaminated Land and Acid Sulfate Soil)summarises the areas of potential environmental concern (AEC) based on the results of the desk-top review, interviews and site inspection.

Table 8-3 Outcomes of Desk-top Review

Description	Rationale/Details	Potential Contamination
Fill Material	◗ Imported fill used to construct access roads within the storage area and along the pipeline. ◗ Imported fill may have also been used in the construction of some of the dwellings within the site.	◗ PAHs, TPH, BTEX, heavy metals, OCPs, OPPs, phenols, asbestos and PCBs
Agricultural land	◗ Herbicides and/or pesticides may have been used on the agricultural land. ◗ Fuels, oils, greases and agricultural chemicals ◗ Buried waste	◗ TPH, BTEX, heavy metals, OCPs, OPPs, phenols and PCBs.
Dwellings	◗ Herbicides and/or pesticides may have been used around dwellings within the site. ◗ Asbestos and lead paint may have also been used in the construction of the dwellings within the site.	◗ Lead, arsenic, PAHs, OCPs, OPPs and asbestos
Illegal dumping	◗ There is a potential for indiscriminate illegal dumping to have occurred within the study area.	◗ PAHs, TPH, BTEX, heavy metals, OCPs, OPPs, phenols, asbestos and PCBs

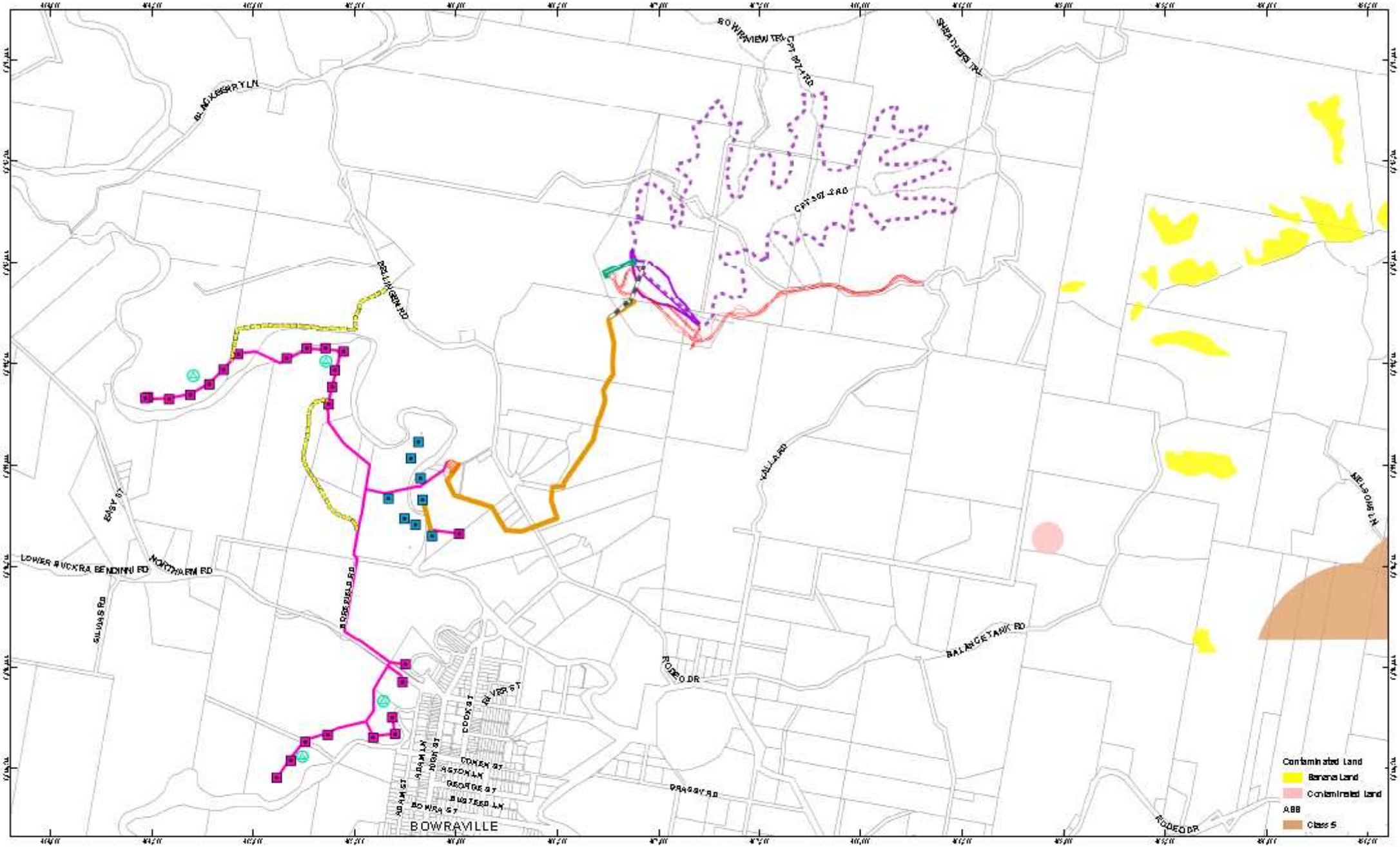
The PSI was undertaken to establish potential past site usage and identify and locate any potential past contaminating activities at the site.

The study area is primarily used for agricultural and forestry purposes. The agricultural purposes are predominately beef and dairy cattle.

GHD identified the following past and current activities as having occurred on or adjacent to the site as having the potential to contribute to on-site soil and groundwater contamination:

- Fill material used in the construction of roads and residential dwellings;
- Previous and current agricultural activities;
- Potential asbestos bearing materials and lead-based paint in dwellings; and

- Potential indiscriminate illegal dumping around Monitoring Bore 7. Water quality sampling was undertaken by Hydroilex (2009) from select monitoring bores along the Nambucca



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Contaminated Land and Acid Sulphate Soils

Figure 8.2

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Data Source: Department of Lands: Cadastre, Aerial - 2007; Nambucca Shire Council: LEP - 2007; DECC: Soil Landscapes - 2004. Created by: tmackay, vmoore

River. The results in Table 14 from Hydroilex report, for Monitoring Bore 7 (within Lot 1941, DP 829142), showed extremely high results for many parameters when compared to the Australian Drinking Water Guidelines (ADWG) 2004 including lead - dissolved (71µg/L), aluminium - dissolved (45,000 µg/L), manganese - dissolved (4,300 µg/L). Parameters such as pH, turbidity, total suspended solids and electrical conductivity also returned higher than expected readings above the ADWG 2004. Whilst this was a one-off sample, further sampling at this location would be undertaken to confirm the above results.

8.3.2 Nambucca River

The Nambucca River is characterised by a moderately sinuous channel planform with an approximate slope of 0.002 m/m. The channel flows through a valley approximately 200 to 300 metres wide. This wider valley setting means floodplains are often present on both sides of the channel. The channel through this reach is approximately 30 to 50 metres wide on straight sections and 50 to 80 metres wide on bend apexes. The channel exhibits steep banks and is characterised by a series of deep pools (~0.5 – 1.5m deep) separated by vegetated riffle zones. Cobbles and gravels have been deposited within the channels, particularly within the riffle zones.

Hydroilex (2008) undertook a geomorphic process study and risk assessment of the lower Nambucca River and South Creek as part of a borefields investigation. The key findings of this study are summarised as:

- The river has undergone significant alteration since European settlement through channel entrenchment (bed lowering) and widening, increasing the flow capacity of the channel;
- The river is susceptible to ongoing lateral instability through channel widening, meander cut-offs and meander migration. Key locations subject to these processes within the study area were identified by Hydroilex (2008);
- The river has the potential for future bed instability through the formation and upstream migration of knick points. Knick point formation can develop through changes in sediment and/or flow regimes, direct channel impacts (eg vegetation clearing, removal of woody debris, crossing constructions) or changes in the channel planform (shortening of channel length through meander cut-off processes leading to a steepening of the bed profile); and
- Several lower-lying floodplain surfaces exist along the channel and are prone to potential floodplain stripping during moderate to high flow events (i.e. > 5 year ARI).

Site Investigations

Based on the review of Hydroilex (2008), potential infrastructure locations and aerial imagery, a number of key sites along the Nambucca River and South Creek were selected for field investigations. These sites are described below.

- Site 1 -Nambucca River (Lot 8 DP253386) – The channel of the Nambucca River at this point has defined bed and banks, continuous flow and a riparian zone dominated by Camphor Laurel. There was no evidence of any infrastructure within the channel zone or any stability works. On the outside of each meander bend, there is mass bank failure of a significant degree. The outside banks are approximately 10m in height with the eroding sections between 10 to 15m in length.

- Site 2 - Nambucca River (Lot 326 DP777074) – At this location, the existing borefield pipe crosses the Nambucca River. Due to its positioning within the river and concrete casing, large amounts of bed load debris, mainly gravel and some woody, have been trapped against the pipe. It now acts as a weir with water pooling upstream of the pipe and a deeper hole immediately downstream. Water depth immediately upstream is approximately 1.5m deep. The inside bank of the meander, immediately upstream of the pipe crossing the river banks are high (approximately 2-3m) and steep with stabilisation works, in the form of medium to large loose boulders lining the banks. At the point where the pipe crosses, rock gabion baskets have been placed to prevent bank erosion and downstream of the crossing point, more loose boulders have been placed which may be mitigating the undermining/undercutting of banks.
- Site 3 - Nambucca River (Lot 4 DP786358) – At this point along the river a flood channel appears on the right hand side of a large meander bend. This feature has been created by means of high velocity flood flows scouring a more direct path through the flood plain. In the aerial photo, this feature is devoid of vegetation. However the field investigation revealed that there has been recent mitigation works undertaken at this point. The works consist of native plant revegetation throughout the flood channel, fill material within the re-entry end of the channel to a height consistent with the flood plain and bank stabilisation works (coarse debris) in the Nambucca River throughout the meander bend.
- Site 4 - Nambucca River (Lot 463 DP710439) – At this point of the channel there is a confluence with an ephemeral gully. The natural flows of this feature have been modified by the presence of a large dam, reducing all but high flow events utilising this drainage line. At the entry point there is an area of instability in the form of lateral erosion of approximately 5m in length, with no evidence of any bank protection works in place. The riparian zone at this point consists largely of dense Lantana.
- Site 5 - South Creek (Lot 3 DP612962) – There is potential for the proposed borefield pipeline to cross South Creek at this point. The channel currently showed poorly defined bed and banks with a low, discontinuous flow, camphor laurel, lantana and privet throughout the riparian zone and no infrastructure works. There was evidence of channel instability in the form of undercutting resulting in vegetation collapse within the channel zone.

These site investigations confirm the findings of Hydroilex (2008) that the lower Nambucca River and South Creek have undergone significant post-European settlement change and are still experiencing adjustments, largely through lateral migration of outside bends. However, there are also risks of potential meander cut-offs and bed lowering.

8.3.3 Bowra Creek

At the confluence with the Nambucca River, Bowra Creek has a catchment area of approximately 775 hectares. The catchment area at the proposed storage embankment is approximately 238 hectares. Upstream of the proposed storage embankment, the catchment of Bowra Creek is largely well vegetated and supports forestry operations. The creek channel is largely confined within the valley sides and has limited capacity for lateral and vertical adjustments.

Downstream of the proposed storage embankment, Bowra Creek can be characterised as a partly confined, bedrock controlled fine grained system. This reach is characterised by a relatively straight channel planform with an approximate slope of 0.005 m/m. The valley is generally less than 50 m wide and is dominated by bedrock. This wider valley setting has allowed floodplains to develop such that the channel is generally bounded by bedrock on one bank and alluvial deposits on the other. As a result the channel has some potential to adjust laterally via expansion through erosion of the alluvial channel margin.

Instream geomorphic features consist largely of pools separated by channel sections where a small low flow channel is inset within the broader channel by vegetated bar/bench features. Bars and banks typically consist of fine grained cohesive sediments, however, on some exposed banks, lenses of sand and gravel are present.

Riparian vegetation along the creek is generally continuous, albeit relatively narrow and, in places, dominated by the exotic Camphor Laurel.

At the location of the proposed transfer pipeline crossing, the channel is approximately 2m wide and 0.5-1m deep, low lying, has defined bed and banks, slow continuous flow and a continuous riparian zone consisting largely of Camphor laurel. The eastern bank at this point has sections of undercutting, adjacent to the Camphor laurels, resulting in one larger tree being uprooted. Further downstream, the western bank steepens with undercutting and bank slip/erosion was observed.

8.4 Impact Assessment

The assessment of potential impacts of the Proposal on landscapes, geology, soils, groundwater and soil contamination have been divided into impacts that could potentially occur during the construction and operational phases of the Proposal.

Potential construction phase impacts to landscapes, geology and soils are those that could occur during the construction of the proposed transfer pipeline, borefield and collection system, storage embankment and associated infrastructure. Mitigation measures would be implemented to minimise the potential construction impacts.

Potential operational phase impacts to landscapes, geology, soils, groundwater and soil contamination are, in general, likely to be minimal as mitigation measures to address these impacts have been incorporated into the design of the Proposal.

8.4.1 Geology and Soils Impacts

Bores, Borefield Pipelines and Power Supply

Bores would be installed at identified locations adjacent to the Nambucca River and South Creek to a depth of between 10 and 15 metres. To link the borefields with the existing headworks and the storage transfer pipeline, a borefields collection pipeline would be constructed. This would involve excavation of a trench within the alluvial soils to average depths of approximately 3 m below ground level. It is expected that the excavation of soils could be undertaken using conventional earthmoving equipment and / or trench excavating equipment. Excavated soils would likely be temporarily stockpiled and reused for backfilling and

landscaping of the pipeline trench to pre-existing ground levels. The backfilled trench would be immediately stabilised, rehabilitated and revegetated.

The existing local area power supply would be extended to provide power to the bore pumps. The arrangement would involve:

- Placement of two additional transformers to supply power to the proposed bores along the Nambucca River; and
- Placement of two additional transformers to supply power to the proposed bores along South Creek.

The transformers would be placed on poles and connected to the existing power grid via overhead lines. Underground cabling would link the transformers to the each of the individual bore pumps. Cables would be at a minimum depth of 500 mm. This would involve excavation of trenches of up to 1 metre wide and 0.7 metres deep. Excavated soils would likely be temporarily stockpiled and reused for backfilling and landscaping of the trenches to pre-existing ground levels. The backfilled trench would be immediately stabilised, rehabilitated and revegetated.

Transfer Pipeline

The construction of the transfer pipeline would involve soil excavations, stockpiling of soils, and significant vehicle traffic along the pipeline route and land access points. Excavated soils would likely be temporarily stockpiled and reused for backfilling and rehabilitation of the pipeline trench. Where possible and appropriate, excess spoil would be reused on the allotments in areas impacted by erosion. Excavating and stockpiling of soils potentially exposes the soils to increased risks of wind and water erosion.

The transfer pipeline traverses the Warrell Creek and Bowra Creek soil landscapes. As detailed in Table 8-2, both Bowra Creek and Warrell Creek soil landscapes generally have low erosion risks largely due to the limited relief in these landscapes. As a result, there is a low potential for soil erosion and sedimentation of surface water and gully erosion to occur as a result of ground excavations and disturbance with this option. Hence, if the proposed mitigation measures are implemented, then the potential impacts would be minimised.

Access Roads

Access to the Headworks and Borefield

The current borefield is located in an area approximately 700m x 400m along Nambucca River approximately 1 km north of Bowraville. The borefield straddles both sides of the river.

Vehicular access to the eastern side is via Bellingen Road to a laneway 750m north of High Street and the headworks is 200m west toward the river. The headworks is adjacent to the existing borefield.

Access to the western side of the borefield is via High Street, North Arm Road and Borefield Road. Five additional borefield localities have been identified to augment the supply to the Proposal. One is located partly on the eastern side of the existing borefield. Access to the enlarged borefield area would be via existing routes.

Two are located within 1.5 km north of the existing borefield on Nambucca River and would be accessed via Bellingen Road. If a permanent access to the northern area is proposed off

Bellingen Road the access point on Bellingen Road would be assessed for sight distances in accordance with AS 2890.1 as for a property access.

Two borefields are located within 1.6 km south of the existing borefield along South Creek. Access to the southern borefield would be via High Street and North Arm Road to the western side of South Creek. A new access off North Arm Road is also expected to be required and would need to meet sight distance requirements noted above.

Proposed Access Route to the Storage

It is proposed to gain access to the storage via Valla and Bobo Roads. Bobo Road would be upgraded to provide for better construction vehicle access to the storage and once operational, would also provide for visitors to the storage. It is proposed that Bobo Road be upgraded to a 6 metre wide formation with a 3 metre wide bitumen seal. The vegetation clearing and associated earthworks associated with this upgrade has the potential to leave large areas of disturbed sol exposed to wet weather. This in turn could result in erosion of those areas together with the generation of sediment laden stormwater runoff. Measures to divert clean water and direct sediment laden water into sediment control devices are detailed in Section 8.5. .

Storage

Key activities involved in the construction of the storage that are likely to have impacts on soils and landforms include:

The bulk of the storage construction activities are located on steep slopes (10 to 15%) within the Pine Creek soil landscape. From Table 8-2, this soil landscape has a moderate to high risk of sheet erosion where ground cover has been removed and a moderate to high risk of gully erosion where drainage is concentrated. Hence, given that the construction activities of the storage would be undertaken on and adjacent to Bowra Creek, there is a high risk of erosion within the disturbed area during rainfall events and the subsequent transport of sediments into the downstream creek environment. Mitigation of this impact would require careful planning and design of construction staging, creek flow detention and diversion structures and erosion and sediment control measures and practices. Stringent adherence to the erosion and sediment control plan and regular monitoring of erosion and sediment control measures and practices would be required during the construction phase.

Clearing of the vegetation within the inundation area is proposed. Again, much of this area is located within the Pine Creek soil landscape on moderate to steep slopes. Hence, disturbance of the ground cover in the inundation area carries a high risk of soil erosion during rainfall events and the subsequent transport of sediments into the downstream creek environment. To mitigate the risk of this impact, it is proposed that clearing of the immediate riparian areas within the inundation area be undertaken only once the coffer dams have been constructed. This would allow the coffer dams to act as a flow detention and sediment trap in the event of a significant rainfall event.

8.4.2 Geomorphology Impacts

Borefields and River Stabilisation Works

Several borefield layout options were considered based on different configurations of bore locations within the floodplains of the Nambucca River and South Creek. The proposed

borefield layout involves construction of 15 additional bores along the Nambucca River and 9 bores along South Creek.

The constructed bores would have limited surface expression, involving a concrete bore head and pump housing covered with a steel lid at ground level. As a result, the constructed bores would not alter localised flood flow hydraulics and are therefore not expected to increase the propensity for the scour of floodplain soils during flood flows.

In respect to the river stability risks as detailed in Hydroilex (2008) and contained in Appendix B, most bores along the Nambucca River are proposed to be located on higher floodplain surfaces and generally at a distance of at least 50 metres from the channel banks. This limits the risk of damage to or loss of bores due to future channel adjustments. As a result channel stabilisation works are not currently required to protect bores from future channel lateral adjustments. Monitoring of Nambucca River channel adjustments and assessment of erosion risks to bores following large floods is proposed, especially along the true right (eastern) bank in the vicinity of Bores 16 and 17 and the concave true left bank to the south of Bore 4.

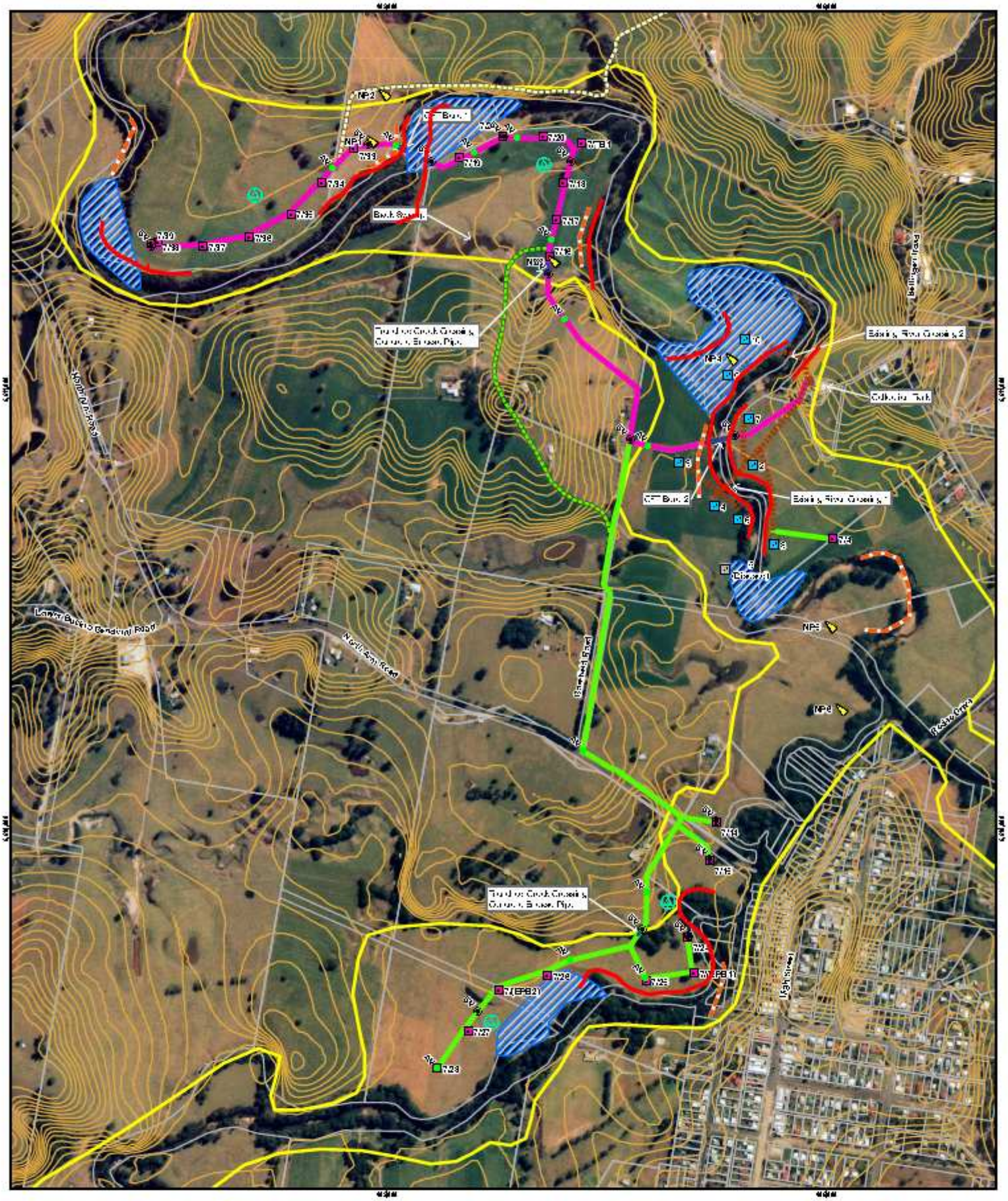
Along South Creek several bores, namely bores 7/24 and 7/25, are located within 20 metres of the bank. While these areas were not considered by Hydroilex (2008) to be at risk of potential river instability, it is proposed that this be reassessed during the detailed design phase and stabilisation works be designed and implemented if required in these locations in line with the design concepts developed by Hydroilex and documented in Appendix B.

Borefield Operation and River Geomorphology Impacts

The abstraction of water from the alluvial aquifer through the operation of the borefields has the potential to impact on river flow quantities within the lower Nambucca River and South Creek. The adopted environmental flow rules together with the implementation of an adaptive management framework would enhance the management of environmental flows. From a geomorphic perspective, the abstraction of water is expected to have a limited to negligible impact on sediment transfer and bank stability as the abstraction quantities are small compared to the flows required to maintain fluvial transport and channel form particularly given adopted environmental flow rules. Whilst bank slumping can result from rapid drawdown of groundwater levels, maximum pumping regimes would occur when there are higher river flows and therefore extraction rates would be miniscule compared to the replenishment flows.

Typically, flows that maintain channel form are those that exceed at least half the bank full height of the channel. Along the Nambucca River such flows are equivalent to approximately the 1 in 1 Annual Return Interval (ARI) events with peak discharges in the order of 100 to 200 m^3/s. In comparison, the extended borefield would have a maximum capacity to abstract up to 57 ML/day, an instantaneous draw of 0.65 m^3/s. This indicates borefield operation would have negligible impact on sediment transport and channel form.

Site assessment observations confirm the findings of Hydroilex that the lower Nambucca River and South Arm have undergone significant post-European settlement change and are still experiencing adjustments, largely through lateral migration of outside bends. However, there are also risks of potential meander cut-offs and bed lowering. It is therefore proposed to undertake river stabilisation works at those locations identified in Figure 8-3 to ensure the borefields are protected from any future lateral movement or instability through channel widening, meander cut-offs and meander migration.



Gunnedah Shire Council
Gunnedah Effluent Storage

Geomorphologic Risk Areas

Job Number 22 14[illegible]
Revision A
Date 13 AUG 2009

Figure8-3

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Existing Borefield and River Crossings

The existing bores located on the true right bank floodplain are linked to the existing headworks via a bed level pipeline crossing. Some of the bores within the existing borefield are located within 20 metres of the channel bank and have the potential to be impacted by future flood events. Bank erosion is also evident adjacent to the existing pipeline crossing. This structure comprises a concrete encased pipe with loose rock placed on the downstream side to restrict scour (Figure 8-3). A vertical drop of approximately 1 to 1.5 metres is exhibited across the overall structure. As a result, the structure acts as a key bed control, maintaining the level of the channel bed in the immediate upstream reach. Hence, given the propensity for the channel to undergo vertical adjustments (Hydroilex, 2008), it is proposed that the crossing be retained.

However, in its current form the structure presents a significant impediment to fish passage, such that during low flows the upstream pool level is considerably lower than the crest of the structure (Hydroilex, 2008). It is considered that making the structure more impermeable to allow low flows to overtop the structure is unlikely to improve this situation, as flows within the upstream pool are likely to be diverted laterally to the broad alluvial aquifer.

Instead, to improve fish passage, it is proposed that a fish passage structure and bank revetment works be installed on the true left (western) bank to allow fish to bypass the existing pipeline crossing obstruction in line with the concepts developed by Hydroilex and detailed in Appendix B. Further development of the design for a fish passage and bank revetment would be undertaken in conjunction with the river stabilisation design during the detailed design phase of the Proposal.

Consultation would be undertaken with Department of Industry and Investment, Northern Rivers Catchment Management Authority and Nambucca Valley Landcare during the design of the proposed fish passage and bank revetment.

Figure 8-4 Existing Pipeline Crossing

The borefields collection pipeline would cross the Nambucca River at two locations and would be constructed using trenchless techniques. To enable the trenchless crossing, two 5 metre diameter shafts would need to be excavated either side of the river channel for both the launch and the receival of a closed face tunnel boring machine. Spoil generated would be returned through slurry pipelines to the surface and then to settlement tanks. Following installation of the pipeline, the launch and receival pits would be backfilled to pre-existing ground levels with appropriate soil materials.

Excess soil material would also be generated through drilling for bore placement and excavation of the launch and return pits for the directional drilling of the waterway crossings for the borefields collection pipeline.

The borefields collection pipeline would also cross several smaller waterways. Here, standard open trenching would be employed.

The above excavations and construction activities are located within the low erosion risk Nambucca River soil landscape and there is a low risk for soils and sediments to be transported off site during normal flow conditions. However, there is the risk of transport of additional sediment downstream from disturbed sites during flood events. Hence, careful management during the construction phase would be required to ensure that soils are exposed for the shortest time practical and no materials are stockpiled within the influence of flooding. In this case, the construction of the additional borefields, power supply infrastructure and the collection pipeline would only have temporary and mitigable impact on soils, landforms and waterways.

Bowra Creek

Pipeline Crossing

The transfer pipeline would cross Bowra Creek via the existing vehicle access crossing. Whether the pipe is attached to the side of the bridge, laid in the road with concrete encasement or would pass under the culverts would be determined in detail design. In any case, the impact on Bowra Creek would be temporary and limited to minor disturbance of the creek banks. Such impacts can be easily mitigated using standard erosion and sediment control practices during construction and appropriate reinstatement and rehabilitation of creek banks following construction. Hence, the impact on Bowra Creek is considered of low significance and short duration.

Downstream Storage Impacts

The following potential impacts associated with the operation of the storage on the downstream morphology of Bowra Creek have been identified:

- Altered hydrological and sediment regimes;
- Channel scour immediately downstream of the outflow due to flow jet from outlet pipe.

These resulting impacts associated with the above are discussed in the following sections.

Altered Hydrological and Sediment Regimes

Construction of the storage would impede the transfer of flow and sediment along Bowra Creek. In respect to flows, it is proposed for the storage to transparently pass all flows derived from the upstream catchment. However, infrastructure constraints would limit the ability to pass flood

flows transparently such that events have a natural hydrograph. The current proposed outlet/inlet pipeline to the storage is estimated to have a maximum outlet capacity of 3.47 m^3/s. In comparison, the peak discharge within Bowra Creek at the storage embankment for the 1 in 1 year natural flow event has been estimated to be 6.8 m^3/s using the Probabilistic Rational Method. In addition to these transparent flows, two additional annual releases are proposed to limit the potential for vegetation encroachment and sedimentation within the pool environments of the creek. Releases would occur during the higher rainfall seasons to ensure that there are no ecological impacts on downstream aquatic fauna. Further details regarding potential impacts on aquatic fauna are documented in Chapter 9 – Aquatic and Terrestrial Flora and Fauna.

The storage would trap all sediment derived from the upstream catchment, reducing the long term sediment yield to the Nambucca River. However, as Bowra Creek is essentially a fine grained system and the affected area (238 hectares) is small compared to the overall catchment of the Nambucca River, the impact of the reduced sediment load on the Nambucca River would be negligible.

Channel Scour Downstream of Outlet and Spillway

Channel scour may be experienced immediately downstream of the storage as a result of high velocity flows from the outlet and during spillway operation. This would result in morphological channel changes and release of sediment to downstream reaches. This impact can be mitigated through placement of flow dissipation structures and channel protection works.

8.4.3 Contaminated Land Impacts

GHD has identified that past and current activities within the study area have the potential to contribute to on-site soil and groundwater contamination. Generally these relate to the use of pesticides and insecticides associated with agricultural practices. Consideration would need to be given to the removal and relocation of excavated soil from one place to another to avoid spreading potentially contaminated soil. Of particular concern are the results of the water sampling at Monitoring Bore 7. Whilst this was a one-off sample, it may suggest indiscriminate illegal dumping at this location and therefore further sampling would be undertaken to confirm the Hydroilex results.

8.5 Mitigation Measures

8.5.1 General

Appropriate measures can be adopted to minimise or eliminate potential impacts associated with the geological and soil conditions at the sites of the pipeline routes, storage, borefields, access roads and associated infrastructure. These measures are outlined in the following sections and are to be incorporated into an EMP for the Proposal.

Sediment and Erosion Control Plan

A site Sediment and Erosion Control Plan would be prepared (and incorporated into a Construction Environmental Management Plan). The Sediment and Erosion Control Plan would be developed in accordance with the requirements of the 'Blue Book' (Managing Stormwater: Urban Soils and Construction, NSW Department of Housing).

The Sediment and Erosion Control Plan would have the following structure:

- Site characteristics – including existing contours, limitations of the site's soil type and climatic data including rainfall;
- Clearing and disturbance of the site – nature and extent of proposed ground disturbance, final contours and location of any temporary soil stockpiles and visual screening mounds;
- Existing and proposed drainage patterns – including existing surface water drainage paths and proposed drainage design;
- Erosion control practices – including the location and design of erosion control measures and the monitoring and maintenance of these control structures. Erosion protection measures would be implemented to minimise the potential for erosion of soils from the proposed development. Provided these measures are adequately implemented and maintained it is unlikely that any significant erosion would occur following excavation of soils and disturbance of ground areas. Controls would be implemented before any construction commences and inspected regularly particularly after a rainfall event;
- Sediment control practices - including the location and design of sediment control measures and the monitoring and maintenance of these control structures. Controls would be implemented before any construction commences and inspected regularly particularly after a rainfall event; and
- Rehabilitation program – including the revegetation of landscaped areas and visual mounds.

Erosion and Sediment Control Practices

Sediment and erosion control practices and measures would include:

- The location of site compounds would consist of existing cleared areas and, where possible, on the right of way in order to minimise disturbance;
- All cut and fill batters would be protected from run-off and stabilised immediately following construction;
- Permanent drainage structures would be installed with sediment traps at completion of initial earthworks;
- Where possible 'clean' surface water would be directed away from disturbed areas to stable or stabilised discharge points;
- Upstream diversion drains and downstream sediment traps would be used to carry run-off away from disturbed areas;
- Where creation of sediment laden runoff cannot be prevented or where extracted groundwater cannot be discharged to existing surface waters, temporary sediment control ponds would be constructed to intercept sediment laden run-off and to trap and retain sediment; and
- Sediment traps would be placed in drainage lines to prevent sediment transport via surface water flows.

Soils and Spoil Management

The following management measures are made in regard to the management of soils and spoil during construction:

- Construction excavation activities would be limited to the original construction design to minimise the influence to geology and soils.
- The extent of exposed and unprotected areas would be limited by preserving existing groundcover;
- Construction practices would aim to eliminate the generation of excess topsoil (i.e. all topsoil would be used to rehabilitate the near surface ground following backfilling of the pipeline trench);
- Topsoil would be held in storage (preferably piled to one side of the trench) for the minimum possible time before being re-used directly on-site, preferably being replaced in its original location;
- Top soil would be seeded for the duration of storage, and silt barriers used whilst seeding is establishing;
- Where possible, topsoil would be recovered through the reuse of materials for remediation purposes. This would involve being spread evenly over the backfill material to reflect the final backfill contours;
- General spoil would be removed from the site and adequately covered during transportation to avoid wastage;
- Spoil would be stored stock-piled material with the appropriate covering and, if required, additional wind protection;
- Topsoil and spoil would be stockpiled separately to eliminate contamination through mixing;
- Stockpiles would not be placed in high water flow areas and would be protected by sediment control barriers or diversion drains;
- Where possible, spoil would be recovered through the reuse of materials for remediation purposes. Reinstatement would occur prior to hydrostatic testing of the installed pipeline, where practical;
- Following backfilling of the pipeline trench all disturbed areas would be seeded to promote stabilisation through revegetation, as soon as possible.
- Excess spoil materials would be utilised at other locations along the pipeline for remediation purposes, or utilised by landowners or NSC; and
- Disposal of spoil material, where inappropriate for reuse as an example, would be undertaken as a last resort.

Stabilised Access Point and Site Traffic

The following management measures are made in regard to the management of soils for site traffic and at site access points:

- The number of access points would be limited to one entry/exit point where possible;

- All access roads would be controlled on the site and vehicles and plant would be kept to well defined haul roads to minimise ground disturbance and compaction;
- Where there is more significant and heavier traffic, the use of a grid or vehicle wash bay would be considered to remove excess soil and dust before leaving the site. The grid or vehicle wash bay would be lifted and cleared out periodically; and
- Oil or fuel leakages from vehicles and equipment through regular maintenance would be minimised. Refuelling of vehicles would only occur in designated areas where spill containment and control equipment is stored.

Storage Construction and Clearing of Inundation Area

Given the high risk of soil erosion and the subsequent transport of sediment into Bowra Creek associated with the construction of the storage embankment and clearing of the inundation area, the following additional measures are provided to reduce this impact:

- Clearing of riparian vegetation within the inundation area would not take place until the coffer dams are complete to reduce the risk of transport of sediments into the downstream environment of Bowra Creek;
- Prior to construction, establish and stabilise temporary surface drainage, erosion protection and ongoing water quality management across the site through measures such as:
  - creek flow diversion structures, outfall protection and upstream and downstream detention ponds
  - temporary runoff barriers
  - sedimentation ponds
  - progressive rehabilitation as work stages are completed.
- Make provision for safety and site stability in the event the upstream detention basin is over-topped and the site is flooded;
- Regularly monitor turbidity levels within detention ponds;
- Ensure releases from the detention basins do not exceed set limits; and
- Ensure permanent surface drainage system avoids drainage concentration over disturbed areas. In the event this is not feasible, adequate permanent erosion protection and flow detention in the form of sedimentation ponds would be required.

Monitoring

As part of the Erosion and Sediment Control Plan, monitoring measures would be implemented and include:

- Regular monitoring on the effectiveness of sedimentation and erosion controls measures after significant rainfall;
- Regular monitoring on the effectiveness of erosion controls during construction would include inspection of sediment traps to ensure sediments are not transported off site;
- Regular water sampling of sedimentation ponds;
- Ensuring suspended sediments in released waters do not exceed set limits; and

- Monitoring of turbidity downstream of construction sites.

8.5.2 Nambucca River Mitigation Measures

The following sections outline mitigation measures to limit the identified impacts on soils, landforms and waterways from the construction and operation of the additional borefields, power supply infrastructure and the borefields collection pipeline.

Design and Construction Impact Mitigation

The following measures are made to mitigate identified impacts on soils and landforms along the Nambucca River and South Creek in respect to the design and construction of the Proposal:

- Avoid heavy vehicle movements across the floodplains soils following rainfall events;
- Vehicle access routes across the floodplain soils would avoid lower lying areas where water may pond for extended periods;
- Avoid or minimise disturbance of flood channel areas. Where soils within floodplain channels require disturbance, ensure the duration of construction activities are minimised as far as practical and rehabilitate the disturbed area as soon as possible after construction activities have ceased in the area;
- Limit the duration that trenches that run parallel to river flow are open;
- Soil material generated from bore placement, trenching and waterway crossing excavations would be transported to a storage area outside of the effects of flooding along the Nambucca River and South Creek;
- Avoid any disturbance or removal of riparian vegetation along the Nambucca River and South Creek;
- Avoid disturbance to the banks and bed of the Nambucca River and South Creek; and
- Implement appropriate erosion and sediment control practices and measures during construction as outlined in Section 2.4.

Operational Impact Mitigation

The following measures are made to mitigate identified impacts on soils and landforms along the Nambucca River and South Creek in respect to the operation of the Proposal:

- Implement identified stabilisation works in conjunction with DI&I, NRCAM and Nambucca Valley Landcare (see Appendix B);
- Maintain the existing pipeline crossing across the Nambucca River and retrofit to provide fish passage;
- Monitor fish passage and stabilisation works through visual inspections following flood events equivalent to the 1 in 1 year ARI or greater.

8.5.3 Bowra Creek Mitigation Measures

The following measures are made to mitigate the identified operational impacts of the storage on the downstream geomorphology of Bowra Creek:

- To avoid scour immediately downstream of the proposed outlet, placement of a flow dissipation structure and channel protection works may be required;
- To limit the potential for vegetation encroachment and sedimentation within pool environments of Bowra Creek, it is proposed that maximum capacity outflows with durations of several hours be released from the storage twice yearly during the flood season. The success or otherwise of this measure is difficult to predict as the potential channel adjustments are dependant on a range of variables that cannot be readily quantified. Hence, it is proposed that an adaptive management framework be implemented to inform the management of flow releases based on a monitoring program that includes:
  - Monitoring of pool depths;
  - Monitoring of the bed and bank stability of the waterway; and
  - Monitoring of changes in the distribution of vegetation colonisation within the channel.

8.5.4 Contaminated Land

- It is proposed that further sampling be undertaken to confirm the Hydroilex results at Monitoring Bore 7 to confirm the results obtained from Hydroilex.
- Excavated soil proposed to be moved from one place to another would be verified to confirm it is not contaminated.

The Environmental Management Plan (EMP) for the Proposal would need to detail appropriate procedures for the handling, stockpiling and assessment of potentially contaminated fill and materials during the construction phase.

9 Terrestrial and Aquatic Ecology

The information in this Chapter is taken from 'Bowraville Off-River Storage and Associated Works, Aquatic and Terrestrial Flora and Fauna Assessment, prepared by GHD Pty Ltd, March 2009. An unabridged version of the report is provided in Appendix C, Volume 2 respectively.

9.1 Introduction

This Chapter identifies the potential terrestrial, aquatic and riparian flora and fauna impacts associated with the Proposal and the management measures to reduce these impacts. Table 9-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 9-1 Agency Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Assessment of flora and fauna impacts including a detailed description of land to be cleared for storage inundation area and any other proposed clearing of lands. The assessment must take into consideration impacts on any threatened species, population, ecological communities, any critical habitat, impacts on any groundwater dependent ecosystems (GDE) and the establishment and dispersal of environmental weeds. This assessment shall justify the need for any clearing of native vegetation and/or habitat features and would identify the need for any clearing of native vegetation and / or habitat features and would identify proposal for any compensating habitat/ biodiversity protection areas.	Sections 9.7 and 9.8
Department of Environment, Climate Change and Water (formerly DWE)	◗ Assessment of the impact of the altered flow regime on the health of the upper estuary. Development of a monitoring strategy that would detect changes to in-stream vegetation and / or salinity in the upper estuary. ◗ Assessment of the impact of the altered flow regime on the movement of native fish, in particular Australian Bass. ◗ GDE Dot point 5. ◗ Impacts on Bowra creek instream values. The above are specific assessment requirements there are also general EIS guidelines attached which identify other issues to be addressed with respect to flora and fauna eg vegetation clearing and management of retained vegetation, threatened species impact assessment etc.	Sections 9.8.3 and 9.8.4
Northern Rivers Catchment Management Authority (NRCMA)	◗ *Native Vegetation:* unless the vegetation being cleared is an EEC or in an over cleared Mitchell Landscape, the *Native Vegetation Act* (NVA) assessment process requires offsets depending on the classification of vegetation. As the proposal is considered under Part 5 of the EPA Act as meets the criteria of s25(g) and (h) of the NVA, NVA approval may not be required however,	Section 9.8.8

Statutory Authority	EIS Requirements	Where Addressed
	the provision of compensatory areas are recommended.	
NSW Department of Industry and Investment (formerly DPI)	◗ *Requirements for activities that block fish*; purpose and type of works proposed, timing, duration and manner of proposed blockage, methods to be used to avoid stranding fish and any remediation works ◗ *Requirements for activities that damage marine vegetation*; type of marine vegetation to be harmed; amount of marine vegetation to be harmed – map distribution noting percentage densities of species of marine vegetation; reasons for harming marine vegetation, methods of harming marine vegetation, construction details including proposed drainage, duration/timing of works, measures for minimising harm to marine vegetation, environmental measured to be employed and method and location of transplanting activities or disposal. ◗ *Requirements for Activities that Could Impact on Threatened Species or Contribute to Key Threatening Processes*; statement about the presence of threatened species, consideration of habitat types, discussion of condition of habitat within the area, assess potential impacts on threatened species via the 'Eight-Part Test' and consult with NSW Fisheries prior to finalising the EIS, where a significant impact is likely, a Species Impact Statement must be prepared and note the penalties under the *Fisheries Management Act 1994*. ◗ Identification of threatened species likely to occur in the area or be affected by the proposal. ◗ How damage to marine vegetation and other fish habitats would be minimised. ◗ Whether dredging, reclamation or activities that obstruct fish passage are proposed and if do, how impacts would be minimised ◗ As Nambucca River contains important habitat for many species with commercial and recreational values, the EIS must address methods used to minimise disturbance and impacts to fish habitat within lower Bowra Creek and the Nambucca River ◗ As the proposal involves pipeline infrastructure crossing Bowra Creek, the EIS would need to address methods for minimising harm to riparian vegetation and aquatic habitat associated with any crossing and detail dredge and reclamation works within the water land of Bowra Creek as defined by the *Fisheries Management Act 1994*. ◗ The EIS would need to address the extent to which fish passage is impacted upon by the construction of the pipeline crossing and design methods for constructing crossings and strategies for ensuring ongoing fish passage. ◗ The EIS would need to address the extent to which fish passage is impacted upon by the construction of the storage embankment including opportunities for works	Sections 9.4, 9.6, 9.6.5,9.8.5, and 9.8.6

Statutory Authority	EIS Requirements	Where Addressed
	providing connectivity between the storage and Bowra Creek.	
Department of Environment, Climate Change and Water (formerly DECC)	**Flora** An assessment of vegetation on the site must include: ◗ A comprehensive description of the vegetation on the site. This would include an assessment of the condition of the plant communities present, including the designation of conservation significance at a local, regional and State level, and an assessment of the likely occurrence of any threatened species, populations or ecological communities listed under Schedules 1 or 2 of the "Threatened Species Conservation Act 1995" and any Rare or Threatened Australian Plant (ROTAP) species. ◗ A plan showing the distribution of any threatened or ROTAP species and the vegetation communities on the site, and the extent of vegetation proposed to be cleared. This plan would be at the same scale as the plan of the area subject to development in order to assist in the assessment of the impact of the proposal on the existing vegetation. ◗ A statement about the degree of conformance with the DECC guidelines, "Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities – Working Draft 2004" and "Threatened Species Assessment Guidelines – The Assessment of Significance" (DECC August 2007) for surveys completed. This would include the adequacy and limitations of the survey efforts, timing and techniques used in determining results, in order to establish an appropriate level of confidence in the conclusions drawn. ◗ Where the assessment concludes that threatened species, populations or ecological communities, or their habitats, exist on or in proximity to the subject land, the effect of the proposed development would be determined in accordance with the Assessment of Significance described in Section 5A of the "Environmental Planning and Assessment Act 1979". An assessment of the impact of the development on the plant communities and/or ROTAP species would also be provided. ◗ A description of the measures proposed to mitigate and/or ameliorate the impact of the development on the plant communities, threatened and ROTAP species.	Sections 9.5, 9.4, 9.8 and 9.9
	Fauna An assessment of fauna on site must include: ◗ A fauna survey to identify the distribution and abundance of fauna species known or likely to utilise the site, including a description of available fauna habitats and an assessment of the conservation status of each of the faunal components at a local, regional and State level. ◗ A plan showing the results of the above survey. This	Sections 9.5, 9.4, 9.8 and 9.9

Statutory Authority	EIS Requirements	Where Addressed
	plan would be at the same scale as the plan of the area subject to development to assist in the assessment of the impact of the proposal on fauna. ◗ A statement about the degree of conformance with the DECC guidelines, "Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities – Working Draft 2004" and "Threatened Species Assessment Guidelines – The Assessment of Significance" (DECC August 2007) for surveys completed. This would include the adequacy and limitations of the survey efforts, timing and techniques used in determining results, in order to establish an appropriate level of confidence in the conclusions drawn. ◗ An assessment of the impact of the development on the identified fauna. ◗ An assessment of the existence or likely occurrence of threatened species, populations or ecological communities, or their habitats on the subject land. Where the assessment concludes that threatened species, populations or ecological communities, or their habitats exist on or in proximity to the subject land, the effect of the proposed development would be determined in accordance with the Assessment of Significance described in Section 5A of the "Environmental Planning and Assessment Act 1979". ◗ A description of the measures proposed to mitigate and/or ameliorate the impact of the development on fauna. **Surveys & Assessments** ◗ Surveys and assessments would be undertaken by suitably qualified persons and the qualifications and experience of the persons undertaking the work detailed. ◗ Dates, site locations, design, methodology, analysis techniques, and weather conditions at the time of the assessments and surveys must be described. The limitations of surveys would be identified and the results interpreted accordingly. ◗ Conclusions drawn in surveys and assessments would be substantiated by evidence resulting from those surveys and assessments. The document being supported by the surveys and assessments would reflect these conclusions and clearly state where recommendations of the survey and assessments have been incorporated in the proposal. ◗ DECC's Estuary Management Policy encourages integrated, balanced, responsible and sustainable use of State estuaries. In light of this Nambucca NSC has developed an Estuary Management Plan (EMP) covering Estuary Health, Climate Change and Riparian Land Management. The key points in the EMP are: ◗ Implications of altered freshwater flow regimes on extensive plant beds in the upper estuary and their role as critical habitat;	Sections 9.5, 9.4, 9.8 and 9.9

Statutory Authority	EIS Requirements	Where Addressed
	◗ Investigate implications of changed flow regimes on salinity patterns and its ecology; ◗ Intensification of droughts and sea level rise and resultant changes in the flushing and salinity regimes must be discussed in response to the tidal limit moving further upstream and potential implications on surface groundwater interactions and ecology; and ◗ Identify how riparian land is to be managed within the study area to improve overall riverbank condition including riparian habitats on all of the catchments steams.	

9.2 Scope of Assessment and Approach

Detailed terrestrial ecology and aquatic ecology surveys (including macroinvertebrate and fish surveys) were undertaken for the Proposal. The survey effort for this EIS comprised the following:

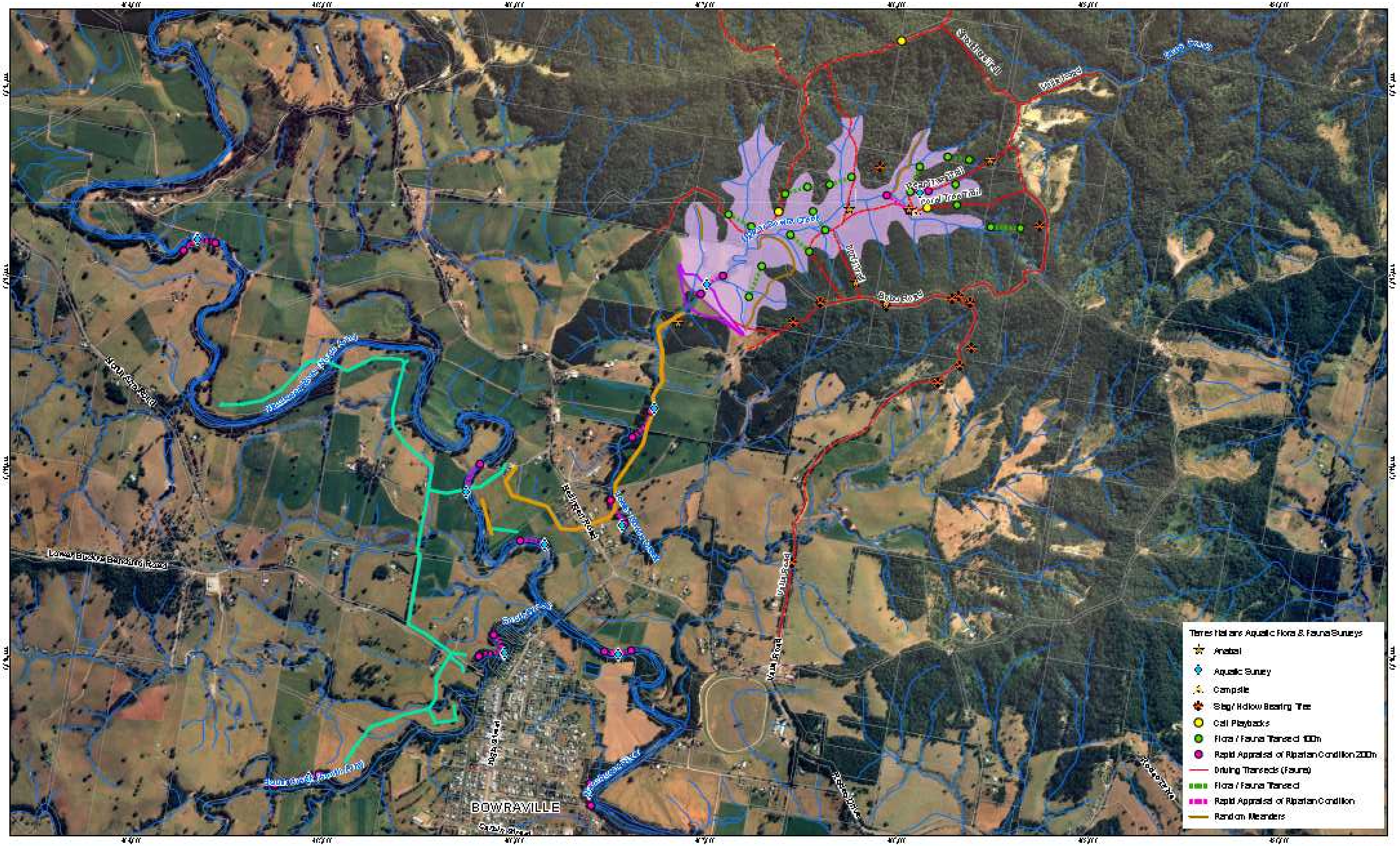
- Literature review of recent ecological assessments.
- Desktop database searches to identify potential threatened species and matters of National Environmental Significance in the locality.
- Field surveys of flora and fauna species, both terrestrial and aquatic, targeting threatened species known or likely to occur in the study area and their habitats.
- The findings of previous ecological assessments with updated database reviews were ground-truthed using various survey techniques appropriate to the ecological values identified in the searches and previous assessments.

All field investigation was undertaken with techniques which broadly follow DECCW's *Draft Threatened Biodiversity Survey and Assessment guidelines* (DEC 2004). Figure 9-1 shows the locations of the flora and fauna survey locations. The methods used are detailed in the Ecology report.

For the purpose of this assessment, the study area consisted of the proposed off-river storage inundation area, the riparian zones of three potentially impacted waterways (Nambucca River and, South and Bowra Creeks), the pipeline route, the existing and proposed borefields and Valla Road.

9.3 Terrestrial Flora

Where applicable, vegetation communities have been classified with reference to *North East New South Wales: Field Key to Forest Ecosystems* (DECCW, 2004). Communities that don't fit these classifications have been classified based on dominant canopy species and floristic structure (i.e. riparian vegetation dominated by Camphor Laurel and Small-leaf Privet). The survey locations in the inundation area were based upon covering the different vegetation communities, as depicted in Biosis's Figure 3 *Vegetation communities present in the study area* (Biosis, 2005). The survey locations of the current study are shown in Figure 9-1.



1:18,000 (at A3)

0 95 190 380 570 760

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Cadastre | Proposed Inundation Area | Proposed Pipeline Option 7
Creeks | Proposed Storage Wall | Proposed Borefield Collection Pipeline

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Nambucca Shire Council
Bowraville Off-River Storage

Job Number 22-14133
Revision A
Date 27 AUG 2009

Flora & Fauna Survey Locations

Figure 9-1

2115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: Generated by, Checked by: Checked by

The vegetation communities recorded are summarised in Table 9-2, whilst the survey locations are shown in Figure 9-1 above and details pertaining to each community are described below. Additionally Table 9-2 summarises the dominant canopy species, approximate areas to be impacted and condition assessment scoring for each vegetation community identified in the study area.

Table 9-2 Summary of Terrestrial Flora Survey Results

Vegetation Community Type	Dominant Species	Approximate Area (ha) that may be Impacted	Condition Assessment Scoring
Hardwood Plantation	Flooded Gum, Blackbutt and Broad-leaved Mahogany	27.45	Poor
Wet Flooded Gum – Tallowwood Forest	Flooded Gum with Tallowwood, Dunn's White Gum, Pink Bloodwood and Turpentine.	20.02	Moderate
Northern Wet Tallowwood – Blue Gum Forest	Tallowwood and Sydney Blue Gum with Brush Box, Blackbutt and Turpentine	7.85	Moderate
Foothills Grey Gum – Broad-leaved Mahogany Forest	Small-Fruited Grey Gum, Broad-leaved Mahogany, Grey Ironbark and Turpentine	7.16	Moderate
Wet Bloodwood – Tallowwood Forest (Temperate Rainforest)	Pink Bloodwood, Tallowwood, Small-Fruited Grey Gum and Blackbutt	0.64	Moderate
Pastureland	Common Paspalum and Kikuyu	13.55	Poor
Riparian Vegetation	Camphor Laurel, Small-leaf Privet and Lantana with scattered native canopy species	3.79	Poor

9.3.1 Inundation Area

The inundation area consists of remnant native forest on the upper slopes with managed plantation forest on the lower slopes and flatter ground associated with Bowra Creek. Descriptions of each forest community identified in the inundation area, as well as the plantation forest, are provided below.

Wet Flooded Gum – Tallowwood Forest

This community is classified as Ecosystem 154 Wet Flooded Gum - Tallowwood (DECCW, 2004) and is consistent with Forest Type 48 as described in Forestry Commission (1989). Wet Flooded Gum - Tallowwood Forest occurs along the upper southern facing slopes of the Bowra Creek catchment. This tall open forest had a canopy up to approximately 35 m in height. Approximately 20.02 ha of this vegetation community would be removed from the inundation area, as shown in Figure 9-2.

The dominant canopy species was Flooded Gum (*Eucalyptus grandis*), with Tallowwood (*E. microcorys*), Dunn's White Gum (*E. dunnii*), Pink Bloodwood (*Corymbia intermedia*), and Turpentine (*Syncarpia glomulifera*) making up the remainder of the canopy. The understorey included trees such as Blackwood (*Acacia melanoxylon*), Green Wattle (*Acacia irrorata*), Coachwood (*Ceratopetalum apetalum*) and Large Mock-Olive (*Notelaea longifolia*), shrubs such as Native Peach (*Trema tomentosa* var. *viridis*), Breynia (*Breynia oblongifolia*), Veiny Wilkiea (*Wilkiea huegeliana*) and Narrow-Leaved Palm Lily (*Cordyline stricta*), and climbers such as Twining Guinea Flower (*Hibbertia dentata*) and Five-Leaf Water Vine (*Cissus hypoglauca*).

Weed species included Lantana (*Lantana camara*), Camphor Laurel (*Cinnamomum camphora*) and Small-leaf Privet (*Ligustrum sinense*), which were present throughout the understorey. This vegetation was considered to be in **moderate** condition, because the understorey and groundcover was infested with weeds.

Northern Wet Tallowwood – Blue Gum Forest

This community is classified as Ecosystem 104 Northern Wet Tallowwood – Blue Gum (DECCW, 2004) and is consistent with Forest Type 47 (Forestry Commission, 1989). Northern Wet Tallowwood – Blue Gum forest occurs on west and north-facing slopes of the Bowra Creek catchment. This tall open forest had a canopy up to approximately 35 m in height. Approximately 7.85 ha of this vegetation community would be removed from the inundation area, as shown in Figure 9-2.

The dominant canopy species were Tallowwood and Sydney Blue Gum (*Eucalyptus saligna*), with Brush Box (*Lophostemon confertus*), Blackbutt and Turpentine making up the remainder of the canopy. The understorey included trees such as Forest Oak (*Allocasuarina torulosa*), Scrub Turpentine (*Rhodamnia rubescens*), Bangalow Palm (*Archontophoenix cunninghamii*), Jackwood (*Cryptocarya glaucescens*), Guioa (*Guioa semiglauca*) and Rough Treefern (*Cyathea australis*) and climbers such as Five-Leaf Water Vine (*Cissus hypoglauca*), Anchor Vine (*Palmeria scandens*) and Water Vine. Groundcovers included Gristle Fern (*Blechnum cartilagineum*), Narrow-Leaved Palm Lily and Spiny-Headed Mat-Rush (*Lomandra longifolia*).

Weed species included Lantana, Camphor Laurel and Small-leaf Privet, which were present throughout the understorey. This vegetation community is considered to be in relatively **moderate** condition, however the understorey and groundcover was infested with weeds.

Foothills Grey Gum – Broad-leaved Mahogany Forest

This community most closely fits the DECCW classification of Ecosystem 55 Foothills Grey Gum – Spotted Gum (DECCW, 2004), however no Spotted Gums were observed only co-dominants such as Broad-Leaved Mahogany and Grey Ironbark. Therefore the naming of this community has been modified to Foothills Grey Gum – Broad-Leaved Mahogany to make it applicable to the site. This community is consistent with Forest Type 62 (Forestry Commission 1989). Foothills Grey Gum – Broad-Leaved Mahogany primarily occurs on the outer perimeter upper slopes of the Bowra Creek catchment. This tall open forest had a canopy up to approximately 35 m in height. Approximately 4.14 ha of this vegetation community would be removed from the inundation area, as shown in Figure 9-2.

The dominant canopy species included Small-Fruited Grey Gum (*Eucalyptus proprinqua*), Broad-Leaved Mahogany (*E. carnea*), Grey Ironbark (*E. siderophloia*) and Turpentine.

Understorey trees included Forest Oak, White Dogwood (*Ozothamnus diosmifolius*), Maiden's Wattle (*Acacia maidenii*), Blackwood, Blueberry Ash (*Elaeocarpus reticulatus*), and Elderberry Panax (*Polyscias sambuccifolia*) associated with climbers such as Twining Guinea Flower and Green-Leaved Bramble (*Rubus nebulosus*). Groundcovers included grasses such as Blady Grass (*Imperata cylindrical*) and Kangaroo Grass (*Themeda australis*).

Weed species including Lantana were present throughout the understorey. This vegetation community is considered to be in **moderate** condition.

Wet Bloodwood – Tallowwood Forest (Temperate Dry Rainforest)

This community most closely fits the DECCW classification of Ecosystem 152 Wet Bloodwood – Tallowwood (DECCW, 2004) and is consistent with Forest Type 23 (Forestry Commission 1989). Wet Bloodwood – Tallowwood (Temperate Dry Rainforest) is found on the upper west-facing slopes appearing as narrow strips in close proximity to drainage lines. This tall open forest had a canopy up to approximately 35 m in height. Approximately 0.64 ha of this vegetation community would be removed from the inundation area, as shown in Figure 9-2.

The dominant canopy species included Pink Bloodwood, Tallowwood, Small-Fruited Grey Gum and Blackbutt. The midstorey (approximately 20 m in height) was relatively dense and included Brush Box (*Lophostemon confertus*), Forest Oak, Black Wattle (*Callicoma serratifolia*), Blueberry Ash, Creek Sandpaper Fig (*Ficus coronata*), and (*Rhodamnia rubescens*) with Epiphytes such as Elkhorn (*Platycerium bifurcatum*). The understorey included Citriobatus pauciflora, Narrow-Leaved Palm Lily and Burrawang (*Lepidozamia peroffskiana*) with numerous vines such as Sarsaparilla (*Smilax australis*), Water Vine and Five-Leaf Water Vine.

The vegetation at one of the survey locations for this community was in good condition with a healthy tall canopy with a diverse understorey and groundcover, whilst the vegetation at the other survey location was in poorer condition due to past disturbances and encroaching weeds (Lantana) around the perimeter. Weed species identified included Camphor Laurel, Small-leaf Privet, Lantana and Broad-Leaf Privet (*Ligustrum lucidium*) that were scattered throughout this vegetation community in low numbers. This vegetation community is considered to be in **moderate** condition.

Hardwood Plantation Forest

The most dominant vegetation class in the inundation area (25.94 ha) is hardwood plantation forest primarily dominated by Flooded Gum in association with Blackbutt and Broad-Leaved Mahogany. The plantation forest was dominated by either Blackbutt or Broad-Leaved Mahogany with Flooded Gum as a minor component. The trees are on average 180 - 250 mm diameter at breast height (DBH) and 20-25 m high. Approximately 25.94 ha of this vegetation community would be removed from the inundation area, as shown in Figure 9-2.

The plantation forest has been logged several times since being managed as harvestable forest resulting in a disturbed understorey and groundcover, with very few emergent trees greater than 25 m tall. The understorey and groundcover consisted mainly of Camphor Laurel, Lantana and Small-leaf Privet especially on the lower slopes and along drainage lines. Native understorey species included White Dogwood, Maiden's Wattle, Blackwood and Breynia.

Remnant and cleared vegetation across the inundation area maintains good connectivity with vegetated areas to the north, including areas of Viewmont State Forest (890 ha) and Bollonolla

Nature Reserve (666 ha) which connect with Newry State Forest towards the coast and Gladstone State Forest towards the interior of the State. The degree of Lantana infestation creates a high level of competition for native flora that may be introduced into the plantation area by means of native fauna, wind or surface water runoff. The plantation forest resembles a monoculture and as a result would have reduced ecological function and conservation significance due to a lack of species diversity and simplified floristic structure typically associated with forestry managed land. This vegetation was considered to be in **poor** condition due to heavy weed infestation and past disturbances.

This vegetation community also occurs in the form of a small plantation forest located at the off-river storage dam embankment footprint and would be partially cleared to make way for the off-river storage dam embankment and access road.

Pastureland

The floodplain of the Nambucca River, to the west and south of Viewmont State Forest, consisted largely of agricultural land that has been cleared of native vegetation. Approximately 10.54 ha of this vegetation community would be removed from the inundation area, as shown in Figure 9-2.

This vegetation community was dominated by introduced grass species such as Common Paspalum (*Paspalum dilatatum*) and Kikuyu (*Pennisetum clandestinum*), and was infested with agricultural weed species such as Tall Fleabane (*Conyza albida*), Dandelion (*Taraxacum officinale*) and Purpletop (*Verbena bonariensis*). A few scattered native species were present, including Star Cudweed (*Euchiton involucratus*) and Blown Grass (*Lachnagrostis filiformis*). This vegetation community was in **poor** condition.

Riparian Vegetation

The riparian areas along Nambucca River, Bowra Creek and South Creek potentially impacted by the Proposal were surveyed for terrestrial and aquatic flora and fauna. Water quality testing was carried out at these same locations. Riparian zones along the Nambucca River, Bowraville Creek and South Creek would have originally been comprised of undisturbed native vegetation typical of coastal floodplains Eucalypt forest that may have once resembled something similar to the listed *River-flat Eucalypt Forest on Coastal Floodplain* EEC and would have been substantially wider then what is currently present. At present the riparian zones are typically 0 to 25 m wide with some locations > 40 m. All of the riparian vegetation surveyed was highly disturbed due to logging and land clearing for agricultural purposes and is now dominated by exotic plant species. Approximately 1.5 ha of riparian vegetation would be removed would be removed from the inundation area.

The Nambucca River and South Creek are permanent streams whilst Bowra Creek is ephemeral. The dominant species along all of the surveyed streams were exotic species, generally comprising Camphor Laurel, Small-leaf Privet and Lantana. Although, there were a number of large scattered native trees, including Forest Red Gum (*Eucalyptus tereticornis*), Weeping Lilly Pilly (*Waterhousea floribunda*), Strangling Fig (*Ficus watkinsiana*) and Swamp Oak (*Casuarina glauca*) that may provide resources for a number of native bird species. There were also moderate amounts of leaf litter and large woody debris (LWD) in the riparian areas.

The riparian vegetation along Bowra Creek upstream of the proposed off-river storage dam embankment generally consisted of dense stands of plantation Flooded Gum in association with the exotic Camphor Laurel. The understorey was dominated by Lantana and Small-leaf Privet with native vines such as Morinda (*Morinda jasminoides*) and Snake Vine (*Stephania japonica*) and scattered emergent rainforest seedlings. This vegetation was considered to be in **moderate to poor** condition.

The riparian vegetation along Bowra Creek where it emerges into pastureland from the plantation forest and downstream of the proposed off-river storage embankment to the confluence with the Nambucca River at Rapid Appraisal of Riparian Condition (RARC) survey locations generally consisted of dense stands of the exotic Camphor Laurel with scattered Flooded Gum and Forest Red Gum and the naturalised Weeping Willow (*Salix babylonica*). The understorey was generally sparse and dominated by Lantana and Small-leaf Privet with scattered native species such as Grey Myrtle (*Backhousia myrtifolia*), Rainbow Fern (*Calochlaena dubia*), Large-Leaf Hop-Bush (*Dodonaea triquetra*) and Large Mock-Olive. Native vines such as Morinda and Snake Vine were also present in the understorey. Exotic understorey species such as Paddy's Lucerne (*Sida rhombifolia*) and Wandering Jew (*Tradescantia albiflora*) were frequently recorded. This vegetation was considered to be in **poor** condition.

9.3.2 Bank Stabilisation Works

The riparian vegetation along the Nambucca River and South Creek would be removed or disturbed as part of proposed riverbank stabilisation works. These works are designed to ensure that the unstable riverbanks identified in the study area are modified to ensure their long-term stabilisation. The impacted area along the riparian zones, where riverbank stabilisation is proposed to take place, comprises of the area between the waters edge and the immediate river bank approximately 5 m wide at separate designated locations totalling approximately 2,970 m. Therefore the total area to be impacted by proposed bank stabilisation works is approximately 1.49 ha.

The riparian vegetation at the proposed release and pump points along the Nambucca River and South Creek, where some of the proposed riverbank stabilisation works are to take place, consisted of highly degraded native vegetation with scattered remnant trees, including the native Swamp Oak (*Casuarina glauca*) and Forest Red Gum (*Eucalyptus tereticornis*) and the exotic Camphor Laurel (*Cinnamomum camphora*). Native understorey species included shrubs, grasses and ferns such as Rough Maidenhair (*Adiantum hispidulum*), Water Gum (*Tristaniopsis laurina*), Spiny-Headed Mat-Rush (*Lomandra longifolia*) and *Opismenus imbecillus*. Exotic understorey species included Tall Fleabane (*Conyza albida*), Lantana (*Lantana camara*) and Small-leaf Privet (*Ligustrum sinense*) and Wild Tobacco (*Solanum mauritianum*). There were numerous vine species present, including the native Water Vine (*Cissus antarctica*) and the exotic Moth Vine (*Araujia sericifera*) and Japanese Honeysuckle (*Lonicera japonica*). This vegetation was considered to be in **poor** condition.

Borefield/ Transfer Pipeline Route

The majority of the vegetation associated with the borefield and transfer pipeline options is open pastureland and is considered to be of low ecological value due to previous land clearing and present grazing activities.

The final borefield and transfer pipeline routes was primarily selected on the basis of engineering constraints and associated costs of establishment. Therefore the proposed options are the most cost effective and logical choice in regards to engineering simplicity and effectiveness. In regards to environmental impact, the establishment of the proposed pipeline routes are considered to have minimal environmental impacts, because the only vegetation to be impacted is pastureland.

No riparian vegetation is to be impacted 'removed' by the construction of the proposed pipeline routes. Underboring of the Nambucca River for the installation of the borefield pipeline would not impact upon riparian vegetation and is to occur within pastureland. The transfer pipeline would also not impact upon any riparian vegetation as the exitsting culvert across Bowra Creek would be used to attach the transfer pipeline.

The two proposed minor trenched creek crossings for the borefield pipeline are to occur on creeks that run through farmland and no riparian vegetation is to be directly or indirectly impacted at these sites.

The riparian vegetation that is located adjacent to or in close proximity to the pipeline route is dominated by the noxious weed species Camphor Laurel, Lantana and Small-leaf Privet with scattered small clusters of native trees such as Flooded Gums and Forest Red Gums. Minimal amounts of native understorey and groundcovers were present due to livestock grazing and maintained residential gardens.

Overall the riparian vegetation is in **poor** condition and any potential impacts associated with the riverbank stabilisation works are considered minimal.

Borefield Sites and Headworks

The existing borefields and headworks are located adjacent to the Nambucca River upstream from South Creek. There is a small weir next to the existing borefield, which has been created by an accumulation of debris behind the existing pipeline crossing.

The proposed borefields are located north of the existing borefield along the Nambucca River. The borefield sites typically consist of grazing land and a thin riparian zone. The riparian vegetation in these locations is disturbed and in poor condition comprising Camphor Laurel and River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) with an understorey dominated by Lantana and introduced pasture grasses. The vegetation associated with the existing and proposed borefields and headworks is highly disturbed and considered to be in **poor** condition.

The thin strip of riparian vegetation would not be impacted 'removed' at these locations as the infrastructure associated with the borefield sites are located within pastureland beyond the riparian vegetation. The existing headworks are to be upgraded to accommodate the increased volume of water to be delivered to the storage and are also located within pastureland beyond the riparian vegetation and as such no riparian vegetation is to be impacted by the proposed upgrading activities.

9.3.3 Bobo Road Upgrade

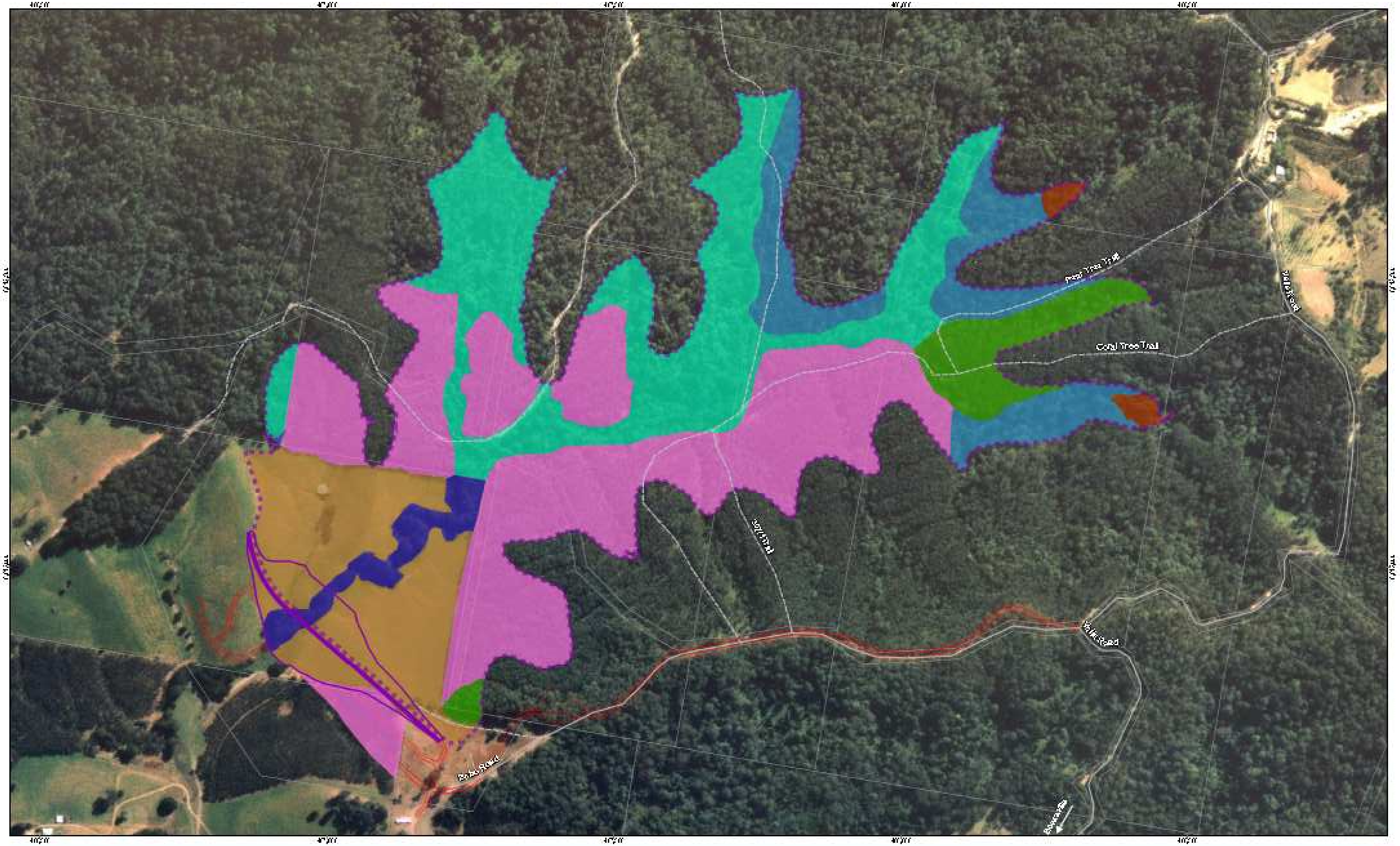
Bobo Road runs through the Viewmont State Forest. This section of road was vegetated on both sides with varying compositions of dominant canopy trees such as Flooded Gum, Tallowwood, Small-Fruited Grey Gum, Pink Bloodwood, Dunn's White Gum, Grey Ironbark, Broad-Leaved Mahogany, Blackbutt, Turpentine, Forest Red Gum, Sydney Blue Gum, Brush Box, Forest Oak, Blackwood, Black Wattle and Turpentine. The composition of the canopy changed as the road traversed ridges and gullies, different soil types and increased in elevation.

The understorey was primarily infested with weeds from approximately a 2 to 10 m depth from the roadside along the majority of the section of road surveyed, extending >100 m in one gully. The density of Lantana decreased with distance from the road edge into the forest. The overall condition of the canopy along either side of Bobo Road was considered to be good, whilst the understorey was considered to be poor because of heavy weed 'Lantana' infestation. In consideration of the different ratings for canopy and understorey, a resulting rating of moderate has been used to describe the overall condition of this vegetation.

It is proposed that Bobo Road provide access to the storage area and would be upgraded to accommodate construction traffic and to ensure public safety. The upgrade would involve approximately 2 km of road being widened to a 6 metre formation with a 3 metre wide bitumen seal. The survey effort examined 5 m either side of Bobo Road identifying canopy tree species and the presence of weeds.

Approximately 4.04 ha of vegetation may be removed as part of road upgrade activities. Of which 1.39 ha is Hardwood Plantation Forest and 2.65 ha is Foothills Grey Gum – Broad-leaved White Mahogany Forest dominated by the exotic plant species Camphor Laurel.

The vegetation communities described above are shown in Figure 9-2.



Nambucca Shire Council
Bowraville Off-River Storage

Vegetation

Job Number	22-14133
Revision	A
Date	08 OCT 2009

Figure 9-2

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9.3.4 Terrestrial Flora of Conservation Significance

Threatened Flora Species

The Commonwealth Protected Matters Online Search Tool and the DECCW Wildlife database were used to identify a preliminary suite of flora species of conservation significance that occur, or are predicted to occur (based on known distributions and habitat assessment) within the study area. Table 9-3 presents a list of these species, and identifies their conservation status, if they were detected during the surveys or if not, and their likelihood of occurrence in the study area based on habitat requirements.

Twelve Commonwealth and/or State listed flora species were identified on the databases, of which none were recorded during the current surveys and the results of previous studies that were undertaken in relation to the same proposal:

- Newry Golden Wattle (*Acacia chrysotricha*);
- Rusty Plum (*Amorphospermum whitei*);
- Hairy-joint Grass (*Arthraxon hispidus*);
- Leafless Tongue-orchid (*Cryptostylis hunteriana*);
- White-flowered Wax Plant (*Cynanchum elegans*);
- Monkey Nut (*Hicksbeachia pinnatifolia*);
- Clear Milk Vine (*Marsdenia longiloba*);
- *Quassia* sp. *Moonee Creek (J. King s.n. 1949)*;
- Milky Silkpod (*Parsonsia dorrigoensis*);
- Minute Orchid (*Taeniophyllum muelleri*);
- Austral Toadflax (*Thesium australe*); and
- *Tylophora woollsii*.

Four of these species are considered likely to occur (the Rusty Plum, *Tylophora woollsii*, Leafless Tongue-orchid and Minute Orchid), therefore an assessment of significance has been undertaken for these species and is summarised in Table 9-11. The Newry Golden Wattle is the only other species that has the potential to occur in the study area. Biosis undertook a five-day targeted search for the Newry Golden Wattle in 2005 and recorded no individuals in the study area or surrounding lands (Biosis, 2005). This species was also not recorded during this survey effort.

Table 9-3 Summary of the Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Likelihood of Occurrence
Acacia chrysotricha	Newry Golden Wattle	Unlikely. Unsuitable habitat found on site due to logging and weed infestation.
Amorphospermum whitei	Rusty Plum	Possible. Suitable habitat found on site.
Arthraxon hispidus	Hairy-joint Grass	Unlikely. Little to no suitable habitat found on site. Competitive grass species occur where suitable habitat exists.
Cryptostylis hunteriana	Leafless Tongue-orchid	Possible. Suitable habitat found within the inundation area
Cynanchum elegans	White-flowered Wax Plant	No. Unsuitable habitat found on site.
Hicksbeachia pinnatifolia	Monkey Nut	Unlikely. Unsuitable habitat found on site due to logging and weed infestations including Lantana.
Marsdenia longiloba	Clear Milk Vine	Unlikely. Due to logging and weed infestations.
Parsonsia dorrigoensis	Milky Silkpod	Unlikely. Due to logging and weed infestations including Lantana, as well as unsuitable soil type found on site.
Quassia sp.	Moonee Quassia	No. The study area does not contain appropriate habitat. Not known from the immediate locality.
Taeniophyllum muelleri	Minute Orchid	Possible. Suitable habitat found within the inundation area.
Thesium australe	Austral Toadflax	No. This species habitat was not recorded within the study area.
Tylophora woollsii	Tylophora	Possible. Suitable habitat found on site.

Endangered Ecological Communities

The riparian vegetation in the study area has been substantially altered (both structurally and floristically) and degraded as a result of previous land management activities (logging, clearing and grazing) and is dominated by Camphor Laurel, Privet and Lantana with scattered native canopy trees. Areas of this vegetation along the Nambucca River, South Creek and lower reaches of Bowra Creek contain some elements possibly representative of the *River-flat Eucalypt Forest on Coastal Floodplains* EEC listed under the TSC Act. However, the riparian vegetation in these areas is not considered to constitute this EEC given:

- The vegetation, including canopy, understorey and groundcover strata, is dominated by exotic species;
- Native species, potentially indicative of the EEC, including Forest Red Gum and Flooded Gum, are only present as scattered and isolated individuals. The majority of the understorey was clear of vegetation due to livestock grazing and the remainder was comprised of exotic species, whilst no native understorey species typically associated with this EEC were present; and

- The study area is located well beyond the identified northern-most occurrence of the community in the Port Stephens LGA (Scientific Committee Determination, (DEC, 2005).

Whilst the riparian vegetation of the Nambucca River and South Creek is not considered to comprise the River-flat Eucalypt Forest on Coastal Floodplains EEC as determined by the Scientific Committee, a precautionary approach has been taken and an assessment of significance has been prepared with respect to this community (refer to Appendix C). Given the relatively small area along the Nambucca River and South Creek of highly modified and disturbed riparian vegetation to be impacted (approximately 1.49 ha), a significant impact on the community is considered highly unlikely even if it does occur in some areas.

A similar riparian community was also recorded at various locations on the upper slopes of Bowra Creek catchment. These areas of vegetation are not considered to constitute 'floodplain' ecosystems and hence are not considered to constitute this EEC.

No other EECs listed under the TSC or EPBC Acts were recorded in the study area.

9.3.5 Noxious and Environmental Weeds

The noxious weed policy of the Nambucca Shire NSC is to meet the requirements as outlined in the NW Act. Acting as the Local Control Authority (LCA), NSC has a responsibility to ensure that all plants declared as Noxious within the Shire are controlled according to their classification. Noxious Weeds are currently classified from Class 1 to Class 5, with differing control requirements according to their Class. Currently there are approximately 100 plants that are declared as Noxious Weeds within the Shire. There are many other plants within the Shire that are considered Environmental Weeds (NSC, 2009).

Weeds that pose a threat to lands within the Shire include Groundsel Bush (*Baccharis halimifolia*), Lantana (*Lantana* spp.) and various invasive aquatic weeds such as Salvinia (*Salvinia molesta*) and Water Hyacinth (*Eichhornia crassipes*) (NSC, 2009). There are no legal requirements to remove environmental weeds from your land unless they are declared noxious weeds (NCWAC, 2003).

Figure 9-3 below depicts the degree of Lantana infestation encountered in the inundation area.

Figure 9-4 depicts Camphor Laurel infestation along the lower reaches of Bowra Creek.

Figure 9-3 Degree of Lantana infestation within the inundation area

Figure 9-4 Degree of Camphor Laurel infestation along the lower reaches of Bowra Creek

9.4 Riparian and Aquatic Flora

9.4.1 Rapid Appraisal of Riparian Condition (RARC)

The floristic and species composition of the riparian vegetation demonstrated significant variability. This variability was related to four major elements:

- Weed infestation;
- Erosion;

- Degree of flood exposure; and
- Cattle access.

All four of the above variables contributed extensively to the degree of canopy coverage, the nature and type of ground cover present, and degree of exotic species (weed) or native dominance, and intensity and type of erosion evident on the bank and riverbed.

The condition of the riparian vegetation for each of the surveyed locations is summarised in Table 9-4 and photographs of each survey location is available in Appendix D. A maximum score of 50 out of 50 is indicative of intact riparian vegetation where:

- All layers of native vegetation are present and provide good coverage;
- The vegetation is free of introduced weed species;
- There is a good layer of mulch present; and
- Fauna habitat is present in the form of fallen logs, branches and hollow bearing trees.

A low score below 20 out of 50 is indicative of degraded vegetation where:

- Layers of native vegetation are missing, in low numbers, fragmented and provide poor coverage;
- There is high content of introduced weed species;
- There is very little mulch present to stabilise surface soils;
- Fauna habitat in the form of fallen logs, branches and hollow bearing trees is absent or minimal.

Table 9-4 Summary of RARC Survey Results

Site	Stream Name & Location	Dominant Species	RARC Scoring (score out of)					
			Habitat	Cover	Natives	Debris	Features	Total
			11	*12*	*9*	*10*	*8*	*50*
R1	Bowra Creek upper catchment	*Eucalyptus grandis and Cinnamomum camphora with Ligustrum sinense, Lantana camara and native species understorey*	11	10.5	6.25	6	3.25	**37**
R2	Bowra Creek centre of proposed off-river storage dam embankment	*Cinnamomum camphora with Ligustrum sinense understorey*	7.75	8.5	1.5	3.5	1.25	**22.5**
R3	Bowra Creek downstream of proposed off-river storage dam embankment	*Exotic grasses with Cinnamomum camphora, Eucalyptus grandis and Ligustrum sinense understorey*	5.5	7.25	3	5.75	0.75	**22.25**

Site	Stream Name & Location	Dominant Species	RARC Scoring (score out of)					
R4	Bowra Creek lower catchment	*Exotic grasses with Cinnamomum camphora, Eucalyptus grandis with Ligustrum sinense understorey*	1.75	7.25	2.25	3.25	0.75	**15.25**
R5	South Creek	*Casuarina cunninghamiana* subsp. *cunninghamiana, Eucalyptus grandis and Cinnamomum camphora, with Ligustrum sinense understorey*	6	8.75	1.25	4.5	0.13	**20.63**
R6	Nambucca River adjacent to the borefields	*Exotic grasses with Cinnamomum camphora, Casuarina cunninghamiana* subsp. *cunninghamiana*	2	9	4	2.75	1	**18.75**
R7	South Creek upstream from confluence with Nambucca River	*Cinnamomum camphora, Casuarina cunninghamiana* subsp. *cunninghamiana with Ligustrum sinense and Lantana camara understorey*	6.75	9.5	0.75	4.5	0.5	**22**
R8	Downstream of Nambucca River and South Creek confluence	*Cinnamomum camphora and Waterhousea floribunda*	5.75	5.25	2.25	5.25	0.38	**18.88**
R9	Nambucca River just above confluence with South Creek	*Exotic grasses with Cinnamomum camphora, Casuarina cunninghamiana* subsp. *cunninghamiana and Waterhousea floribunda*	4.25	9	0.75	3.75	0.75	**18.5**
R10	Downstream of Nambucca River and Bowra Creek confluence	*Cinnamomum camphora and Waterhousea floribunda with Ligustrum sinense understorey*	2.75	9	2	5	0.75	**19.5**
R11	Nambucca River up North Arm Road	*Exotic grasses with Salix babylonica and Casuarina cunninghamiana* subsp. *cunninghamiana*	1.5	7	1.25	2	0	**11.75**
R12	(Missabotti Control) Unnamed Creek along Hellivells Road	*Exotic grasses with Cinnamomum camphora, Eucalyptus grandis and Tristaniopsis laurina*	3	6.75	2	3.75	1.75	**17.25**
Average Score								***20.36***

As indicated in Table 9-4 the average condition score for the riparian vegetation assessed was 20.36 which is indicative of past disturbances associated with grazing in the pastural land and logging within the inundation area. However the highest condition score of 37 was located at R1 in the upper reaches of Bowra Creek within the inundation area where less disturbance overtime has occurred, which is in contrast to R2 located further downstream scoring 22.5 where the hardwood plantation is located.

The lowest condition score was 11.75 at R11 located along the Nambucca River where very little riparian vegetation is present due to agricultural grazing activities. The remainder of condition scores are reflective of this same scenario where agricultural landuse has reduced the amount of riparian vegetation and encouraged the invasion of weeds.

Riparian and Aquatic Flora of Conservation Significance

The Commonwealth Protected Matters Online Search Tool and the DECCW Wildlife database were used to identify a preliminary suite of flora species of conservation significance that occur, or have the potential to occur (based on habitat assessment) within the study area. Appendix C presents a list of these species, their conservation status, and their detection during the surveys and likelihood of onsite occurrence in relation to the habitat present in the study area. No additional threatened aquatic flora species appeared in the database searches, therefore all relevant threatened flora species have been discussed in Section 9.3.4.

Noxious and Environmental Weeds

Six noxious weeds listed under the NW Act for the Nambucca LCA were recorded in the riparian vegetation assessed whilst undertaking RARC surveys. These were Camphor Laurel (*Cinnamomum camphora*), Giant Parramatta Grass (*Sporobolus fertilis*), Lantana (*Lantana camara*), Small-Leaf Privet (*Ligustrum sinense*) and Weeping Willow (*Salix babylonica*). Lantana and Weeping Willow are listed as Weeds of National Significance in Australia Aquatic Weeds.

One aquatic environmental weed Parrot's Feather (*Myriophyllum aquaticum*), listed by the Nambucca LCA was recorded in a waterbody adjacent to riparian vegetation whilst undertaking RARC surveys.

9.5 Terrestrial Fauna

9.5.1 Terrestrial Fauna Habitat

The fauna habitats recorded during the current assessment are described below. For the purpose of this assessment, the study area consisted of the inundation area, a section of three potentially impacted waterways (Nambucca River and, South and Bowra Creeks), the pipeline route, the existing and proposed borefields and Valla Road. The above mentioned areas are shown on Figure 9-2 and described below.

Inundation Area

The inundation area consists of 58.59 ha of both managed plantation forest and remnant native forest, as described below.

Native Forest Habitat (32.65 ha)

The non-plantation forest habitat comprises of four different vegetation communities of varying extent and were typically found on the upper slopes of the inundation area. In general these areas were characterised by larger trees (up to 35 m high) and provided some small hollows and stags potentially used by a variety of bird, mammal and reptile species. However the hollows observed were small and unsuitable for larger forest fauna. The majority of hollows were recorded in the higher elevations of the study area above the inundation area and were of a small to medium size whilst some larger more developed hollow-bearing trees and stags were recorded along the upper section of Valla Road.

Dominant canopy species included Flooded Gum, Tallowwood, Blackbutt and Sydney Blue Gum. The understorey consisted of sapling trees and groundcover typically comprising ferns and grasses. Smaller sections of rainforest habitat with dense vegetation were also present in gullies.

There was an abundant groundcover of fallen debris and leaf litter (approximately 10 %), which would provide suitable foraging and shelter habitat for bird, mammal, frog and reptile species. The larger debris mainly comprised of fallen branches and small trees.

Good connectivity remains with surrounding habitats of greater habitat value whilst the native forest within the inundation area is considered to be of low to moderate habitat value to native fauna, due to a shortage of large hollow bearing trees, a high level of noxious weed infestation and a low level of floristic diversity in the understorey.

Hardwood Plantation Forest Habitat (25.94 ha)

A large proportion of the inundation area is Flooded Gum and Blackbutt hardwood plantation forest. The trees are on average 200 –350 mm diameter at breast height (DBH) and 20-25 m high. Due to this area being historically logged, there were no hollows in this area identified that would provide shelter and breeding habitat for hollow dependant forest fauna such as microbats and owls, however some small hollows and fissures in trees may provide roosting habitat for microbats. The understorey and groundcover consisted mainly of Camphor laurel and Lantana especially on the lower slopes and along drainage lines. These species are both considered noxious weeds but are providing shelter and foraging resources for a number of species.

There was also typically an abundant groundcover of fallen debris and leaf litter (approximately 20 %), which would provide suitable foraging and shelter habitat for bird, mammal, frog and reptile species, however no large logs with hollows were identified as present as most debris was form thin small trees and fallen branches.

Remnant and cleared vegetation across the inundation area maintains good connectivity with vegetated areas to the north including areas of Viewmont State Forest (890 ha), Bowraville Nature Reserve (80 ha) and Bollonolla Nature Reserve (666 ha) which connect with Newry State Forest towards the coast and Gladstone State Forest (7,200 ha) towards the Great Dividing Range. The plantation forest was considered to have low fauna habitat value. The conservation significance of this vegetation community is considered low due to decreased species diversity and structural modification due to human management.

Riparian Habitat

The riparian habitat was a mixture of hardwood plantation forest and native forest. This habitat was primarily dominated by Flooded Gum and Blackbutt that averaged 180 –250 mm diameter at breast height (DBH) and were in the range of 20-25 m high. This native canopy was associated with the weed Camphor Laurel and had an understorey primarily infested with the weeds Lantana and Small-leaf Privet. Due to this area being historically logged, there were little to no hollows in this area that would provide shelter and breeding habitat for hollow dependant forest fauna such as microbats and owls, however some small hollows and fissures in trees may provide roosting habitat for microbats. The weed species occurring in the riparian habitat may provide shelter and foraging resources for a number of species.

There was also typically an abundant groundcover of fallen debris and leaf litter, which would provide suitable foraging and shelter habitat for bird, mammal, frog and reptile species, however this debris and leaf litter would become disturbed and unavailable in the advent of flood events. Good connectivity remains with surrounding habitats and this area was thought to be representative of moderate to low fauna habitat due to a lack of hollow bearing trees, a high level of noxious weed infestation and structural modification resulting in a low level of floristic diversity in the understorey.

Pastureland

The pastureland associated with the location of proposed access roads, pipeline route and off-river storage storage embankment infrastructure has been used to graze livestock and grow fodder crops. The habitat values in these areas for native fauna are considered low because most flora species are introduced and frequently grazed by livestock.

Connectivity of Inundation Area with Wildlife Corridors

The study area is 80.09 ha and is situated in the southern-most portion of the Viewmont State Forest (VSF), which covers an area of approximately 890 ha. Directly north of VSF is the Bollonolla Nature Reserve (650 ha), which connects to the northern portion of VSF. Further to the northwest VSF is adjacent to Bowraville Nature Reserve (80 ha) and is contiguous with the large Gladstone State Forest (approximately 7,200 ha). Agricultural land occurs to the south and west of the inundation area. Additionally it is proposed that NSC obtain 122.58 ha of vegetation that surrounds the inundation area from DI&I as a protection area to the Proposal to be conserved and protected from logging over the long-term.

9.5.2 Riparian Corridor Habitat

Riparian areas along the Nambucca River, South Creek and below the inundation area forest along Bowra Creek were typically thin and structurally modified or cleared due to agriculture and other anthropogenic activities.

The Nambucca River is a permanent flowing river while Bowra Creek is ephemeral. The dominant species along all waterways surveyed were exotic species, Camphor Laurel, Small-leaf Privet and Lantana. Although, there were a number of large scattered isolated native trees including Flooded Gum, Forest Red Gum and River Oak that would provide resources for a number of native bird species. There were also sections of the waterways with moderate amounts of leaf litter and large woody debris (LWD) in the thin riparian areas. The riparian

corridors were considered to be of low habitat value due to their minimal width and the prevalence of exotic species in the canopy and understorey.

The relative local and regional value of these riparian corridors is considered low because of land clearing and agricultural land use that has resulted in riparian corridors that are structurally modified, weed infested, fragmented and of reduced habitat value. This is the case with a vast amount of the riparian corridors in the Nambucca catchment. The availability of better riparian habitats is minimal and restricted to the upper reaches of the catchment that are steeper, unsuitable for agriculture and are primarily owned and managed by DI&I.

Pipeline Route

The pipeline route transects agricultural and urban lands adjacent to Bowra Creek and existing roads. The pipeline route runs south along Bowra Creek and veers west toward the existing borefields. These areas adjacent to the riparian zone were considered to be of reduced habitat value due to previous and present clearing and grazing activities resulting in structurally modified vegetation communities.

There would be three under bores created for the pipeline at two locations along the Nambucca River and at one location along Bowra Creek. The underboring process would not impede movement in either the river or the creek and is considered to minimally impact the surrounding environment once construction is completed.

Borefields and Headworks

The existing borefields and pumping station are located adjacent to the Nambucca River upstream from South Creek. There is a small weir next to the existing borefield, which has been formed due to accumulation of debris behind the existing pipeline crossing.

The proposed borefields are located north of the existing borefield along the Nambucca and adjacent to the west bank of South Creek. The borefield sites typically consist of grazing land and a thin riparian zone. These areas adjacent to the riparian vegetation were considered to be of low fauna habitat value due to previous clearing and existing grazing activities.

Bobo Road

Bobo Road, which runs to the west of Valla Road to the inundation area, would need to be upgraded due to improve construction access. The upgrade would involve approximately 2.0 km of road being widened approximately 3 metres.

Bobo Road was considered moderate quality fauna habitat due to several large stags/ hollow-bearing trees and abundant ground debris and leaf litter, however there is a high level of noxious weed infestation and a low level of floristic diversity in the structurally modified understorey.

9.5.3 Fauna Habitat Discussion

The inundation area, dam embankment footprint, pipeline routes and access roads are all considered to possess low to moderate habitat values in comparison to the surrounding lands associated with the greater Viewmont State Forest because:

- The open forest vegetation within the study area has limited native food resources due to structural modification resulting from past logging activities and subsequent weed invasion;
- The understorey and groundcover of the study area is heavily infested with invasive noxious weeds, making the vegetation somewhat unsuitable for most predatory birds such as owls and may restrict the movement of larger native mammals;
- The study area contains forested land, although structurally modified, that makes up a small portion of an extensive tract of native vegetation that is comprised of a large expanse of State Forests and Nature Reserves (Viewmont State Forest 890 ha, Bollonolla Nature Reserve 650 ha and Bowraville Nature Reserve 80 ha). The study area is located at the southern extent of this wildlife corridor;
- The presence of noxious weeds in the study area has modified the floristic structure and reduced diversity in the understorey. This is even more so along the ephemeral creek lines and riparian corridors;
- There were no hollow bearing trees recorded in the inundation area that would typically provide habitat for threatened species such as forest owls and colonies of microchiropteran bats. These trees are more prevalent in the steeper/ elevated areas (ridgelines) above the inundation area associated with the greater Viewmont State Forest, where logging activities appear to have been less frequent; and
- The inundation area contains a variety of preferred Koala feed trees (e.g. Grey Gum, Flooded Gum, Blackbutt and Tallowwood), however this habitat is not considered core Koala habitat, because the study area is located in DI&I land and therefore SEPP 44 does not apply and the one listed feed tree species (Tallowwood) does not occur in densities within the study area greater than 15 %, therefore the study area is only considered potential Koala habitat. However the presence of these trees would provide foraging resources for a population of Koalas. In light of this finding in combination with the recording of one male Koala during a call playback session indicates that the study area may be part of a larger home range and therefore the Assessment of Significance has been undertaken for this species (see Appendix C).

9.5.4 Surrounding Habitat & Habitat Links/Wildlife Corridors

The study area is situated on the southern edge of an extensive wildlife corridor at this locality that links with east-west regional corridors. The habitats in the inundation area are considered to be of moderate to low value given its spatial context within the surrounding landscape. This wildlife corridor is comprised of Viewmont State Forest (890 ha), Bollonolla Nature Reserve (650 ha), Bowraville Nature Reserve (80 ha) and the large Gladstone State Forest (approximately 7,200 ha). The wildlife corridor connected to the study area is vast and provides ideal connectivity to the study area to allow the ease of passage of native fauna.

Visual inspections of the vegetation along driving transects in the surrounding lands associated with the greater Viewmont State Forest indicated a greater abundance of native food resources than that of the study area with and understorey that is less structurally modified.

The abundance foraging resources provides viable foraging habitat for forest and woodland avifauna such as the Wompoo Fruit Dove (*Ptilinopus magnificus*), Glossy Black Cockatoo (*Calyptorhynchus lathami*) and Brown Treecreeper (*Climacteris picumnus*) and bat species such

as the Grey-headed Flying-fox (*Pteropus poliocephalus*), Golden-tipped Bat (*Kerivoula papuensis*), Little Bentwing Bat (*Miniopterus australis*) and Eastern Long-eared Bat (*Nyctophilus bifax*), frogs such as Green and Golden Bell Frog (*Litoria aurea*), Giant Barred Frog (*Mixophyes iteratus*) and Southern Barred Frog (*Mixophyes balbus*) and invertebrate species.

Potential nest sites for passerine birds are present throughout the forest communities of the study area, including dead branches, small tree-hollows, open cavities, and patches of dense undergrowth that was primarily comprised of Lantana and was structurally modified as a result. A number of large tree-hollows in the more elevated areas of the study area and surrounding lands provide potential nesting sites for forest owls such as the Barking Owl (*Ninox Connivens*), Masked Owl (*Tyto novaehollandiae*) and Sooty Owl (*Tyto tenebricosa*) and parrots such as the Glossy Black-Cockatoo and high branch perches and stable branch or trunk nest platforms are present which are used by other non-passerine bird species.

The majority of hollows recorded in the higher elevations of the study area above the inundation area and associated with the proposed access roads were of a small to medium size ideal for most hollow dependant fauna apart from large forest owls and large arboreal mammals (Yellow-bellied Glider). Some larger more developed hollow-bearing trees and stags were recorded along the upper section of Valla Road that may potentially provide hollows large enough for large forest owls and large arboreal mammals.

The open forest within the study area and on surrounding land provides some resources for arboreal herbivorous and sap feeding mammals such as the Koala (*Phascolarctos cinereus*) and Sugar Glider (*Petaurus breviceps*), browsing carnivores such as the Spotted-tail Quoll (*Dasyurus maculatus*) and nectarivorous birds such as the Regent Honeyeater (*Xanthomyzon phrygia*). However the vegetation in adjacent lands is considered of greater habitat value due having undergone a decreased frequency of logging.

Most of the microchiropteran bats recorded apart from the Golden-tipped Bat are likely to forage widely throughout the areas of open forest in the inundation area preying upon insects above and within the canopy and along the ecotones between creek lines, forest stands and open areas. The Golden-tipped Bat prefers to forage in the more elevated areas on upper-slopes, however its roosting sites would be located in the riparian areas of the inundation area in abandoned Yellow-throated Scrub-wren and Brown Gerygone hanging bird nests.

The structurally modified understorey (primarily comprised of noxious weeds) and groundcover would provide some shelter and foraging habitat for certain species, including arboreal and terrestrial mammals, reptiles and passerine and non-passerine bird species. The moderate leaf litter layer provides suitable foraging habitat for some small ground-dwelling mammals as well as small reptiles and foraging birds. Moreover, the fallen timber and hollow logs in some areas may provide suitable denning, sheltering and foraging habitat for a range of fauna such as the Long-nosed Potoroo (*Potorous tridactylus*), Hastings River Mouse (*Pseudomys oralis*), Spotted–tail Quoll, Southern Barred Frog and Giant Barred Frog, non of which were recorded. However the vegetation in adjacent lands is considered of greater habitat value due having undergone a decreased frequency of logging.

Larger terrestrial mammals (Long-nosed Potoroo and Koala) may seek diurnal refuge in the dense gully vegetation and may be more likely to forage on vegetation in surrounding lands that potentially provide a greater range of resources because this vegetation is not as structurally

modified. It is possible that the Spotted-tail Quoll, which requires large areas of forest and woodland habitat to meet its home range requirements, also occurs in the study area and adjacent lands on a transient basis. This species was not recorded during the recent survey.

The Wet Bloodwood - Tallowwood Forest (Temperate Rainforest) located in the upper reaches of the inundation area is likely to provide habitat for the Southern Barred frog, Giant Barred Frog and Wompoo Fruit-dove. This rainforest vegetation could be considered degraded because of past structural modification associated with logging practices and weed infestation. This vegetation is in the early stages of successional development with a canopy dominated by Tallowwood with very few large rainforest trees favourable to the Koala and Wompoo Fruit-dove. Additionally these areas may easily become dry due the canopy being fragmented and not entirely closed potentially making it seasonally unsuitable for the Southern Barred Frog and Giant Barred Frog.

The Bowra Creek riparian habitat in the inundation area is structurally modified reducing habitat values for the Southern Barred Frog and Giant Barred Frog, however these species were still considered likely to occur. Additionally Bowra Creek is ephemeral in nature and can remain dry for varying periods of time such as during the recent drought period.

Hollow Bearing Trees and Logs

As mentioned earlier there is a shortage of hollow bearing trees present within the inundation area of the study area, of which only small hollows are present. This could be expected due to past logging practices having removed trees large enough to become hollow bearing.

None of the hollow bearing trees identified had hollows large enough to accommodate threatened large forest owls, arboreal mammals or microbat colonies. There were some small hollow fallen logs identified that may provide denning sites for common small ground dwelling mammals, however none were identified as being large enough for the threatened Spotted-tail Quoll or Long-nosed Potoroo.

9.5.5 Fauna of Conservation Significance

The Commonwealth Protected Matters Online Search Tool and the DECCW Threatened Species database were used to identify a preliminary suite of fauna species of conservation significance that occur, or have the potential to occur (based on habitat assessment) within the study area. Forty-two Commonwealth and/or State listed fauna species were identified on the databases.

Seven threatened species were recorded in the present study and another seven threatened species were considered likely to occur based on this assessment. Assessment of Significance (AoS) of impacts on these species are provided in detailed in Appendix D. These species and their EPBC Act and TSC Act status are detailed in Table 9-5 Conservation Status of Threatened Species Recorded or Considered Likely to Occur.

Table 9-5 Conservation Status of Threatened Species Recorded or Considered Likely to Occur

Species Recorded	EPBC Act Status	TSC Act Status
Barking Owl	Not Listed	Vulnerable
Masked Owl	Not Listed	Vulnerable
Sooty Owl	Not Listed	Vulnerable
Koala	Not Listed	Vulnerable
Golden-tipped bat	Not Listed	Vulnerable
Little Bentwing-bat	Not Listed	Vulnerable
Eastern Bentwing-bat	Not Listed	Vulnerable
Species Considered Likely to Occur	**EPBC Act Status**	**TSC Act Status**
Spotted-tail Quoll	Endangered	Vulnerable
Grey-headed Flying-fox	Vulnerable	Vulnerable
Powerful Owl	Not Listed	Vulnerable
Wompoo Fruit-dove	Not Listed	Vulnerable
Glossy Black Cockatoo	Not Listed	Vulnerable
Southern Barred Frog	Vulnerable	Endangered
Giant Barred Frog	Endangered	Endangered

9.6 Aquatic Fauna

9.6.1 Aquatic Fauna Habitat

Nambucca River

The Nambucca River is a moderate sized lowland river (observed width ranging from 5-20 m within study area) surrounded by floodplain that is used for grazing livestock. The river is characterised by low to moderate flows (generally between 1-2.5 m/sec) and water is generally clear indicated by low turbidity (NTU #). It is typically 10-15 m wide and 1-2 m deep and exhibits riffle run and pool habitats along its length. The substrate consists of sand and gravel and has regularly exposed sandbars.

Large woody debris and overhanging vegetation is abundant and provides habitat for aquatic fauna. The banks are typically steep and vegetated with Camphor Laurel and some *Salix babylonica* (Weeping Willow). Native species including *Eucalyptus tereticornis* (Forest Red Gum) and *Casuarina glauca* (Swamp Oak) are interspersed throughout the canopy. Riparian vegetation within the study area ranges from 3-7m in width due to clearing for agricultural purposes. The river provides potential habitat for at least 18 native species.

Bowra Creek

Bowra Creek is displays characteristics of both an ephemeral creek, in the upper to mid reaches, and a permanent/semi-permanent creek in the mid to lower reaches. It flows southwest through the middle of the Plantation habitat and discharges into the Nambucca River. The habitat along the length of the creek transitions from its headwaters to the confluence with Nambucca River. The headwaters (BC1) consist of a tall open forest system with a continuous mixture of native and exotic riparian vegetation comprised of Flooded Gum, Blackbutt and Camphor Laurel with an understorey of Lantana camara and Small-leaf Privet.

The lower reaches of Bowra Creek, within the cleared agricultural sites (BC2, BC3 and BC4), are an open system of semi-permanent pools with scattered exotic tree and understorey species. Banks are gradual and undisturbed in the upper reaches and become steep and highly disturbed in the agricultural areas. The substrate mostly consists of sand, silt and clay sized particles which released odorous gasses when disturbed, suggesting anoxic conditions. The upper reaches and small feeder drainage lines that supply Bowra Creek are ephemeral and only flow intermittently during rain events.

There was minimal in-stream vegetation at sites within the upper reaches of the creek. These sites did have an abundance of woody debris and leaf litter, which provide potential habitat for crayfish, frogs/tadpoles and aquatic invertebrates. The striped marsh frog (*Limnodynastes peronii*) was noted calling and numerous tadpoles were observed at BC-1. Numerous mosquito fish (*Gambusia holbrooki*), an exotic pest, were observed at BC2.

Riparian vegetation on the lower reaches within the agricultural region typically consisted of a narrow strip of Camphor laurel (<5 m) with and understorey of saplings and Privet. Approximately 20% of the creek was devoid of any canopy or understorey vegetation due to clearing for pastoral land. Emergent vegetation was abundant in the lower reaches, which appeared to provide habitat for common frog species such as *Crinia signifera* that was noted calling during the survey.

The creek was not fenced and livestock has had a major impact along most of the lower reaches. Several farm dams located adjacent to the creek could potentially provide habitat for frogs and turtles. These dams are typically unconnected to the creek system, making them unlikely refuge for common creek dwelling animals. These dams did not have riparian vegetation and contained approximately 30% surface cover of both emergent and floating vegetation.

South Creek

South Creek is a moderate sized creek (observed width ranging from 7-15m within the study area) that flows northeast into the Nambucca River. The creek has a moderate (4-20 m wide) riparian corridor dominated by Camphor laurel with 5-10% interspersed native species and an understorey of Privet and Camphor laurel saplings. The entire length of the creek is surrounded by agricultural and residential land. The substrate consists of sand and gravel and has regularly exposed sandbars. There was abundant large woody debris in areas and the banks are typically steep and undercut. The confluence of South Creek and Nambucca River is in Bowraville and has been historically used for recreational purposes including swimming and is also a Department of Industry and Investment survey site.

9.6.2 Fish

There are 20 known species of freshwater fish in the Nambucca catchment including two exotic species. Thirteen of these species have been recorded at the NSW Fisheries Survey Site at the Bowraville Gauging Station on the Nambucca River.

A total 216 individual fish, representing two species were netted during the survey. Of the two species, the Empire Gudgeon (*Hypseleotris compressa*) dominated samples (164 individuals) at sites SC1, SC2 and NR4. All fish caught at SC1 and SC2 were assumed to be near mature and ranged from 50 to 70 mm in length. Individuals caught at NR4 were assumed to be juvenile and all were approximately 35 mm in length.

Pacific Blue-eye (*Pseudomugil signifer*) was the second most abundant species sampled (52 individuals) at sites SC1 and SC2. All individuals were approximately 35 mm in length, which is close to their maximum size of 40 mm, and thus they were assumed to be mature based on size.

Seven species of fish were recorded during the survey, as identified in Table 9-6 Threatened and Recorded Fish of the Study Area.

Table 9-6 Threatened and Recorded Fish of the Study Area

Common Name	Scientific Name	Family Name	Native/ Exotic	EPBC status	TSC status	Location netted during this survey	Location observed during this survey
Longfinned eel	*Anguilla reinhardtii*	Anguillidae	Native	Least concern	Not listed	Not recorded	Not recorded
Empire gudgeon	*Hypseleotris compressa*	Eleotridae	Native	Least concern	Not listed	SC1, SC2 and NR4	NR3, NR5
Striped gudgeon	*Gobiomorphus australis*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Cox's gudgeon	*Gobiomorphus coxii*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Firetail gudgeon	*Hypseleotris galii*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Gudgeon	*Hypseleotris sp.*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Flathead gudgeon	*Philypnodon grandiceps*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Oxeye herring	*Megalops cyprinoides*	Megalopidae	Native	Least concern	Not listed	Not recorded	NR3, NR4
Crimson-spotted rainbowfish	*Melanotaenia duboulayi*	Melanotaeniidae	Native	Least concern	Not listed	Not recorded	Not recorded
Freshwater mullet	*Myxus petardi*	Mugilidae	Native	Least concern	Not listed	Not recorded	NR2, NR4
Sea mullet	*Mugil cephalus*	Mugilidae	Native	Least concern	Not listed	Not recorded	NR2, NR4

Common Name	Scientific Name	Family Name	Native/ Exotic	EPBC status	TSC status	Location netted during this survey	Location observed during this survey
Freshwater catfish	*Tandanus tandanus*	Plotosidae	Native	Least concern	Not listed	Not recorded	NR2, NR3
Gambusia	*Gambusia holbrooki*	Poeciliidae	Exotic	Least concern	Not listed	Not recorded	BC2
Pacific blue-eye	*Pseudomugil signifer*	Pseudomugilidae	Native	Least concern	Not listed	SC1, SC2	Not recorded
Bullrout	*Notesthes robusta*	Scorpaenidae	Native	Least concern	Not listed	Not recorded	Not recorded
Yellowfin bream	*Acanthopagrus australis*	Scaridea	Native	Least concern	Not listed	Not recorded	NR4

9.6.3 Reptiles

One species of threatened reptile (Bellinger River Emydura (*Emydura signata*)) was listed by the EPBC as 'species or species habitat may occur within area', however no individuals of this species were observed or captured during the survey. A total of 17 individuals of the eastern long neck turtle (*Chelodina longicollis*) were captured during the field survey, as shown in Table 9-7 Threatened and Recorded Aquatic Reptiles from the Study Area.

Table 9-7 Threatened and Recorded Aquatic Reptiles from the Study Area

Common Name	Scientific Name	Family Name	Native/exotic	EPBC status	TSC status	Location
Bellinger River Emydura	*Emydura macquarii signata*	Chelidae	Native	Vulnerable	Vulnerable	Not recorded
Eastern long-neck turtle	*Chelodina longicollis*	Chelidae	Native	Least concern	Not listed	SC1, Upstream of BC4

9.6.4 Mammals

The Nambucca River is suitable habitat for one aquatic mammal, the Platypus (*Ornithorhynchus anatinus*). Historically, based on local resident's reports, Platypuses have been observed in the Nambucca River. Sightings occurred along the Nambucca River during GHD's survey. No platypuses were observed at these sites, or any other, during the survey as shown in Table 9-8 Recorded Aquatic Mammals of the Study Area.

The platypus is widespread in eastern Australia, ranging from tropical lowlands to sub-alpine areas. Although the platypus is a strong swimmer they prefer slow flowing streams. Platypuses live in burrows that they dig on the banks of fresh water rivers, lakes or streams. Burrows are

usually 4.5 to 9 m in length, oval shaped and are constructed just above the water line, often obscured by vegetation. This habitat was readily available along the Nambucca River at the time of the survey.

This species is listed on the International Union for the Conservation of Nature (IUCN) Red List as 'near threatened' but is not currently listed as threatened under NSW or Commonwealth legislation.

No threatened aquatic mammals were recorded in the study area.

Table 9-8 Recorded Aquatic Mammals of the Study Area

Common name	Scientific name	Family name	Native/exotic	EPBC status	IUCN status	Location
Platypus	*Ornithorhynchus anatinus*	Ornithorhynchidae	Native	Least concern	Near threatened	Not recorded

9.6.5 Macroinvertebrates

An estimated 24,168 individuals from 47 families of macroinvertebrates were collected from the eleven survey sites. The community composition for the family taxa of macroinvertebrates recorded at each site. The five more dominant families across all the sites combined were:

- Diptera, chironomidae (Non-biting Midge);
  - Chironomidae can be simple detritivores, omnivores or carnivores that feed on a mixture of algae and bacteria in soft sediments. They are found in a variety of water sources and most genera are relatively tolerant to pollution. This family is the third most species family of diptera.
- Isopoda, sphaeromatidae (Water Slater);
  - Sphaeromatidae are generally limited to saline waters within estuaries, they are mostly detritivores and shredders of leaves and other organic material. Some genera of the family are known to be parasitic on freshwater fish.
- Ephemeroptera, caenidae (Mayfly);
  - Caenidae inhibit slow-flowing streams and are often found on bark, logs and rocks in streams, wetlands and pools. They are detritivores and herbivores. Most mayflies are pollution intolerant and are frequently used as an indicator group for environmental monitoring programs (Dean and Suter 1996).
- Coleoptera, elmidae (Riffle Beetle); and
  - Elmidae adults and larvae are aquatic. They are herbivorous feeding on decaying vegetation and algae. They are found on log and stone surfaces of well oxygenated streams and rivers.
- Diptera, tanypodinae (Non-biting Midge).
  - Tanypodinae are predators but feed on some algae, bacteria and diatoms in their early larval stages.

Nambucca River

Sites NR2R (riffle), NR2E (edge), NR3 (edge) and NR4 (edge) displayed similar patterns of order dominance between sites. The most dominant orders were diptera (flies), coleoptera (beetles) and ephemeroptera (mayflies). The dominant families in the groups are those associated with slow flowing low-land rivers and the associated riffles and pools along the length of the rivers. *Coleoptera elmidae* are usually found in the riffles of fast following sections of the creeks. The high number of individuals captured indicates that water in this section of the Nambucca River is well oxygenated as indicated by the dissolved oxygen (DO) results for sample locations NR1 to NR5 that ranged between 77 and 92.1 % saturation.

NR5 (edge) was exceptionally depauprate in terms of overall numbers of animals in comparison to the other sites from the Nambucca River. This site was dominated by two families – isopoda sphaeromatidae (water slater) and amphipoda paramelitidae (side swimmers). The isopod is usually associated with high electrical conductivity or salinity and is generally found in the estuaries, as indicated by the electrical conductivity results for sample location NR5 of 117.4 uS/cm. Many genera of amphipods are associated with saline waters. This family is known to occur throughout south-eastern Australia and are grazed upon by other aquatic invertebrates.

South Creek

The South Creek sites had a high level of variation between the two sites (i.e. SC1 and SC2) but similarity between the two sampling habitats at each site (i.e. edge and riffle). SC1M (riffle) was dominated by ephemeroptera (mayflies) with sub-dominance by diptera (flies) and coleoptera (beetles). SC2 (riffle) was dominated by orders of diptera (flies), isopoda (water slaters) and coleoptera (beetles). The major difference between the two riffle sites is the greater abundance of isopods at SC2.

The edge sites SC1E and SC2E were dominated by isopoda (water slaters). Both sites recorded low numbers of five other orders.

South Creek and NR5 (Nambucca River) were the only sites to be dominated by the isopoda (water slaters). The EC (us/cm) was higher at South Creek sites than at any other site sampled and can explain the presence of the isopods, a family generally associated with the marine environment, although it is uncertain how they moved so far upstream from a marine environment. The NR5 site had a much lower EC and it is unusual for this family of isopods to be captured in a freshwater environment.

Bowra Creek

The Bowra Creek sites are widely distributed from the creek headwaters in the Viewmont State Forrest, south west to its confluence with the Nambucca River, within the agricultural district of Bowraville. The most upstream site (BC1 (edge)) was dominated by emphemeroptera (mayflies). BC2, approximately 0.75 km downstream was dominated by coleoptera (beetles), diptera (flies) and hemiptera (true bugs). The two most downstream sites (BC3 (edge) and BC4E and M (edge and riffle)) were dominated by diptera (flies).

The Bowra Creek sites recorded the highest turbidity, the lowest percentage of dissolved oxygen and the lowest pH of all the sites sampled. The most upstream site (BC1) recorded slightly less harsh physiochemical conditions than the 3 downstream locations. The presence and dominance of mayflies at BC1 and absence from all other sites is an indicator that water

quality is poor and the habitat likely to have been degraded downstream from BC1. The physiochemical conditions are likely to have contributed to the low diversity of pollution tolerant animals recorded at the lower sites. Less tolerant species are unlikely to survive in these harsh environmental conditions.

9.6.6 Aquatic Species of Conservation Significance

Threatened Fish Species

The FM Act lists threatened aquatic species, populations and endangered ecological communities for marine and freshwater habitats. None of the FM Act listed fish species are known to occur in the study area and no listed species or preferred habitat was recorded during the survey.

Threatened Reptiles

One threatened species listed under the EPBC Act may potentially occur in the study area, the Bellinger River Emydura. No members of this species were recorded during the survey. This species distribution is restricted to the upper Bellinger River above Thora and therefore is unlikely to occur in the Nambucca catchment.

Threatened Mammals

No threatened aquatic mammals were recorded in the study area.

9.6.7 Groundwater Dependent Ecosystems

A groundwater dependent ecosystem is an ecosystem where the species composition and natural ecological processes are determined by groundwater (Department of Land and Water Conservation, 2002), and is therefore reliant on groundwater for at least some of its water requirements. Examples of groundwater dependent ecosystems include wetlands and red gum forests, some terrestrial vegetation communities, ecosystems in streams fed by groundwater, limestone cave systems, springs, and hanging valleys and swamps. For such ecosystems, access to groundwater can be critically important to the maintenance of ecosystem viability and biodiversity.

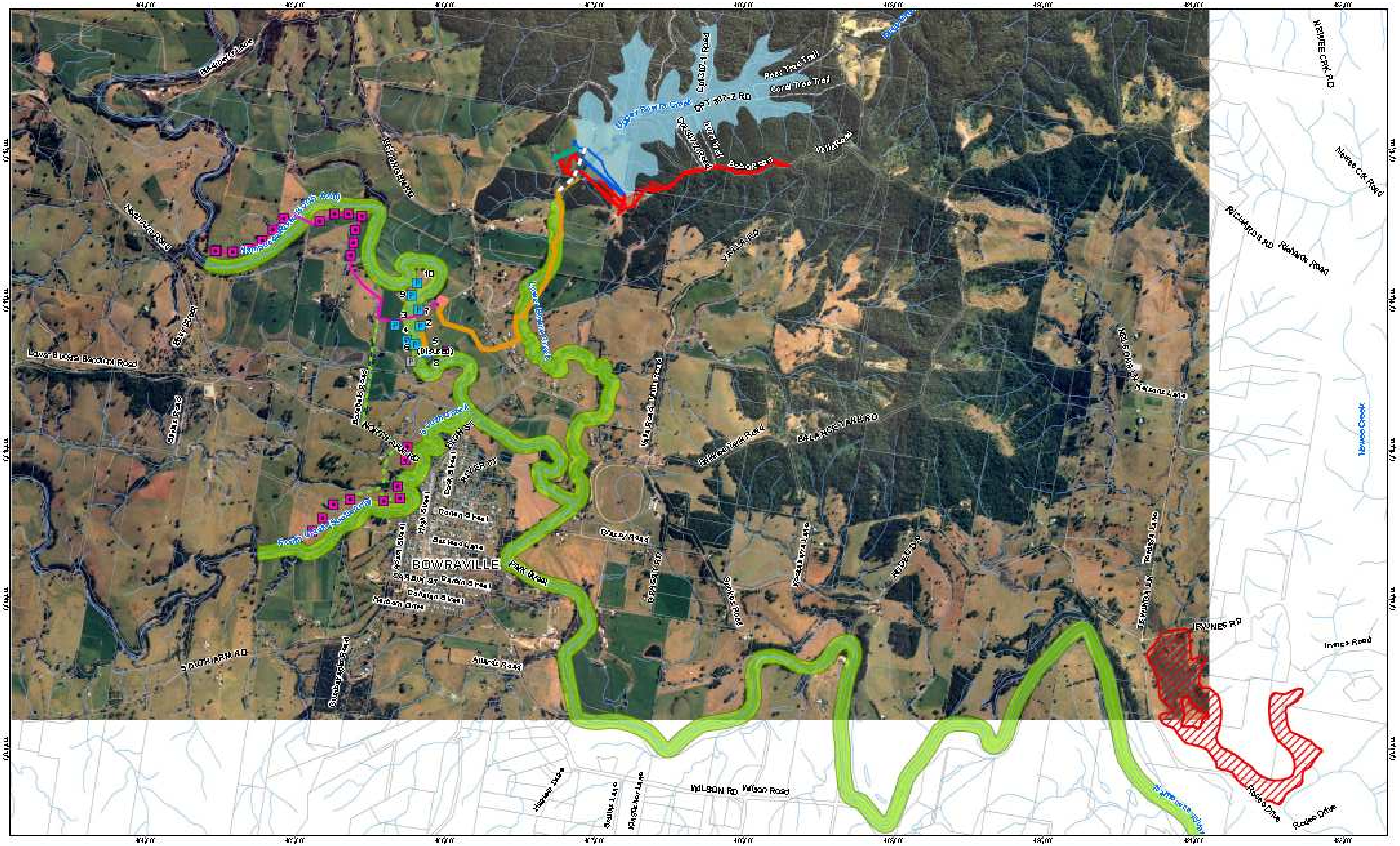
Surface groundwater dependent ecosystems can be considered in two classes. The first class is reliant on the surface expression of groundwater and includes swamps, wetlands and rivers, while the second class relies on the availability of groundwater below the surface but within the rooting depth of the vegetation (Eamus, 2009). The riparian vegetation along Nambucca River, South Creek and Bowra Creek could be considered as being first class dependant ecosystems.

The dependency upon groundwater of these ecosystems varies, with obligate and facultative dependent ecosystems recognised. For an obligate groundwater dependent ecosystem, groundwater forms a critically important water source in the hydrological regime of the ecosystem. However the term 'obligate' does not mean that the ecosystem is totally dependent upon, or requiring of, continuous access to groundwater (Howe and Prichard, 2007). Facultative groundwater dependence refers to an ecosystem where the presence or absence of groundwater is not crucial to the presence of species within an ecosystem. For facultative groundwater dependent ecosystems, other environmental factors such as landscape position,

geology, hydrology, and climate, are of greater importance to the species composition of the ecosystem.

With respect to obligate and facultative groundwater dependent ecosystems, surface ecosystems, such as those ecological communities in the inundation area, generally have dynamic water requirements with some dependence on surface water and soil water and are not often totally dependent upon groundwater (Howe and Prichard, 2007). On this basis it can be inferred that any groundwater dependent ecosystems occurring within the inundation area would only be partially dependent upon groundwater (or 'facultative groundwater dependent ecosystems') with groundwater supplementing water gained from soil water.

Figure 9-5 below depicts the facultative groundwater dependant ecosystems of the study area.



1:23,000 (at A3)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Cadastre
- Creeks
- Outlet Pipe
- Spillway
- Existing Headworks Area
- Proposed Inundation Area
- Proposed Storage Wall
- SEPP 14
- Existing Bores
- Disused Bores
- Proposed Borefield Locations
- Riparian Vegetation
- Borefield South Option 4
- Borefield North Option 6
- Proposed Pipeline Option 7
- Preliminary Road Design

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Bowraville Off-River Storage

Job Number	22-14133
Revision	A
Date	07 OCT 2009

Groundwater Dependant Ecosystems

Figure 9-5

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9.7 Impact Assessment

9.7.1 Overview of Potential Ecological Impacts

The assessment of potential ecological impacts arising from the proposed Bowraville storage was based on:

- Field surveys targeting terrestrial vegetation communities and habitats;
- GIS mapping to determine the areas of terrestrial vegetation and habitats to be inundated and/or removed;
- Compilation of broad aquatic habitat descriptions drawn from Bishop (2005);
- Review of Bishop (2005) to ascertain potential impacts on fish communities;
- Review of profiles on threatened species and endangered ecological communities recorded, or considered likely to occur, within the study area;
- Knowledge of species' life cycle requirements, distribution and current threats; and
- Review of various other ecological studies previously conducted on the Bowraville site, including Biosis (2005) and Connell Wagner (1997).

The study area provides resources and habitat features for threatened and common native terrestrial and aquatic flora and fauna. Consequently, some of these species are likely to be adversely affected by the Proposal. The potential short and long term impacts of the Proposal to the terrestrial and aquatic flora and fauna values of the study area are discussed below.

It is unlikely that the threatened species known from the study area would be significantly impacted by the proposed activities. The significance of these impacts is discussed in Section 9.7.6.

For the purpose of addressing the potential ecological impacts, the proposed works area includes the construction of the storage embankment, inundation area, access roads, pipelines routes and other water supply infrastructure.

Potential Short Term Impacts

Short-term impacts are primarily related to the immediate construction and post construction period of the storage. There exists a likelihood of fauna mortality over the short-term in relation to vegetation clearing activities. The time that it may take to clear the storage area is dependent on climatic conditions, and this in turn would determine the immediacy of the impacts, and potentially the degree of impact. Impacts are likely to be less severe if the storage is cleared over a longer time, as terrestrial fauna populations may be able to more readily disperse with the gradual clearing of the storage. By comparison, the rapid clearing of the inundation area would have a greater impact on species and populations.

Long term impacts

Longer-term impacts are associated with the ongoing maintenance and operation of the storage. These primarily involve impacts on population dynamics and river morphological processes. The potential long-term effects are described below.

9.7.2 Terrestrial Flora and Fauna

Removal and modification of terrestrial vegetation and habitat

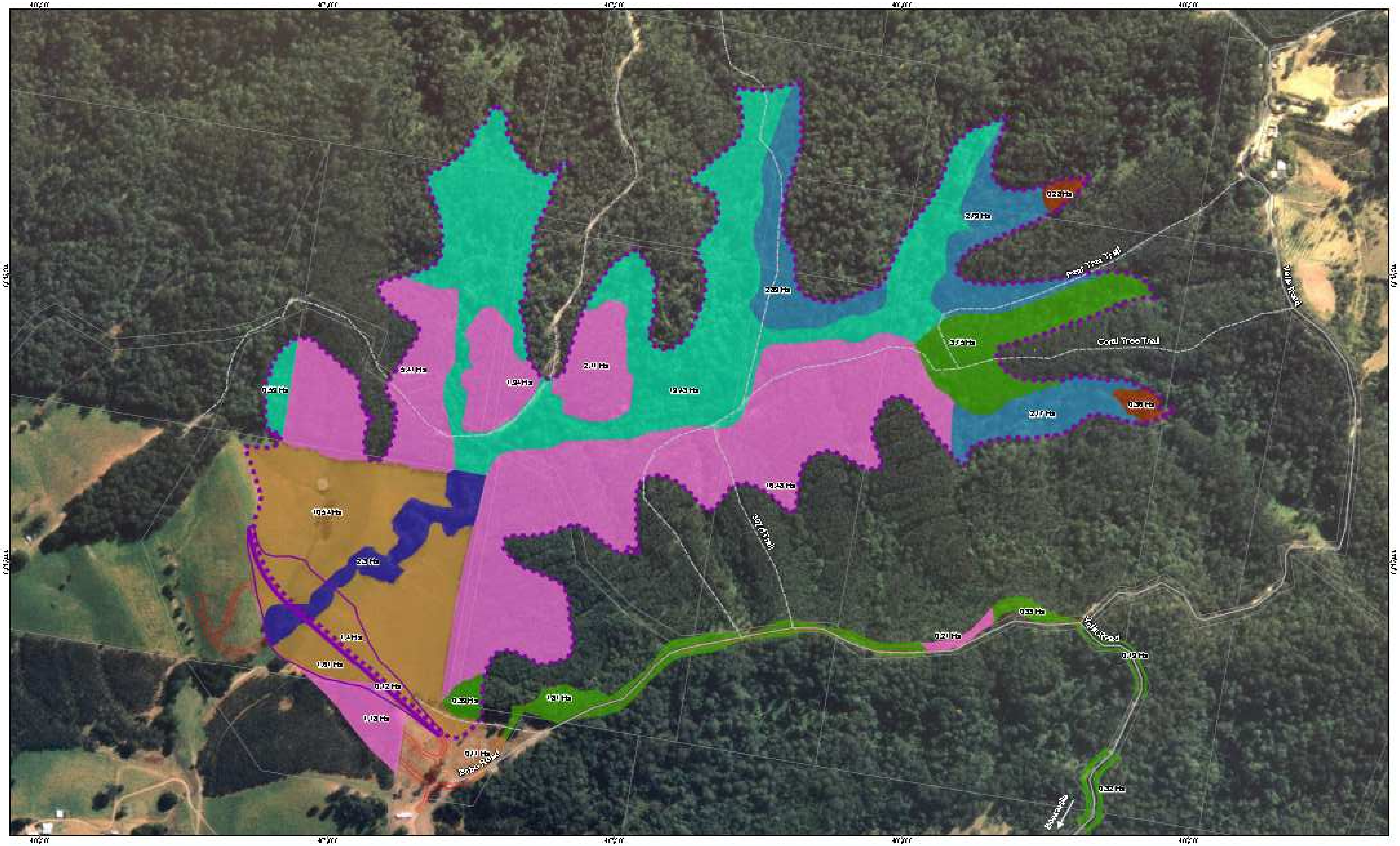
The construction of the storage embankment, construction and maintenance of access roads, and water supply infrastructure would require the immediate clearing of vegetation for this and other associated infrastructure. The extent of vegetation clearing and habitat types is depicted in Table 9-9 below and shown in Figure 9-6.

Vegetation and associated habitat within the inundation area would be cleared prior to inundation. As previously identified, this may be undertaken in two stages. However, it would seem more logical that the clearing be a continuous operation considering the cost associated wth locating heavy machinery to site and access issues getting to selective trees only. The approximate extent of vegetation clearing for the Proposal and the habitat types are depicted in Table 9-9.

Substantial earthworks would also be required and there is a high risk of erosion and sedimentation if erosion and sediment control measures are not put into place. The highest risks would be concentrated at the construction site of the storage embankment; however access road upgrades throughout the area during construction would also require vegetation removal and erosion and sediment control measures put in place.

The maximum amount of riparian vegetation to be removed is along the Nambucca River and South Creek where riverbank stabilisation works are proposed to occur and along Bowra Creek where pastureland meets forest vegetation of the inundation area to just beyond the storage embankment where the proposed access road is to be located as shown in Figure 9-6. The total area of riparian vegetation to be removed from the study area is 3.79 ha.

This riparian vegetation has undergone past disturbances due to land clearance for agriculture and is mainly comprised of exotic plant species, such as Camphor Laurel. Where the pipeline traverses pastureland, pasture would be re-established and measures would be taken in accordance with a weed management plan to minimise the invasion of the noxious weed Giant Parramatta Grass.



1:5,000 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Fire Trail
- Road
- Cadastre
- Stage 1 Dam Wall
- Stage 1 Dam FSL

Vegetation Communities

- Foothills Grey Gum - Broad Leaved Mahogany
- Hardwood Plantation
- Northern Wet Tallowwood - Blue Gum Forest
- Pastureland
- Riparian Vegetation
- Wet Bloodwood - Tallowwood Forest (Temperate Forest)
- Wet Flooded Gum - Tallowwood Forest
- Preliminary Road Design

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Extent of Vegetation Clearing

Figure 9-6

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Table 9-9 Extent of Removal of Terrestrial Vegetation and Associated Fauna Habitat within the Study Area

Vegetation Community / Habitat Type	Storage Embankment Footprint (Ha)	Vegetation to be removed			
		Native Vegetation within Inundation Area (Ha)	Bobo Road Access (Ha)	River Stabilisation Works	Total Removed from Study Area (Ha)
Hardwood Plantation Forest	0.12	25.94	1.39	0	**27.45**
Wet Flooded Gum – Tallowwood Forest	0	20.02	0	0	**20.02**
Northern Wet Tallowwood – Blue Gum Forest	0	7.85	0	0	**7.85**
Foothills Grey Gum – Broad-leaved Mahogany Forest	0	4.14	2.65	0	**6.79**
Wet Bloodwood – Tallowwood Forest (Temperate Rainforest)	0	0.64	0	0	**0.64**
Pastureland	3.01	10.54	0	0	**13.55**
Riparian Vegetation	0.8	1.5	0	1.49	**3.79**
Totals	***3.93***	***70.63***	***4.04***	***1.49***	***80.09***
Total Storage Embankment Footprint and Inundation Area (Ha)		***74.56***			

Fauna displacement

The degree of impact would vary depending on the rate at which the staged clearing of vegetation and associated habitat would occur and the rate of which the storage fills. Threatened fauna and common native flora and fauna would be displaced and/or removed as a result of the Proposal from the study area as a proportion of vegetation and habitat would be permanently removed and modified. Removal of vegetation and habitat and the inundation process would ultimately, disrupt the lifecycle of species that currently utilise the proposed works area.

In the short term, fauna may be subject to mortality and would be displaced by immediate noise, construction and other human activity, and through the initial clearing of the inundation area over a 3 month time period. Displaced terrestrial fauna are likely to move into the surrounding vegetation of greater habitat value increasing pressures on adjacent populations through territorial disputes, and competition for the resources.

Displacement of fauna is likely to be progressive across the life of the Proposal depending on the species. The activity is likely to result in reducing the local populations of some species (e.g.

plants, resident fauna species and less mobile fauna species including reptiles and amphibians) in the proposed works area that may be subject to mortality.

Disrupt the breeding cycle, dormancy period, foraging and roosting behaviour

The breeding cycle, dormancy period, roosting and foraging behaviour of fauna species and flowering and breeding periods of flora species is likely to be affected by the Proposal, particularly for those individuals which are resident within the proposed inundation area.

The Proposal is likely to disrupt the breeding cycle of resident species through the direct removal of breeding habitat (e.g. hollow trees for birds and microchiropteran bats) along Bobo and Valla Roads where road upgrade activities are proposed to take place. Although the level of impact is difficult to gauge, it is not expected to be significant given that hollow-bearing trees are not abundant in the majority of the proposed inundation area and that relevant threatened species, including forest owls and microbats, are highly mobile. Furthermore, the proposed clearing activities are likely to be undertaken throughout the year during the breeding seasons of all species that utilise the study area; however the clearing methodologies and pre-clearance surveys would prevent significant impacts during these breeding seasons

The Proposal could disrupt the roosting behaviour of many native fauna (e.g. forest owls) by directly removing habitat including diurnal roosting sites through the study area (e.g. habitat trees, fallen timber), but given the extent of surrounding vegetation and similar habitats the impacts are not expected to be significant.

All of these habitat resources would be permanently removed from the proposed inundation area and other related infrastructure areas (proposed storage embankment, access roads and riverbank stabilisation works along Nambucca River and South Creek) over the life of the Proposal. Removal of these habitats would reduce the overall availability of harbourage within the study area.

There would be some disruption or alteration of foraging behavior for all species, but would mostly effect those species that are less mobile and/or have smaller home ranges i.e. impacts are likely to be greater on the Koala if the inundation area forms a large proportion of its home range whereas highly mobile forest owls that occupy much more extensive home ranges would be less impacted.

Impacts on Migration and Dispersal Ability

The impact upon the migration and dispersal ability of native flora and fauna like most of the other impacts is species specific. Species, which are less mobile (e.g. reptiles and amphibians), residents (e.g. some birds) or species whereby the habitat forms an important component of the overall habitat area and/or important habitat linkages are those that would most likely be impacted.

The size and shape of existing vegetation and habitats within the study area would be altered. Aside from the direct impacts of the inundation area the construction of roads and additional infrastructure (e.g. power) is likely to create or exacerbate internal vegetation and habitat fragmentation and edge effects.

The inundation of the storage would reduce the opportunities for movement of wildlife along and across Bowra Creek. It is unlikely that a similar riparian ecosystem would be re-established

below the inundation area as the environmental flow characteristics of the inundation area, and the seasonal fluctuation in water levels would not facilitate a similar riparian ecology as pre-inundation.

Connectivity of vegetation immediately surrounding the inundation area and existing links and connectivity with more extensive vegetation in State Forests and Conservation Areas in the wider locality would be maintained. It is also unlikely to impose a significant barrier to more mobile species such as microbats and forest owls.

Disruption of Pollination Cycle and Seed Dispersion

The dispersal ability, pollination cycle and seed bank of the native flora of the proposed inundation area would be reduced through the direct removal of vegetation and inundation. The Proposal would disrupt the recruitment of native plant species within the proposed inundation area. Furthermore, excessive dust from the proposed activities could potentially disrupt the pollination cycle and ability of native plants to regenerate (i.e. germination, revegetation and re-colonisation of existing plants). Mitigation measures to suppress excessive dust are referred in Section 9.8.5.

Introduction of Weeds and Feral Pest Species

The Proposal has the potential to create favourable conditions for introduced weed species within the study area, which could potentially lead to an increase of existing weed populations. It is also likely that the Proposal could exacerbate existing impacts relating to feral animals. This may potentially occur where increased grassland habitats at the storage embankment that may be favourable to Rabbits. Also the areas around the storage that may become more open as seasonal variations dictate the maximum and minimum water levels of the storage this may provide open areas that could make predation of native fauna by Foxes or feral Dogs easier.

Weed control measures would primarily focus on preventing the spread of the noxious weed Giant Parramatta Grass (*Sporobolus indicus*) and to a lesser extent the environmental weed Fireweed (*Senecio madagascariensis*) along private property access roads, access tracks through paddocks and along the pipeline route where surface soils are disturbed in paddocks through the installation of the pipeline and groundwater bores.

A detailed weed audit (see Appendix C) was undertaken to determine the extent and type of existing weed infestations across the private and NSC owned properties where proposed works such as pipeline infrastructure and access roads are likely to be located. The Weed Audit would be instrumental in establishing noxious, environmental and agricultural weed control measures prior to and after the proposed activities, as it provides details on the types of weeds identified and their location in regards to allocated property numbers and Lot numbers.

The potentially cleared land adjoining the upper limit of the inundation area, as well as areas associated with infrastructure such as the storage embankment, access roads, pipeline routes and borefields, would potentially provide bare soil and make conditions favourable for invasive noxious weeds such as Lantana, Small-leaf Privet, Camphor Laurel and Giant Parramatta Grass. Where practical these weeds would be removed from site or controlled by means of herbicide applications to help prevent or minimise their re-occurrence.

Revegetation of this zone would be required as soon as possible after land clearing and infrastructure activities to reduce soil erosion. It would be important to re-establish groundcover

in the form of native grasses, so as to provide competition against invasive noxious weeds. This would also provide some foraging habitat for native fauna.

The increased perimeter of the inundation area and the large variance between the maximum fill level of the storage and dry season condition fill level would create conditions favourable to feral animals, such as Foxes and feral Dogs that may lay in waiting for native fauna accessing the waters edge through open exposed areas. The greater availability of permanent water in the area would also favour feral species, such as Foxes and feral Dogs that rely on water more so then some native species and may begin become permanent residents in the vegetation surrounding the inundation area. As previously noted, the opportunities created in the short term for other pest species, notably Gambusia would expand and would continue to do so over the life cycle of the storage. However it must be noted that Gambusia was not identified in Bowra Creek and the storage is to be filled with groundwater from the borefield, thus significantly reducing the likelihood of Gambusia establishing/ migrating in the storage.

Other impacts

Noise pollution as a result of vehicles, machinery and blasting may deter native fauna from utilising the study area and immediate surrounding areas as habitat. The Proposal could affect the migration and dispersal ability of native fauna particularly in relation to noise and vehicular movements. The Proposal may result in increased noise pollution which has the potential to disrupt the breeding cycle and the foraging and roosting behaviour of some native fauna species.

9.7.3 Instream environment and aquatic flora and fauna

Barrier to Aquatic Fauna

The storage embankment would affect fish and turtle passage along Bowra Creek during periods of high rainfall. The species most affected would be those with migratory or highly mobile characteristics. Whilst barriers to fish and turtle movement can have major impacts on communities by dividing populations (upstream and downstream) and disrupting migration and life cycle stages, the location of the embankment on an empheral waterway is unlikely to result in these impacts. Given the characteristics of Bowra Creek, the provision of a fish ladder is not considered necessary.

It is not envisaged that any additional obstructions would be installed as part of construction activities that would typically limit the passage of native fauna.

The existing obstruction to aquatic fauna where the existing pipeline river crossing is located along the Nambucca River would be alleviated through the provision of a fish ladder, thus allowing the migration of aquatic fauna species above and below the existing obstruction.

Impacts of Groundwater Extraction on the Upper Estuary

The assessment of potential impacts of increased groundwater extraction on the upper estuary has been proceeding for several years.

This process included initial collaboration between a number of Government agencies, the former NSW Department of Commerce as project manager, Nambucca Shire Council and Bishop (consultant) to prepare and evaluate a wide range of scenarios. This in turn lead to

agreement in principle on a scenario for flow rules that protects iconic/indicator species. The understanding was that an adaptive management process would need to link with these rules.

Council then engaged Bishop to undertake ongoing aquatic ecology (baseline) monitoring. This monitoring raised some potential concerns with the flow rules, primarily premised on salt intolerant aquatic flora (plant beds). These findings recommended that some specific hydraulic modelling was required to better understand the impacts that the flow extraction regime may have on salt movements up and down the system. Council engaged a second consultant (Manly Hydraulics Laboratories) to undertake this modelling.

Bishop subsequently reviewed the modelling report and found that there may be some reduction in key plant bed areas downstream, but also a possible stabilisation in plant bed areas in the upper reaches. His analysis indicated that percentile flow limits may perform badly in protecting plant beds (i.e. no protection would be provided by the 95%ile flows, and only two months would be protected with the 90%ile flows). The extent of potential impacts that would occur when extractions continue into the percentile period would be positively related to the volume of water extracted. Bishop went on to say that cease to pump limits based on monthly 80%ile flows would perform better than those based on monthly 90 and 95%ile flows and that additional modelling would be required to better understand these impacts. He noted that, in his opinion, the model had significant limitations and suggested that an adaptive management approach would be appropriate and would be "likely to succeed".

The environmental flow rules developed subsequent to Bishop's work were agreed to in-principle by the then DPI and DIPNR.

In recognition of Bishop investigations, it is proposed that 'cease to pump limits' be based on monthly 95%ile flows with on-going adaptive management monitoring of river levels, flow rates, macrophytes and macroinvertebrates undertaken during the detailed design phase to ensure that changes to the downstream riparian and aquatic ecosystem are minimised, managed and do not impact on their current habitat values. Site specific assessment criteria, based on the 95th percentile levels from available historical data, can be used as early warning triggers that there may be impacts to the riparian vegetation. If statistical trend analysis suggests that there are upward trends in concentrations of toxicants and stressors, modifications would be made to the scheme and/or flow rules.

The implementation of an Adaptive Management Framework has been described in Chapter 4 and the associated monitoring is provided in Chapter 24 of the EIS.The potential impact of not having environmental flow rules would be the reduction of aquatic habitats for native flora and fauna, alterations to temperature regimes, restrictions to fauna migration and subsequent disruptions to breeding cycles of both aquatic flora and fauna and increased potential for mortality.

Inundation Area Habitat Alteration

The inundation area would provide an extensive aquatic habitat and thereby logically increase the availability of overall aquatic habitat. This habitat would retain very little of the characteristics of the existing environment. The primary impact within the inundation area would be the change in environmental flow regime from a high energy, high flow environment with high seasonal variability in flow and volume, to a low energy relatively still waterbody with seasonal variability limited to inundation levels. The alteration of the environmental flows would result in a relatively

rapid (immediately following the construction and finalization of the storage dam embankment) impact on these habitat values. The alteration to existing aquatic habitats within the inundation area would be irrevocable whilst the storage remains.

Changes in Water Quality

The water quality of the Nambucca River and Bowra Creek are currently largely within ANZECC/ARMCANZ (2000) Guidelines for Freshwater Aquatic ecosystem health. This has potential to change in the inundation waters with increased depth due to stratification. Reduced flows downstream have the potential to greatly increase the impacts of nutrient enrichment of Bowra Creek. Changes in downstream water quality from an storage typically include increases in water temperature, nutrient load, turbidity, dissolved gases, and concentration of heavy metals and minerals (including those that are naturally occurring). An increased frequency of discharges of water containing toxic algae may affect the fish and aquatic invertebrate community downstream of the storage.

Cold water pollution may also be an issue for some fauna. While platypuses are well adapted to cold conditions, they require a greater intake of food to regulate their body temperature in cold water and low water temperatures may also affect macroinvertebrate productivity. Furthermore, water temperature is a reproductive cue for fish with breeding occurring at a particular temperature or within a particular range. Many native fish would not breed in colder water.

Low oxygen water from the storage releases can be toxic to benthic macroinvertebrates on which the platypus feeds. Bishop and Harris (1990) suggested that the raising of the storage could result in such toxic effects downstream, possibly including fish kills.

The construction of the storage embankment would cause an increase in nutrient loads within the storage. One of the potential ecological impacts associated with poor water quality within water bodies is the occurrence of algal blooms (cyanobacteria). This potentially toxic alga could be released to the Nambucca River downstream of the storage. The potential causes of algal blooms relate the following:

- Depth and stratification of the storage;
- Water clarity;
- Accumulation of nutrients from both natural sources such as leaf litter and adjoining land uses such as livestock grazing; and
- Low abundance of macrophytes, which would otherwise compete with the algae for nutrients.

Potential ecological impacts associated with blue-green algal blooms include toxic poisoning of aquatic biota such as waterbirds and fish, and adverse impacts on aquatic vegetation and macroinvertebrates.

There is also the possibility of an increase in trace metals in the lower levels of the storage and the possibility of these being transferred downstream. A study undertaken in Tasmania (Munday *et al.* 2002), found elevated levels of persistent pesticide residues and PCBs (polychlorinated biphenyls) in platypuses but not at levels, which have produced reproductive or immune system

depression in other species. It is known, however, that trace metals can affect the reproductive success of fish and can bio-accumulate in macroinvertebrate communities.

The implementation of an Adaptive Management Framework has been described in Chapter of 4 and the associated monitoring is provided in Chapter 24 of the EIS.

Increased Invasion by Pest Species

Gambusia has been identified in Bowra Creek and is an immediate and severe threat to aquatic habitats in the area. This species prefers lakes and slow moving streams thus the inundation would create conditions conducive to the establishment of populations of Gambusia. However it must be noted that Gambusia was identified in Bowra Creek and because the storage is to be filled with groundwater from the borefield and the construction of the storage embankment creating a physical barrier, the likelihood of Gambusia migrating into and establishing in the storage is significantly reduced. Appropriate mitigation measures associated with monitoring the potential impacts of this species are provided in Section 9.8.7.

Siltation

Increases in silt load and turbidity in Bowra Creek downstream of the storage are likely to occur as a result of construction work. This could potentially result in a reduced food supply and loss of large-particle substrates and deep-water habitats for fish, as well as effects of suspended solids on native fish. The benthic substrates of Bowra Creek and its tributaries are largely coarse sand and fine gravel, which are re-suspended during flow events. Sediment released during construction and/or operation of the storage could result in the filling of interstitial spaces in the rough substrates (gravel, cobbles and boulders) in which macroinvertebrate food species are found.

The inundation area would to a large degree prevent the re-suspension of sediments below the storage embankment under normal seasonal conditions (non-flood events) consequently having an adverse impact on the benthic substrates and their dependent macroinvertebrate communities. The lack of significant flows immediately below the inundation area would result in sediments settling out of suspension (or not being suspended at all) resulting in increased sediment deposition and changes in channel morphology. These impacts lessen with distance from the storage embankment and may be ameliorated through controlled releases from the inundation area during low flow periods.

Turbidity can also affect the light availability to macrophytes resulting in reduced productivity and supply of organic material to the stream food web.

Changes in Downstream Morphology of Riverbed and Banks

The storage would reduce the magnitude and frequency of flood events and a likely impact of this would be the reduction of channel width of Bowra Creek downstream of the inundation area. This has the potential to provide habitat favourable to invasive flora (Parrots Feather) and fauna (Gambusia) and would compromise the habitat potential for native aquatic species as environmental conditions change.

Potential Changes to Habitats in the storage as a Result of Water Level Fluctuations

The rise and fall in water level resulting from water extraction can influence the physical nature of the substrate within the littoral zone of the storage. For example, storage near full storage

level may contain a high proportion of rocky substrate or woody debris, whilst substrate at a lower level may be predominantly sand or silt. Thus, as water levels fall the habitat changes from rock to silt, a change that may well result in shifts in species assemblages as mobile species migrate to areas closer to being their preferred habitat.

Inundation of Riffle Habitats

Inundation of the headwater of Bowra Creek would result in the loss of shallow riffles and run zones that occur periodically along this ephemeral creek. These zones are regions of high productivity, which are lost when a waterbody is impounded. Many types of macroinvertebrates and microscopic organisms are confined to riffles, and these are highly productive areas providing a food supply for other components of the aquatic system.

Reduced flood events

The flora and fauna populations of the catchment are adapted to annual flood events. The construction of the storage would not only alter flows but also reduce the magnitude and frequency of these flood events. These impacts lessen with distance from the storage dam embankment as tributaries contribute to flood events.

Long-term Flow Alteration below Inundation Area

Flow variations are important to the lifecycles of resident fish and turtle populations. Flow variation can result in exposed sand banks becoming available for turtle nesting and alter water temperature – a key trigger in the promotion of hormonal changes for fish prior to breeding. The area's communities are adapted to the seasonal flows of the catchment and changes to the existing regime would impact on the abundance and diversity of fauna populations. The incorporation of a controlled release program from the storage to maintain environmental flows would be the key element in mitigating long-term impacts on the river environment below the storage.

Further details of the environmental flow rules in regards to impacts below the storage are available in Chapter 4 of the EIS.

Changes in Flooding and Flow Regime Downstream of the storage

River regulation produces a much more constant flow of water. This constancy has had ecological impacts such as aiding the spread of non-native fish species. The practice of capturing water in winter and releasing it in summer has overturned the normal flow pattern in southern regulated rivers. Seasonal patterns in flow and water temperature are key factors influencing several native fish species to mature and spawn, and are critical for their growth. Flow and temperature patterns also control the diversity of aquatic invertebrate animals and other fauna.

This impact would also result in a change in the distribution of riparian vegetation along the banks of Bowra Creek below the storage. This change in vegetation community distribution would occur gradually in response to the new flooding and flow regimes. However, changes may be partly offset by increased visitation to the storage by fauna species that prefer storage and lagoon conditions.

Additionally if storage releases are not appropriately controlled and sudden high volume releases were to occur bank instability and erosion along Bowra Creek below the storage would

be likely, especially if the structural characteristics of riparian vegetation were to change due to changed flow conditions. Monitoring of the transparent operation of the storage would ensure that this does not occur or is minimised.

Groundwater Extraction and Potential Impacts on Riparian Vegetation Structural Characteristics and Bank Stability

The extraction of groundwater from the aquifer associated with the borefields have the potential in the long-term to reduce flow rates and surface water levels and increase groundwater depths in the Nambucca River and South Creek. This may potentially lead to the gradual change in the structural characteristics of riparian vegetation communities.

It must be noted that the majority of riparian vegetation is comprised of introduced species such as Camphor Laurel, Small-leaf Privet and Lantana, which are expected to be tolerant of reduced flow rates and surface water levels and increased groundwater depths.

Interrelationship between Groundwater, Streamflow and the Aquatic and Riparian Environment

There exists the potential for imbalances between the interrelationships between groundwater, streamflow and the aquatic and riparian environment characteristics, due to the extraction of groundwater from the borefield reducing the aquifer and thus altering this interrelationship. The environmental flow rules designed for the extraction of groundwater and the transparent operation of the storage would maintain the interrelationship/ balance between groundwater, streamflow and the aquatic and riparian environment to a level close to what is presently occurring naturally. Therefore potential impacts upon these characteristics are minimal and are unlikely to have adverse effects upon the existing ecology.

Further details of the environmental flow rules in regards to impacts below the storage are available in Chapter 4 of the EIS.

Likely Changes and Impacts on Flora and Fauna adjacent to the Stored Waterbody

When the storage is filled with water, the ground surrounding the perimeter of the stored waterbody would become laidened with increased amounts of groundwater. This would potentially impact upon the floristic characteristics of existing vegetation communities, where some species may perish and others may begin to appear or dominate. Also the water level of the inundation area would fluctuate and only those species tolerant of such fluctuations are likely to persist over the long-term.

The primary risk associated with increased groundwater would be the potential for weeds or natives that may be more tolerant of such conditions becoming invasive. This may then potentially impact on the diversity of flora species where water levels may fluctuate throughout the seasons and alter the habitat values for native fauna, due to a reduced level of biodiversity; however the extent of this occurring may only be limited to this thin area around the perimetre of the storage.

Seasonal Clearing of Vegetation

If vegetation were to be cleared during periods of wet weather soil erosion and sedimentation of waterways is likely. The clearing of vegetation in all areas would be responsive to wet weather during the wetter months of the year between March and May. During the remainder of the year

erosion and sediment control measures would alleviate soil erosion and sedimentation of waterways.

Dispersion Capacity of Local Clays

The clay soils of the inundation area are moderately dispersive and can be appropriately managed to minimise dispersion and potential impacts upon aquatic flora and fauna downstream of the storage embankment. Potential impacts may be associated with increased suspension of fine sediments in the lower reaches of Bowra Creek restricting light penetration and reducing water quality that may potentially impact upon the photosynthesis of aquatic flora and make conditions unfavourable to aquatic fauna.

These impacts can be minimised through applications of gypsum where these soil types are exposed and the installation of sediment traps and coffer dams.

9.7.4 Groundwater Dependent Ecosystems

Although it is not possible with the available information to confidently determine the degree of dependence of the vegetation communities in the inundation area upon groundwater, such that a relationship between the community and the groundwater can be established, potential impacts of the Proposal upon vegetation communities (ecosystems) likely to be at least partially dependent upon groundwater are inferred from the literature as well as the existing groundwater environment and likely impacts upon groundwater as described in the EIS.

In general, the recognised threats to groundwater dependent ecosystems (Sinclair Knight Merz, 2001) include:

- Groundwater resource development;
- Changes in land use – particularly from native vegetation to agriculture or agriculture or native vegetation to plantation forestry;
- Activation of acid sulphate soils in coastal areas by drainage, dredging or groundwater extraction;
- Dewatering or water resource development associated with mining; and
- Commercial, urban or recreational developments.

Key potential impacts to groundwater dependant ecosystems related to these threats include alteration of the water regime experienced by groundwater dependent ecosystems resulting in changes in the structure, function and/or composition of the ecosystem (Sinclair Knight Merz, 2001) as well as the potential for detrimental changes to the groundwater quality to impact upon the vegetation. It is noted that impacts associated with lowered water tables upon groundwater dependant ecosystems can take place over an extended time and can lead to decline in growth, recruitment and enable invasion by exotic species (Eamus, 2009).

The activities (besides clearing) that could have potential impacts upon groundwater dependent ecosystems include:

- Cutting through areas of higher elevation;
- Construction of embankments over low-lying areas; and
- Potential risks associated with construction activity including fuel spills.

Impacts associated with these include:

- Groundwater drawdown;
- Groundwater impedance; and
- Groundwater quality impacts, including groundwater acidification or contamination.

Vegetation dieback may be the potential impact upon groundwater dependant ecosystems and would become apparent over the long-term as the storage is operating and as the environmental flow rules are applied.

The environmental flow rules would alleviate any potential impacts upon groundwater dependant ecosystems of the study area in particular riparian vegetation. Any noticeable impacts upon groundwater dependant ecosystems in the study area would be reflected in the operation of the environmental flow rules and changes could be made accordingly.

Groundwater Drawdown

Despite the operation of flow rules, the extraction of groundwater from the aquifer associated with the borefields may over the long-term reduce flow rates and surface water levels and increase groundwater depths in the Nambucca River and South Creek. This may potentially lead to the gradual change in the floristic characteristics of riparian vegetation communities. This may then lead to riverbank instability if some riparian species were to begin to die off.

It must be noted that the majority of riparian vegetation is comprised of introduced species such as Camphor Laurel, Small-leaf Privet and Lantana, which are expected to be tolerant of reduced flow rates and surface water levels and increased groundwater depths.

Ongoing monitoring of river levels and flow rates would be necessary to ensure that changes to the riparian vegetation are minimal, manageable and do not impact on their current habitat values. This would be most important if extraction regimes are to change.

Excavation within the inundation area could also contribute to localised drawdown through drainage of groundwater from within the storage and from the altered recharge regime. However as these areas are within the upper part of the catchment where the groundwater is at depth, it is not expected that groundwater dependent ecosystems would be impacted as a result of this activity.

Drawdown of the alluvial aquifers may also occur along the floodplain areas as part of the borefield collection pipeline system. This could occur as a result of dewatering during trenching construction. The potential for groundwater drawdown to the degree that the groundwater table is significantly lowered is considered to be minor. As such floodplain, wetland, riparian and aquatic communities are not likely to be impacted. In addition, as these vegetation communities are unlikely to be solely dependant upon groundwater for their environmental water requirements, any temporary or localised impacts associated with dewatering are not likely to result in any long term impacts to these communities.

Groundwater Impedance

Constructing hard compacted surfaces across the Bowra Creek could potentially result in localised impedance to shallow groundwater flow. This may result in localised higher water table on the up-gradient side of the embankment, and lower on the other. With respect to groundwater dependent ecosystems, this could increase the availability of water on the side

where flows are impounded, while a reduction of groundwater availability may occur on the side where groundwater has been impeded. This is only likely to be a localised effect, and only likely to occur where groundwater flow occurs within a few metres of ground surface, and would be adequately catered for by typical drainage facilities associated with construction. Again, as the communities are unlikely to be solely dependant upon groundwater for environmental water requirements, then minimal impact is expected. It is also of note that much of the Bowra Creek catchment has been subject to clearing through forest operations and agriculture and is likely to have been previously subjected to groundwater changes.

Groundwater Quality Impacts

Potential impacts associated with groundwater quality could result from activation of saline waters due to drawdown of groundwater in the floodplain, or from fuel or chemical spills that could occur during construction.

- In relation to activation of saline waters, it is considered that only minor impacts to the groundwater level would result from the Proposal, this is unlikely.
- Localised fuel or chemical spills, while having potential for impacts upon groundwater and riparian systems, may be mitigated. As such they are considered unlikely to significantly impact upon groundwater dependent ecosystems.

Chapter 10 – Surface and Groundwater discusses the existing groundwater environment in the study area, identifies likely impacts as a result of the Proposal, and proposes management measures to reduce these impacts.

9.7.5 Key Threatening Processes relevant to Proposal

A threatening process is defined under the FM Act and TSC Act as 'a process that threatens, or that may threaten, the survival or evolutionary development of a species, population or ecological community'. Threatening processes that adversely affect threatened species, populations or ecological communities, or possibly cause others that are not currently threatened; to become threatened are listed as key threatening processes (KTPs) under the TSC, FM and EPBC Acts. KTPs relevant to the Proposal are discussed in Table 9-10 Key Threatening Processes Relevant to the Proposal.

The proposed mitigation measures to minimise the potential of exacerbating each of the KTPs include:

- Weed control in particular Lantana;
- Environmental Flow Rules;
- Provision of a protection area;
- Placement of removed hollow trees and logs into protection area;
- The provision of fish passage where applicable.

Table 9-10 Key Threatening Processes Relevant to the Proposal

Key Threatening Process	Relevance to proposal
Invasion of native plant communities by exotic perennial grasses	There exists the potential for the spread of Giant Parramatta Grass (*Sporobolus fertilis*) along the pipeline route, borefields, upgraded roadsides and the storage embankment. This species has been already recorded within the study area.
Invasion, establishment and spread of Lantana camara	There exists the potential for the spread of Lantana (*Lantana camara*) along the pipeline route, upgraded roadsides, the storage embankment and around the perimeter of the inundation area. This species has been already recorded within the study area.
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.	The storage would inundate the upper reaches of Bowra Creek resulting in that portion of the creek becoming an artificial lake. Transforming this ephemeral first order stream into a stationary water body. The lower reach of Bowra Creek would have reduced flows as a result of the storage's construction. The groundwater that would be extracted from the proposed borefields would impact on the flow rates of the Nambucca River and South Creek.
Clearing of native vegetation	Approximately 65.05 ha of native vegetation is to removed from within the inundation area, embankment footprint and upgraded access roads, and 1.49 ha from the location of proposed riverbank stabilisation works. A total of 66.54 ha from within the study area.
Loss of Hollow-bearing Trees	Some hollow bearing trees would be removed from the proposed works area at specific locations as part of proposed road upgrade works along Valla and Bobo Roads to allow access for large vehicles into the study area. The majority of road upgrade activities would be occurring in association with tight corners. It is at these locations where the removal of hollow bearing trees is inevitable as part of cut and fill road construction practices.
Removal of dead wood and dead trees	Dead wood and debris would not be removed as such; it would either be left where it lies or mulched and then inundated as the storage fills to capacity. Much of this debris would be left behind with the initial harvesting and clearing activities within the inundation area.
Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams	Bowra Creek would have a substantial permanent instream structure constructed that would permanently inundate the upper reach of the creek and would result in permanently altering the natural flow regimes of the creek.

Key Threatening Process	Relevance to proposal
Degradation of native riparian vegetation along NSW water courses	The riparian vegetation along Bowra Creek, Nambucca River and South Cree is in poor to moderate condition. All are already considered degraded in regards to healthy viable native riparian vegetation. The upper reach of Bowra Creek would be permanently inundated and altered. Some of the riparian vegetation along Nambucca River and South Creek is to be minimally impacted as part of riverbank restoration works and may benefit the long-term persistence of this vegetation and thus reducing the impact of this KTP.
Removal of large woody debris from New South Wales rivers and streams	Large woody debris would be inundated in the upper reach of Bowra Creek and it is not anticipated that any large woody debris would be removed along the Nambucca River or South Creek in association with proposed pipeline routes.

9.7.6 Significance of Potential Impacts

NSW Threatened Species and Endangered Ecological Communities

Section 5A of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of a proposed development on 'threatened species, populations or ecological communities (or their habitats)' listed under the TSC Act. The Assessment of Significance (AoS) '7-part test' is used to determine whether a proposed development is 'likely' to cause 'a significant effect' on threatened biota and thus whether a Species Impact Statement (SIS) is required to accompany the DA.

The AoS is to be applied to each species, population and ecological community that was recorded during the survey within the study area or is likely to exist or utilise habitat within the study area.

Flora

The findings of the 8-part tests undertaken by Connell Wagner and Biosis in regards to threatened flora species that may potentially occur in the locality determined that no significant impacts upon threatened flora were considered likely in regards to the proposed activities.

No threatened flora was identified during the current survey, however 7-part tests have been undertaken for four threatened species that could potentially occur based on known distributions and the habitats present within the study area.

A summary of the potential impacts and proposed mitigative measures for relevant threatened species and the conclusions of the 7-part tests is provided in Table 9-11. The detailed assessments of significance (7-part tests) are provided in Appendix C. It is unlikely that the Proposal would result in 'a significant impact' on any threatened flora species in light of the mitigation measures provided in Section 9.8.

Fauna

The findings of the 8-part tests undertaken by Connell Wagner and Biosis in regards to threatened fauna species that may potentially occur in the locality determined that no significant impacts upon threatened fauna were considered likely in regards to the proposed activities.

An AoS was completed for the 14 threatened fauna species identified in Table 9-12, seven of which were recorded and seven that were considered likely to occur. See Appendix D for the completed AoS. It is unlikely that the proposal would result in 'a significant impact' on any threatened fauna species in light of the mitigation measures provided in Section 9.8.

Table 9-11 Summary of AoS for threatened flora species and endangered ecological communities

Species	Potential Impact	Description	Proposed Mitigation Measures	Significant Impact
Rusty Plum	Loss of habitat	The removal of vegetation communities in which this species could potentially occur.	The vegetation surrounding the inundation area (that comprises the same vegetation communities as would be cleared as a result of the proposed development) is to be acquired by NSC from NSW Forests. This area would be retained and conserved as a protection area to the proposal. The proposed protection area would ensure that existing or potential habitat for this species in the immediate locality of the dam would be conserved into the future.	Significant impact unlikely
Tylophora	Loss of habitat	The removal of vegetation communities in which this species could potentially occur.	The vegetation surrounding the inundation area (that comprises the same vegetation communities as would be cleared as a result of the proposed development) is to be acquired by NSC from NSW Forests. This area would be retained and conserved as a protection area to the proposal. The proposed protection area would ensure that existing or potential habitat for this species in the immediate locality of the dam would be conserved into the future.	Significant impact unlikely
Minute Orchid	Loss of habitat	The removal of vegetation communities in which this species could potentially occur.	The vegetation surrounding the inundation area (that comprises the same vegetation communities as would be cleared as a result of the proposed development) is to be acquired by NSC from NSW Forests. This area would be retained and conserved as a protection area to the proposal. The proposed protection area would ensure that existing or potential habitat for this species in the immediate locality of the dam would be conserved into the future.	Significant impact unlikely
Leafless Tongue Orchid	Loss of habitat	The removal of vegetation communities in which this species could potentially occur.	The vegetation surrounding the inundation area (that comprises the same vegetation communities as would be cleared as a result of the proposed development) is to be acquired by NSC from NSW Forests. This area would be retained and conserved as a protection area to the proposal. The proposed protection area would ensure that existing or potential habitat for this species in the immediate locality of the dam would be conserved into the future.	Significant impact unlikely
River-flat Eucalypt Forest on Coastal Floodplains EEC	Loss of community	The removal of riparian vegetation that resembles this EEC as part of Riverbank Stabilisation Works.	Retain as many of the dominant tree species that occur in this EEC if vegetation that resembles this EEC are identified in areas where riverbank stabilisation works are proposed to occur.	Significant impact unlikely

Table 9-12 Summary of AoS for threatened fauna species

Species	Potential impact	Description	Proposed Mitigation Measures	Significant Impact
Forest Owls (Barking, Masked, Sooty and Powerful Owls)	The Barking, Masked and Sooty Owls were recorded in the study area, whilst the Powerful Owl has the potential to occur in the locality. Loss of habitat	The potential removal of stags and hollow bearing trees from the study area that may provide roosting and breeding habitat. The potential for reducing some foraging habitat that is considered of lower foraging value to these species in comparison to habitat in surrounding lands.	Identify and flag stags and hollowbearing trees to be removed as part of the proposed activities. Pre-clearance surveys of identified stags and hollow bearing trees prior to removal. Inspect any fallen stags and hollow bearing trees for forest owl nests prior to removal. Undertake appropriate measures in case these species become injured as the result of felling stags or hollow bearing trees. The protection area comprising of 122.58 ha is of suitable habitat for the forest Owls and is to be conserved and excluded from logging practices.	Significant impact unlikely
Glossy Black Cockatoo	This species has the potential to occur in the locality. Loss of habitat	The potential removal of stags and hollow bearing trees from the study area that may provide roosting and breeding habitat. The potential for reducing some foraging habitat that is considered of lower foraging value to this species in comparison to habitat in surrounding lands.	Identify and flag stags and hollowbearing trees to be removed as part of the proposed activities. Pre-clearance surveys of identified stags and hollow bearing trees prior to removal. Undertake appropriate measures in case these species become injured as the result of felling stags or hollow bearing trees. The protection area comprising of 122.58 ha is of suitable habitat for the Glossy Black Cockatoo and is to be conserved and excluded from logging practices.	Significant impact unlikely

Species	Potential impact	Description	Proposed Mitigation Measures	Significant Impact
Wompoo Fruit-dove	This species has the potential to occur in the locality within rainforest vegetation. Loss of habitat	The potential removal of potential foraging and breeding that is considered of lower habitat value to this species in comparison to habitat in surrounding lands, in particular rainforest vegetation.	The potential foraging and breeding habitat for the Wompoo Fruit-dove in the study area is considered unfavourable to the species because there is limited rainforest vegetation that is structurally modified. As this species is highly mobile and able to relocate into more favourable rainforest habitats no specific mitigation measures are considered necessary and the 122.58 ha of a protection area may potentially provide an immediate refuge for the species.	Significant impact unlikely
Koala	One Koala was recorded in the study area. Loss of habitat and potential for mortality of Koalas as a result of land clearing.	The potential removal of viable breeding habitat in the study area. The potential removal of foraging habitat associated with Koala feed trees that are scattered throughout the study area.	Identify and flag Koala feed trees during pre-clearance surveys and inspect flagged trees prior to felling. If Koalas are identified undertake the appropriate protocols to limit the potential risk of injury or mortality to individuals of this species. Undertake appropriate measures in case this species become injured as the result of felling trees. The identified clearing practices would assist in the safe relocation of Koalas. The protection area comprising of 122.58 ha is of suitable habitat for the Koala and is to be conserved and excluded from logging practices.	Significant impact unlikely
Grey-headed Flying-fox	This species has the potential to occur in the locality. Loss of habitat	No Grey-headed Flying-fox roosting camps were identified in the study area where proposed land clearing activities are to take place. The potential loss of some foraging habitat that is of lower value to the species in comparison to surrounding habitats.	As this species is highly mobile and able to relocate into more favourable foraging habitats no specific mitigation measures are considered necessary and the 122.58 ha of a protection area may potentially provide an immediate refuge for the species.	Significant impact unlikely

Species	Potential impact	Description	Proposed Mitigation Measures	Significant Impact
Spotted-tail Quoll	This species has the potential to occur in the locality. Loss of habitat and potential for mortality of Spotted-tail Quolls as a result of land clearing.	The potential removal of hollowlogs and rocky outcrops from the study area that may provide denning and breeding habitats. The potential for reducing foraging habitat that is considered of lower foraging value to these species in comparison to habitat in surrounding lands.	Identify and flag any hollowlogs and rocky outcrops that may provide potential denning and breeding habitat during pre-clearance surveys and inspect flagged sites prior to land clearing. Relocate any hollowlogs and large rocks into the protection area to provide potential denning and breeding habitat. The identified clearing practices would assist in the safe relocation of Spotted-tail Quolls. Control any potential feral pests (Foxes and feral Dogs) that may potentially occur in the study area The protection area comprising of 122.58 ha is of suitable habitat for the Spotted-tail Quoll and is to be conserved and excluded from logging practices.	Significant impact unlikely

Species	Potential impact	Description	Proposed Mitigation Measures	Significant Impact
Eastern Bentwing-bat, Little Bentwing-bat and Golden-tipped Bat.	These microbat species were recorded in the study area. Loss of habitat and the potential for mortality of individuals as a result of land clearing.	The Eastern Bentwing-bat and Little Bentwing-bat primarily occupy cave/mine shaft habitats where breeding colonies roost and may on occasion roost in stags or hollow bearing trees of the study area. The Golden-tipped Bat may potentially roost in abandoned hanging bird nests typically associated with dense riparian vegetation. The potential loss of foraging habitat that is considered of lower foraging value to these species in comparison to habitat in surrounding lands. The potential loss of some flyways along existing fire trails that may potentially be removed; however the high mobility of these species and the continuation of the flyways in the broader study area would ameliorate these impacts.	Identify and flag stags, hollowbearing trees and hanging bird nests to be removed as part of the proposed activities. Pre-clearance surveys of flagged stags, hollow bearing trees and hanging bird nests prior to removal. Inspect any fallen stags and hollow bearing trees for microbats prior to removal. Undertake appropriate protocols to handle and relocate any microbats found in stags, hollow bearing trees and hanging bird nests. In the case of the Golden-tipped Bat, provide bat boxes in the protection area for any individuals that need to be relocated from hanging bird nests. Undertake appropriate measures in case these species become injured as the result of felling stags or hollow bearing trees. The protection area comprising of 122.58 ha is of suitable habitat for the Micro-bat species and is to be conserved and excluded from logging practices.	Significant impact unlikely
Giant Barred Frog and Southern Barred Frog	These frog species have the potential to occur in the locality. Loss of habitat and the potential for mortality of individuals as a result of land clearing.	The potential removal of viable breeding habitat in the study area. The potential removal of foraging habitat in dense moist forested gullies. The potential of individuals of these frog species being present in the study area where suitable habitat may be available is unlikely because of past logging and land clearing practices.	If any individuals of these species are found during pre-clearance surveys or land clearing activities, care would be taken to relocate them into dense moist gullies that may occur along drainage lines in the study area. The protection area comprising of 122.58 ha is of suitable habitat for the Giant Barred frog and Southern Barred Frog and is to be conserved and excluded from logging practices.	Significant impact unlikely

Endangered Ecological Communities

As detailed in Section 9.3.4 the riparian vegetation of the Nambucca River and South Creek is not considered to comprise the River-flat Eucalypt Forest on Coastal Floodplains EEC as determined by the Scientific Committee. However, a precautionary approach has been taken and an assessment of significance has been prepared with respect to this community (refer to Appendix D).

A similar riparian community was also recorded at various locations on the upper slopes of Bowra Creek catchment. These areas of vegetation are not considered to constitute 'floodplain' ecosystems and hence are not considered to constitute this EEC.

No other EECs listed under the TSC or EPBC Acts were recorded in the study area.

Assessment under EPBC Act Significance Guidelines

The assessments of significance were carried out in accordance with EPBC Act guidelines.

In January 2007, the Commonwealth and NSW governments signed a Bilateral Agreement which allows DEWHA to accredit the assessment regimes under Part 3A, Part 4 and Part 5 of the EP&A Act for assessment purposes under the EPBC Act. The Bilateral Agreement applies only to proposals that the Commonwealth Environment Minister has determined are controlled actions under the EPBC Act, with the exception of nuclear actions (DoP 2007).

A number of EPBC Act listed threatened species have previously been recorded or are predicted to occur in the locality. The NSW Wildlife Atlas (DECC, 2008) also revealed records of EPBC Act listed threatened species previously recorded in the locality. EPBC Act listed threatened species are discussed above, along with TSC Act listed biota, and described in detail in Appendix C.

The matters of national environmental significance (NES) listed under the EPBC Act of potential relevance to the study area are:

- Threatened fauna species (e.g. Spotted-tail Quoll, Giant Barred Frog);
- Threatened flora species (e.g. Minute Orchid, Tylophora); and
- Migratory species (e.g. Rufous Fantail, Cattle Egret).

No world heritage properties, national heritage places, Ramsar sites or threatened ecological communities are relevant to the study area.

Potential Impacts on Nationally Listed Threatened Species

No threatened flora species listed under the EPBC Act were recorded at the site; however ten threatened species are known or predicted to occur in the locality. These species are presented in Appendix C, along with an assessment of their habitat requirements and likelihood of occurring at the site. The likelihood of occurrence revealed that three species might possibly occur in the study area, Leafless Tongue Orchid, Minute Orchid and Tylophora. Targeted surveys of the inundation area did not locate any individuals of these species, nor any evidence that important habitat occurs at the site (Biosis, 2005). Therefore the Proposal is unlikely to have a significant impact on any EPBC Act listed flora species as was determined whilst undertaking the 7-part tests for each of these species.

No threatened fauna species listed under the EPBC Act was recorded at the site during the current study. Fourteen species have been previously recorded in the locality of which six may utilise habitat at the site (refer Appendix C). Based on the results of this and other assessments four EPBC Act listed fauna species are likely to occur at the site and potentially be affected by the Proposal:

- Spotted-tail Quoll;
- Giant Barred Frog;
- Southern Barred Frog; and
- Grey-headed Flying-fox.

The outcome of the EPBC Act AoS is that the proposed development is not likely to have a significant impact on any nationally listed threatened species, which may occur at the site in concurrence with the proposed management measures listed in Section 9.8.

Potential Impacts on Migratory Species

The study area provides habitat for a number of EPBC Act listed migratory bird species including the Rufous Fantail and Cattle Egret, which were observed during field surveys. Native vegetation and aquatic habitat at the site are likely to be used by a range of terrestrial, wetland and marine migratory species on a periodic basis.

The habitat to be removed is 80.09 ha in total, inclusive of open grasslands and riparian vegetation associated with access roads and storage embankment infrastructure. Therefore the habitats to be removed are not considered to constitute critical or important habitat for any listed species under the migratory bird provisions of the EPBC Act, because the habitat values of these vegetation communities is considered moderate to poor in relation to surrounding lands and any migratory species that may potentially use the study area as a habitat resource may only do so on a transient basis.

Further, modification of the habitat through inundation is unlikely to make it unsuitable for occupation by the majority of migratory species. Migratory waterbirds are likely to occupy the site during inundation periods, such as the White-bellied Sea Eagle. The Proposal is also unlikely to create a barrier to migration, increase the risk of injury or mortality or otherwise impact on migratory species. Therefore the Proposal is unlikely to impose "a significant effect" on any of the listed migratory fauna species, which could possibly occur in the study area on occasion, in particular the Rufous Fantail and Cattle Egret.

9.8 Mitigation Measures

The following mitigation measures would be implemented:

- Mitigation measures to be undertaken prior to commencement of Proposal (e.g. pre-clearance surveys);
- Mitigation measures to be undertaken during the Proposal (e.g. clearly marking areas to be cleared); and
- Mitigation measures to be undertaken after the Proposal has been completed (e.g. the provision of a protection area and environmental monitoring of the study area).

These measures would be implemented to ensure that any unforeseen potential impacts that may occur upon any threatened biota that are known to occur or may potentially occur, or their habitats that are known to occur or could potentially occur within the study area. These measures would also ensure that the impacts upon other native flora and fauna and the general environment of the study area would also be minimised.

9.8.1 Mitigation Measures prior to commencement of Proposal

Preparation of Environmental Management Plans

A CEMP would be prepared for the Proposal and would include:

- An Erosion and Sediment and Control Plan (ESCP) would be developed and implemented before, during and after the works to protect soils and prevent erosion after rainfall events and wind erosion, particularly for works along the steeper slopes and where moderately dispersive soils are identified. Sediment and erosion control structures, which conform with the relevant guidelines, would be installed in stages as vegetation is cleared and appropriately installed where major infrastructure is to be located e.g. dam embankment and access roads;
- A Weed Management Plan (WMP) would be developed in the design stage of the storage and initiated prior to works commencing for implementation before, during and after the works are completed to prevent the spread of introduced species and declared noxious plants recorded within the study area. The WMP would encompass the areas where infrastructure is to be upgraded or developed along the pipeline route, borefield locations, access road upgrades and the dam embankment. Due to under riverbed boring for the pipeline being undertaken, it is not envisaged that riparian vegetation along Nambucca River or South Creek would be adversely impacted. Therefore revegetation and rehabilitation works for these areas is not necessary;
- A Flora and Fauna Management Plan (FFMP) comprising of sub-plans to provide protocols/management strategies to minimise adverse impacts on retained native vegetation and habitat and resident fauna (e.g. pre-clearing and clearing surveys), these are described in more detail below:

9.8.2 Protocols to Protect Vegetation prior to Clearing

- Areas of native vegetation that needs to be cleared would be clearly marked on maps and identified with parawebbing or flagging tape in the field to ensure that clearing does not occur beyond the area necessary for the Proposal; and
- Locating the construction compounds and materials stockpiles in areas that are currently cleared or disturbed wherever possible. This would reduce the need to clear additional areas of natural vegetation.

9.8.3 Protocols to Protect Fauna prior to Clearing

Pre-clearance Survey

It is recommended that a pre-clearance survey be conducted prior to the commencement of any of the proposed activities to identify and flag Koala habitat trees, hollow bearing trees, stags, rocky outcrops, large hollow logs and hanging bird nests, preferably by a qualified ecologist.

A two staged approach would be used to undertake for the pre-clearance surveys as specified below.

Stage 1 – prior to commencement of clearing

Inspection of clearing areas to identify and mark habitat features (large trees with obvious hollows, rocky outcrops, large logs, hanging bird nests etc.) that would need special attention during clearing and to identify features suitable for placement into the protection area to maintain habitat resources (e.g. large rocks and logs).

Stage 2 – surveys during clearing

- Inspection for Koalas and follow protocols relating to Koalas if one is found;
- Banging of habitat trees, careful felling and inspection of hollows once felled (protocols for this are described below);
- Inspection of hanging bird nests for Golden-tipped bats;
- Adhere to protocols for removing fauna e.g. bats, temporarily holding and releasing at dusk to be developed in consultation with DECCW and detailed in fauna management sub-plan of CEMP;
- Inspection of other habitat features ahead of clearing e.g. rocky outcrops and large hollow logs for Spotted-tail Quolls or other denning fauna; and
- Make sure that any fauna that is disturbed are encouraged to move into areas of retained habitat, dealing with injured animals if required in accordance with injured animal protocols.

Habitat inspection and relocation

Habitat inspection of the clearance zone to identify any logs, rocks or other fauna habitats considered suitable for relocation into nearby habitat areas. Habitat suitable for relocation marked with paint to be relocated to protection area. Any felled trees and limbs that were considered suitable for habitat relocation including limbs with hollows, cracks and fissures and shedding bark. Other limbs without these attributes currently may also be used for habitat relocation, as fissures would form in time as these felled limbs decay.

9.8.4 Protocols to Protect Fauna during clearing

A suitably qualified ecologist must be on site during the removal of Koala habitat trees, hollow bearing trees, stags, rocky outcrops, large hollow logs, hanging bird nests and other significant habitat components (as identified in the pre-clearance surveys), to ensure all items are checked. Any injured fauna as a result of the clearing activities must be attended to by a member of WIRES or by a local veterinarian. Protocols relating to certain species are outlined in the following sections.

Vegetation Clearing Protocols

The vegetation clearing protocols would include:

- Hollow logs, leaf litter and woody debris and large boulders that provide refuge for native fauna identified during the pre-clearing surveys would be removed during construction would be redistributed into the protection area. This would minimise the removal of dead wood from the locality, which has been listed on the TSC Act as a key threatening process;
- Each stage of vegetation clearing undertaken by DI&I and then the contractor to NSC would commence from the storage embankment and work upslope through the inundation area;
- Trees would be felled away from retained vegetation where possible to reduce the incidence of unnecessary impacts to adjacent vegetation;
- Fallen timber in the form of hollow bearing trees or stags would be gently lowered during felling and carefully placed into the edge of adjacent forest that is to be retained, whilst avoiding access by heavy machinery into this 'no go' area (i.e. area beyond the cleared storage perimeter). This practice would ensure that additional habitat is provided or maintained for any threatened fauna potentially relocating. This would be completed under supervision by an ecologist or appropriately qualified person;
- Ensure an experienced ecologist or wildlife handler is present to manage and retrieve any displaced wildlife during clearing activities. The handling protocols are detailed below for uninjured and injured fauna;
- Relocating displaced fauna to similar habitat at the closest available secure location; and
- Exposed surface soil would be stabilised as soon as possible to avoid potential erosion (by mulching, covering or replanting with native grass species where appropriate).

Fauna monitoring during clearing

Vegetation or other habitat features identified as potentially harbouring fauna would be monitored by an ecologist during clearing activities.

Removal of Hollow-bearing Habitat Trees and Large Hollow Logs

Particular attention would be given to those trees with substantial hollows or large hollow logs identified during the initial pre-clearing site investigation as potential habitat for native fauna. Adjacent non-habitat trees and other surrounding vegetation would be removed 24 hrs prior to habitat tree removal providing fauna with an opportunity to exit the tree to minimise the potential for unnecessary mortality or injury during tree felling activities and stress associated with handling.

The following steps would be taken before clearing of vegetation surrounding identified habitat trees and logs:

- Surrounding vegetation would be inspected by an ecologist for the presence of native fauna, including searches for Koalas;
- Where a Koala is detected a temporary vegetation clearing exclusion zone of a minimum of 30 m radius must be established around it, until the Koala vacates the tree;

- Where other fauna are encountered they would be captured and released into adjoining secure habitat or gently encouraged to leave the construction area and directed into adjoining habitat; and
- Where no fauna species are detected clearing of vegetation surrounding habitat trees and logs can proceed. The clearing activities would be monitored by an ecologist to detect any fauna observed to be at risk.

The following protocols would be implemented for the removal of identified hollow-bearing trees and hollow logs:

- Hollow-bearing trees or trees thought to harbour fauna would be felled, and large hollow logs removed, under the supervision of two wildlife specialists. These specialists would have appropriate permits and animal-handling equipment. The local veterinarian would also be contacted and informed of the impending clearing activities;
- Prior to felling or removal, clearing machinery would be used to gently shake or 'bang' the habitat tree or log for a period of 2-3 minutes (dependant on tree health and structural integrity) to encourage any resident fauna to vacate hollows. Sticks, poles or other similar hand-held objects would also be used to hit the trunk of the tree or log at various points, to encourage animals to vacate the tree/log. The tree or log would be observed for at least 5 minutes prior to completing the next action; and
- After the observation period, each tree would be felled at the base. Once it has been deemed safe to inspect each tree by the excavator operator, hollows in felled trees would be inspected for fauna that may be present (uninjured, injured or deceased).

Inspection of Rocky Outcrops

Rocky outcrops identified during the pre-clearing surveys would be inspected prior to clearing by a wildlife specialist for the presence of sheltering fauna. Any fauna detected would be captured and released in adjoining areas of suitable habitat or encouraged to vacate the construction area and directed into adjoining habitats.

Uninjured captured individuals

Uninjured captured individuals would either be:

- Released immediately into adjoining retained habitat outside of the Construction Area, particularly for diurnal species (e.g. <150 m away); or
- Temporarily retained in captivity until dusk, then released at the nearest suitable location away from the area being cleared (e.g. <150 m away), particularly for nocturnal species.

Injured and deceased individuals

If injured or deceased animals are found, then the local veterinarian or WIRES representative would contacted.

Stockpiling of hollow logs and branches and rocks

Hollow-bearing branches, logs, tree trunks and large rocks identified during the pre-clearing surveys would be stockpiled for placement in the protection area.

9.8.5 Mitigation Measures during construction of the Proposal

- Any infrastructure and machinery required for the proposed activities would be positioned to avoid retained native vegetation (e.g. adjacent vegetation outside designated clearing areas);
- *Noxious and environmental weeds would be controlled through a WMP included in the CEMP;
- Drainage and runoff would be controlled in such a way as that no foreign substrates or materials leave the site;
- Exposed surface soil would be stabilised as soon as possible to avoid potential erosion (by mulching, covering or replanting with native species);
- Excessive dust would be suppressed via watering dust generating soil or stock piles; and
- *The avoidance of soil disturbance in or near remnants, such as ripping planting lines and road grading.

* - Mitigation measures to be also undertaken after the proposed works are complete.

9.8.6 Timing of Clearing

The colder months of the year represent a time when fauna may be in torpor, less active and less willing to relocate.

In general, for all species, and particularly hollow dependent species, they are generally less likely to survive if you move them in winter because some are in torpor and for others it may be more difficult to find foraging resources and new territory or roosting habitat.

Key times to avoid where possible would be breeding times for Owls, however the only large hollow bearing trees or stags are located along Valla and Bobo Roads and protocols have been provided to reduce the possibility of any potential impacts upon these trees that would be marked during the pre-clearance survey.

The Bentwing-bats breed in caves or similar areas so clearing is unlikely to significantly impact their breeding colonies. Additionally protocols have been provided to reduce the possibility of any potential impacts upon any Bentwing-bats that may be roosting in stags or hollow bearing trees that would be marked during the pre-clearance survey.

The mitigation measures and protocols prescribed above would reduce the potential impact upon any of the threatened fauna species that have been recorded or are considered likely to occur, as well as any non-threatened fauna species that may be present when clearing takes place.

Table 9-13 depicts the seasonal flowering or breeding periods of the threatened flora and fauna species recorded or considered likely to occur in the study area.

Table 9-13 Flowering or Breeding Periods of Threatened Species Occurring or likely to Occur in the Study Area.

Species	Seasonal Flowering or Breeding Periods											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Barking Owl												
Masked Owl												
Sooty Owl												
Powerful Owl												
Glossy Black Cockatoo												
Wompoo Fruit-dove												
Koala												
Golden-tipped Bat												
Little Bentwing-bat												
Eastern Bentwing-bat												
Spotted-tail Quoll												
Grey-headed Flying-fox												
Southern Barred Frog												
Giant Barred Frog												
Rusty Plum												
Tylophora												
Minute Orchid												
Leafless Tongue Orchid	*	*	*	*	*	*	*	*	*	*	*	*

* Indicates unknown flowering period of species

Green indicates the flowering/ breeding periods for the threatened flora and fauna species occurring or likely to occur in the study area.

9.8.7 Mitigation Measures Post Proposal Construction

The amelioration measures to be undertaken after the proposed development include:

- Exposed surface soil would be stabilised progressively as soon as possible to avoid potential erosion (by mulching, covering or replanting with native grass species); and
- The transparently operated storage as specified in the Water Quality Report component of the EIS would be implemented through a spillway system and controlled release of water to

ensure ecological processes are sustained and that adequate flows to maintain habitat for aquatic biota is provided along Bowra Creek;

- Initial detailed monitoring assessments of the transparently operated storage would be conducted for the downstream sections of Bowra Creek below the inundation area. These assessments would serve as a benchmark for determining the long-term effectiveness of the transparent release of water from the off-river storage to sustain the environmental flow below the inundation area;
- Monitor aquatic weeds, particularly Parrots Feather *Myriophyllum aquaticum*, and develop a removal management plan to ensure the ongoing control of aquatic weed species that may be introduced by waterbirds or humans; and
- Monitor for Gambusia and develop a removal management plan if the species if identified.

9.8.8 Provision of Protection Area

There is the potential for direct and indirect impacts on biodiversity values as a consequence of the proposed development. While many of these impacts can be adequately mitigated or managed, there are impacts associated with certain aspects of the proposed development where measures to avoid and mitigate are not possible. These impacts are called residual impacts. The primary residual impact associated with the proposed development would be the loss of native vegetation in the inundation area, including known and potential habitat for threatened flora and fauna species listed under the TSC and EPBC Acts.

To address the residual impacts of the Proposal, NSC have nominated a potential protection area that would be conserved in perpetuity and contribute to the long term conservation of biodiversity in the locality. The proposed protection area has been devised in cooperation with the existing landowner (Forests NSW) and comprises 122.58 ha of native vegetation above and surrounding the proposed inundation area where current logging activities would cease. It contains vegetation communities representative of those that are to be removed from the inundation area and provides for an offset ratio of approximately 1.88 : 1 as detailed in Table 9-14.

The protection area is designed to account for any potential direct, indirect or residual impacts upon threatened species that may be associated with the Proposal that may not be adequately controlled through the proposed mitigation measures. The proposed protection area aims to offset the vegetation to be removed, as a whole, and is not able to offset each vegetation community at the same ratio that the whole protection area does. To achieve such outcome, corresponding vegetation communities of the right size to accommodate the same ratio would need to be identified further a field and purchased by NSC. This could be considered impractical, expensive and difficult to manage.

The protection area has not been designed to offset each vegetation community to be removed at the same ratio as is to be retained (i.e. 1:1). The emphasis is on the long-term protection of habitat for threatened and non-threatened species and the removal of the vegetation clearing KTP, associated with logging practices, from the vegetation to be retained. This is not considered to be significant regards to the vegetation communities identified being only able to support certain threatened or non-threatened species.

The structurally modified state of each vegetation community to be cleared is unlikely to be considered species specific habitat. The species recorded or considered likely to occur or may possibly occur in the vegetation to be cleared are considered likely to breed, forage and/or roost in all of the vegetation communities identified. This then applies to the vegetation communities associated with the proposed protection area.

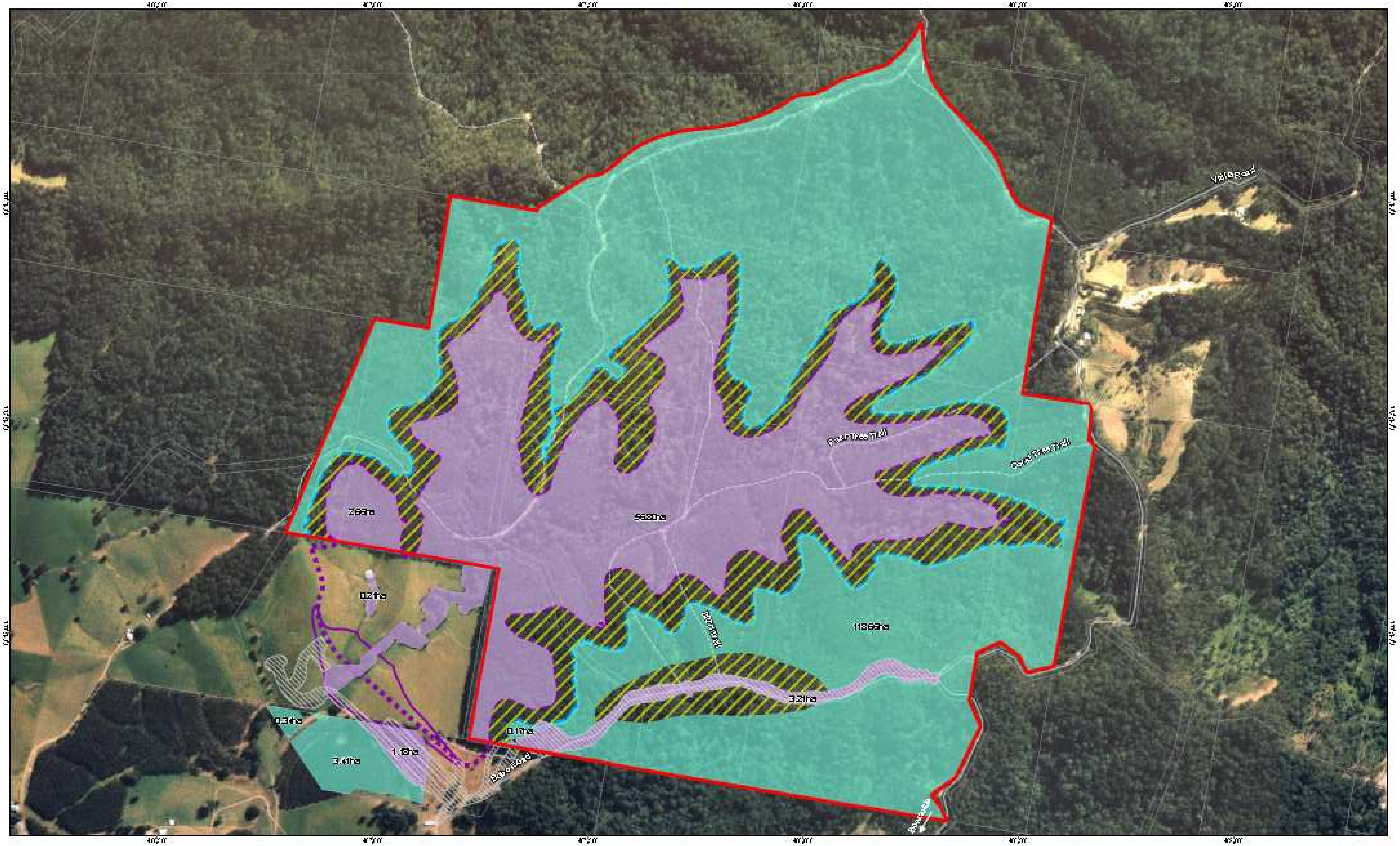
Table 9-14 Protection Area including retained native vegetation

Native vegetation communities to be cleared in the inundation area	Native vegetation communities to be retained in land acquired from DI&I	Total area (ha) to be retained as protection area	Total area (ha) to be cleared
◗ Foothills Grey Gum – Broad Leaved Mahogany; ◗ Northern Wet Tallowwood – Blue Gum; ◗ Wet Bloodwood – Tallowwood (Temperate Rainforest); ◗ Wet Flooded Gum – Tallowwood; and ◗ Hardwood Plantation.	◗ Foothills Grey Gum – Broad Leaved Mahogany; ◗ Northern Wet Tallowwood – Blue Gum; ◗ Wet Bloodwood – Tallowwood (Temperate Rainforest); ◗ Wet Flooded Gum – Tallowwood; and ◗ Hardwood Plantation.	122.58	65.05
RATIO of Cleared Vegetation to Retained Vegetation		**1.88 : 1**	

Note: all figures determined through GIS analysis based upon overstorey vegetation cover.

The protection area is at a ratio of approximately 1.88: 1 as detailed in Table 9-14. In the protection area, fallen limbs, leaf litter and dead trees would be retained insitu for habitat purposes.

Firebreaks must be located outside the protection area wherever possible or along existing fire trails within the inundation area, as shown in Figure 9-7. The way in which fuel loads are to be managed in the protection area is dependant on the use and approval of fuel reduction.



1:8,000 (at A3)

0 35 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Fire Trail
- Road
- Cadastre
- Proposed Limit of NSC Acquired Land
- Storage Embankment
- Storage FSL
- Proposed Road Design
- Area Not Proposed for Clearing and not included in Protection Area Calculations
- Proposed Protection Area
- Proposed Vegetation Clearance

CLIENTS | PEOPLE | PERFORMANCE

Nambucca Shire Council
Bowraville Off River Storage
Environmental Impact Statement

Job Number	22-14133
Revision	A
Date	01 OCT 2009

Vegetation Protection Area

Figure 9.7

2/115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E www.ghd.com.au

10 Surface Water and Groundwater

10.1 Introduction

This Chapter identifies the potential surface water and groundwater impacts associated with the Proposal and the management measures to reduce these impacts. Table 10-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 10-1 EIS Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Assessment of the impacts of the activity (both Construction and operation) on surface water and groundwater, including hydrology and geomorphology, water quality and quantity. ◗ Assessment of impact on waterways	Sections 10.2, 10.2.5, 10.3 and Chapter 11
Department of Environment, Climate Change and Water (DECCW) (formerly DECC and DWE)	◗ Assessment of the impact of the altered flow regime on the health of the upper estuary. Development of a monitoring strategy that would detect changes to in stream vegetation and / or salinity in the upper estuary. ◗ Assessment of the impact on Bowra Creek, its in stream values and down stream stock and domestic users ◗ *Water:* baseline conditions, assess impacts and describe management and mitigation measures.	Sections 10.2, 10.3 and 10.4

10.2 Existing Conditions

10.2.1 Nambucca River

The Nambucca River and its major tributaries have a total catchment area of 1,330 km2 upstream of the mouth of the river. Within the study area the Nambucca River is characterised by a moderately sinuous channel planform with an approximate slope of 0.002 m/m. The channel flows through a valley approximately 200 to 300 metres wide. This wider valley setting means floodplains are often present on both sides of the channel. The channel through this reach is approximately 30 to 50 metres wide on straight sections and 50 to 80 metres wide on bend apexes. The channel exhibits steep banks and is characterised by a series of deep pools (~0.5 – 1.5m deep) separated by vegetated riffle zones. Cobbles and gravels have been deposited within the channels, particularly within the riffle zones.

DECCW (formerly DWE) operates a gauge station at Bowraville. This river station reports river height gauging data from 1972 to current day. It recorded a maximum historic peak flood level of 10.42m on 17 February 2009.

Nambucca River Flows

Nambucca River flows are not monitored on a consistent basis, however the river level monitoring gauge at Bowraville (Station ID 205006) does provide a close approximation of river flows. The relatively short duration of peak river flows from storm events (or flooding) between January 2004 and June 2009 (Ref BoM) can be seen in Figure 10-1 below.

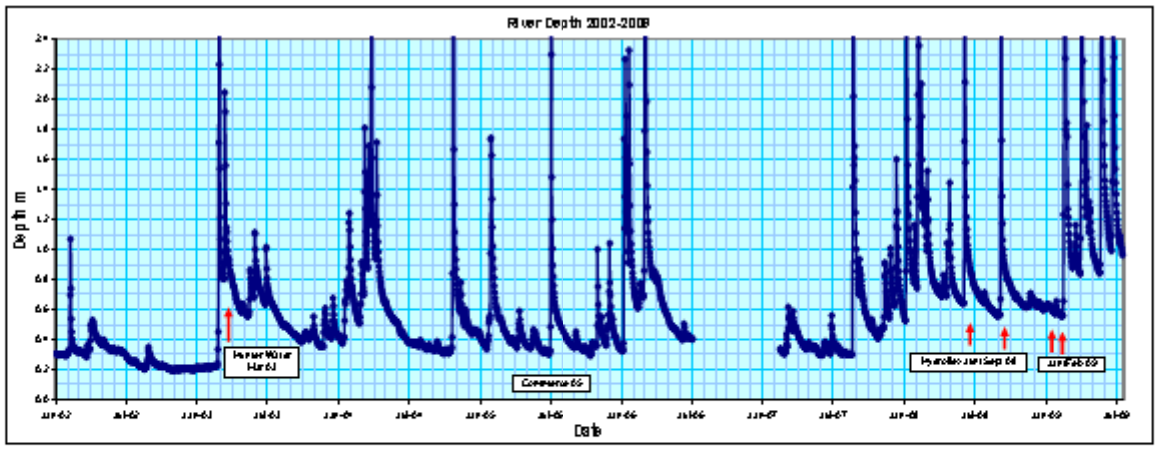


Figure 10-1 Nambucca River Levels

River flows were collected between January and May 2008 and the correlation between river level and volumetric flow (Ref: BoM) is detailed in Figure 10-2 below.

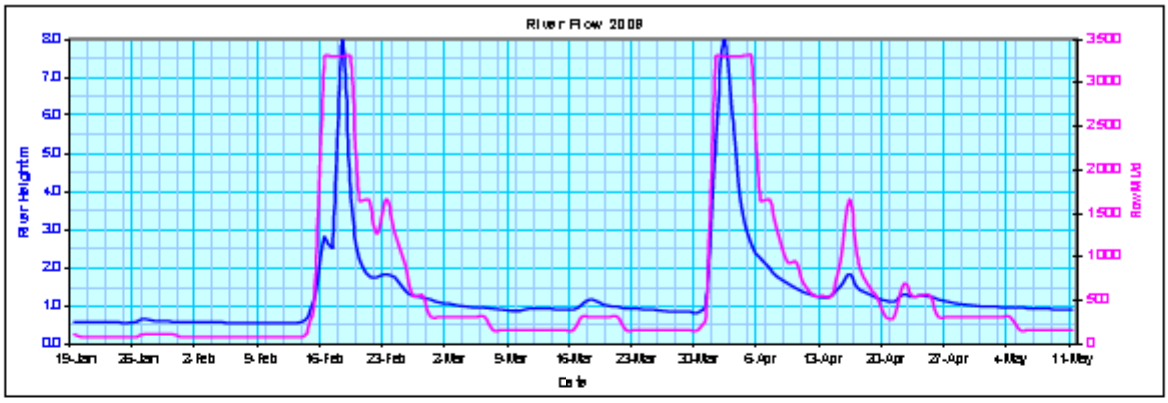


Figure 10-2 River Levels vs Flows

Nambucca River Flooding

Consideration has been given to definition of the 100-yr Average Recurrence Interval (ARI) flood levels and extent of inundation to inform the design of the expanded borefield within the Nambucca River floodplain using MIKE 11 and RAFTS modelling and available existing documentation.

Flood markers surveyed after the 17 February 2009 event within the study area revealed that the flood peak at the Bowraville gauge was 2,130m3/s. The flood markers were identified with the assistance of local residents, and the level of accuracy could at best be within 0.5m to 1.0 m of the actual flood elevation. The flood marker in close proximity to the Bowraville gauge, was surveyed as 11.37 m AHD.

Maximum annual flood peaks were extracted from 1972 to 2009 available data. These flood peaks, were used in a flood frequency analysis. The analysis results show that the February 2009 flood event is estimated as a 1 in 40 to 50 year event. Furthermore the analysis revealed that the 100-year ARI event would likely be in the order of 2,500 m3/s to 2,700 m3/s. The extent of flooding of the Nambucca River within the study area is shown in Figure 10-3.

Comparing the Nambucca River Flood Study (1994) estimate of the 100-year event to the flood frequency analysis undertaken as part of the current assessment, shows that the 100-year ARI flood peak adopted in the 1994 study appears to be low.

A number of amendments were made to the RAFTS model which generally follows the recommendations of the Australian Rainfall and Runoff, and the resultant flood peak at the Bowraville gauge was simulated as 2,070m3/s, which compares favourably to the observed peak of 2,130 m3/s for the February 2009 event. The 100-year 48-hr intensity rainfall was simulated and the resultant flood peak at the Bowraville gauge was 2,430 m3/s, which compares favourably to the range of peaks expected for the 100-year event from the flood frequency analysis.

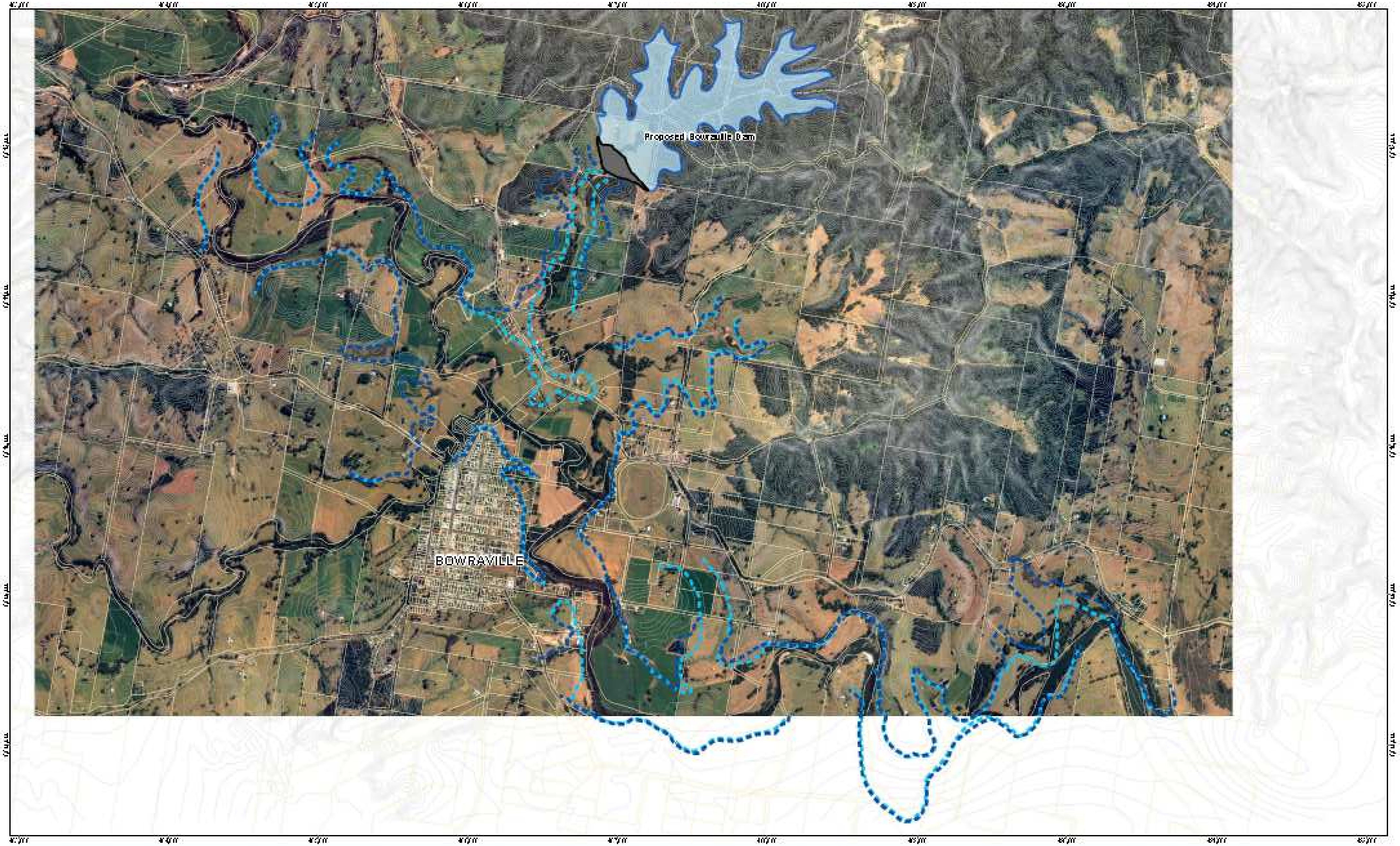
10.2.2 Bowra Creek

At the confluence with the Nambucca River, Bowra Creek has a catchment area of approximately 775 hectares. The catchment area at the proposed storage embankment is approximately 238 hectares. Upstream of the proposed storage embankment, the catchment of Bowra Creek is largely well vegetated and supports forestry operations. The channel here is largely confined within the valley sides and has limited capacity for lateral and vertical adjustments.

Downstream of the proposed storage embankment, Bowra Creek can be characterised as a partly confined, bedrock controlled fine grained system. This reach is characterised by a relatively straight channel planform with an approximate slope of 0.005 m/m. The valley is generally less than 50 m wide and is dominated by bedrock. This wider valley setting has allowed floodplains to develop such that the channel is generally bounded by bedrock on one bank and alluvial deposits on the other. As a result the channel has some potential to adjust laterally via expansion through erosion of the alluvial channel margin.

Instream geomorphic features consist largely of pools separated by channel sections where a small low flow channel is inset within the broader channel by vegetated bar/bench features. Bars and banks typically consist of fine grained cohesive sediments, however, on some exposed banks, lenses of sand and gravel are present.

Riparian vegetation along the creek is generally continuous, albeit relatively narrow and, in places, dominated by the exotic Camphor Laurel.



1:23,000 (at A3)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Cadastre
Proposed Inundation Area
Proposed Storage Wall
100-yr ARI with Dam Break
100-yr ARI without Dam Break
2m Contours

Nambucca Shire Council
Bowraville Off-River Storage

Job Number 22-14133
Revision A
Date 27 AUG 2009

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Nambucca River Flooding Figure 10-3

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Bowra Creek Flooding

A RAFTS model was simulated for a range of events and durations up to the PMF for Bowra Creek catchment as part of the dam break analysis for the storage. A selection of flood peaks for the critical duration within the Bowra Creek catchment for the 10-yr, 100-yr ARI and PMF events are summarised in Table 10-2.

Table 10-2 Flood Peaks at the Storage

Location	Inflow Flood Peak (m3/s)		
	10-yr ARI	100-yr ARI	PMF
Storage Inflow	20.91	33.2	125.7
Storage Outflow	8.01	15.6	57.6

Peak Flow Validation against the Probabilistic Rational Method

The Probabilistic Rational Method is developed for use in eastern New South Wales, Australia, and is based on data from at least 300 gauged catchments. It is therefore an appropriate method to undertake an independent check of the RAFTS results. Table 10-3 shows the comparison of the 100-year ARI RAFTS results and the Rational Method.

The results listed in Table 10-3, show reasonable agreement of the flood peaks calculated using RAFTS compared with the Rational Method for the 100-year ARI event.

Table 10-3 Comparisons of 100-yr ARI RAFTS and Rational Method Results

Catchment	RAFTS Peak Flow (m3/s)	Rational Method Peak Flow (m3/s)
Bowra Creek Catchment	44.4	40.4

10.2.3 Groundwater

The alluvial aquifer system adjacent to Nambucca River and South Creek has been extensively researched as part of the current and historical assessments of the Shire water supply. A detailed summary of the historical reports and recent detailed geophysical survey of the alluvial deposits is presented in the Hydroilex report titled "*Report on Groundwater Model Plan and Contextual Evaluation*", dated September 2008.

The report concludes that "*the alluvial system largely comprises a relatively uniform clayey silt to silty clay top layer from 4 to 6 m thick overlying heterogeneous sands, sandy gravels, coarse gravel lenses, clayey gravels and gravelly sands, of variable extent and thickness, to 9 – 11 m.*" Assessments of the geology of the alluvial aquifer have focused largely on the Nambucca River, thus the geology of the alluvial aquifer adjacent to South Creek is not as well understood as it is adjacent to the Nambucca River. Available data suggest that the clayey alluvium is more common in the South Creek alluvium.

The September 2008 Hydroilex report states that the extent geophysical survey data indicate the alluvial aquifer upstream from Bowraville is less extensive laterally than previously thought.

The modelling work conducted by Hydroilex incorporated this new, revised aquifer extent in all simulations.

This is consistent with the data summarised on Geological Survey of New South Wales Map Sheets 56-10 and 56-11 (Dorrigo and Coffs Harbour), which indicate the quaternary alluvial deposits on all waterways upstream of Bowraville are not sufficiently extensive to merit mapping.

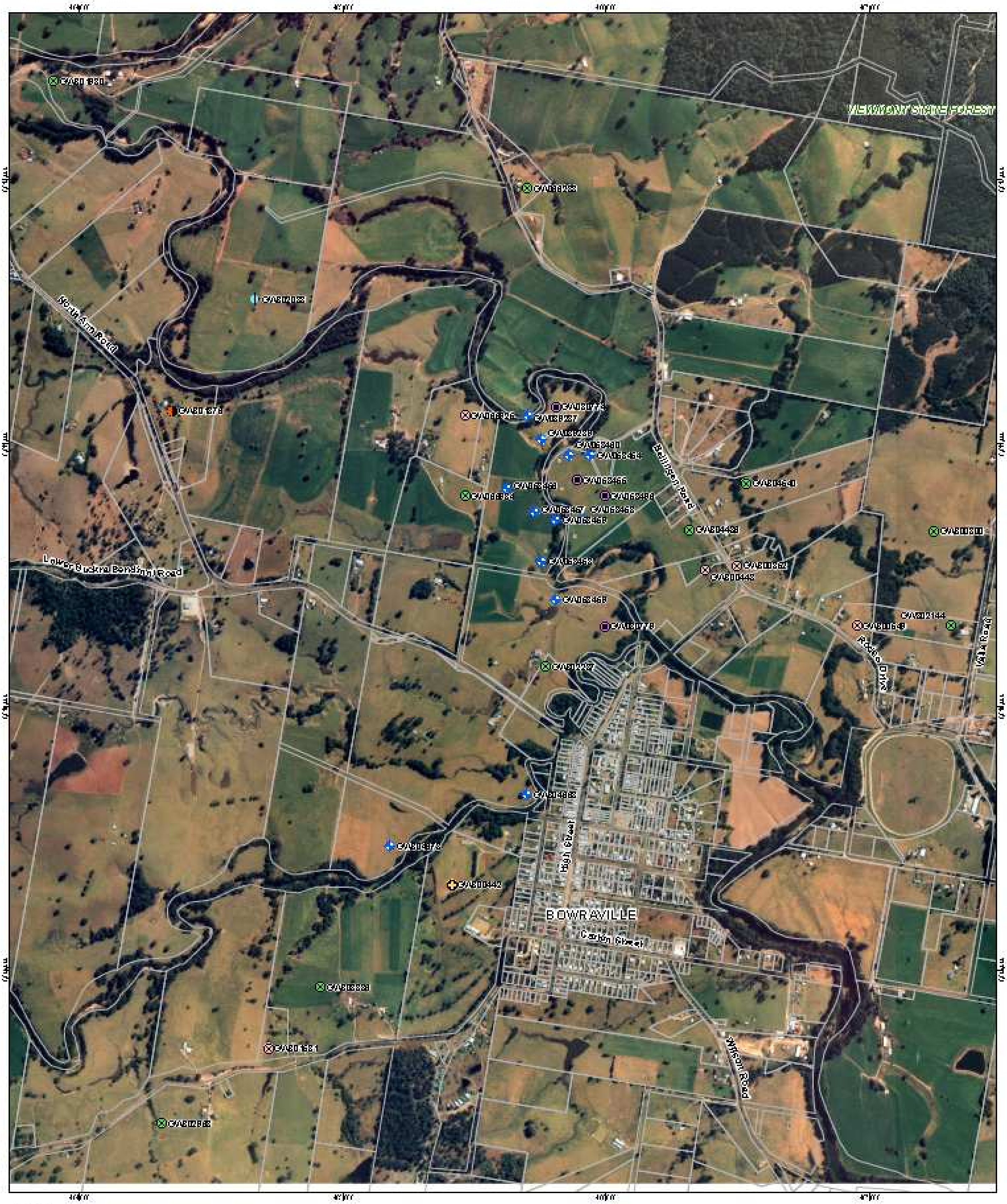
The alluvial deposits are underlain by undulating Permian metamorphic bedrock and volcanic deposits. No significant faulting or fracturing of the basement rock is noted on the Geological Survey of NSW maps sheets, however a geological cross-section presented in the September 2008 Hydroilex report suggests that fault and shear zones may be present in the bedrock underlying the alluvial valley. Significant weathering of the upper bedrock surface is expected, producing a fine grained soil of variable thickness.

Existing Groundwater Bores

GHD conducted a search of the DWE groundwater bore database on the 17 October 2008 for all registered wells within the study area. The search showed that 42 registered groundwater wells exist within the study area. Table 10-4 presents a summary of information for each of the wells within the study area. Figure 10-4 illustrates the location of existing groundwater bores.

Table 10-4 Summary of Groundwater Database Search

Bore ID and Use	Depth (m)	SWL (m)	Yield (L/s)	Northing Coordinates	Easting Coordinates
GW039287 (town supply)	12.3	6.10	33.34	6611107	485703
GW053459 (town supply)	11.70	4.60	31.60	6610707	485810
GW053458 (town supply)	9.40	3.00	26.80	6610553	485757
GW053457 (town supply)	12.10	-	-	6610738	485730
GW053456 (town supply)	13.10	-	-	6610830	485624
GW066934 (domestic stock)	-	18.00	1.00	6610799	485464
GW066925 (domestic)	-	14.00	0.50	6611107	485464
GW302963 (domestic stock)	-	-	-	6608418	484314
GW301531 (domestic)	26.00	-	1.26	6608702	484717
GW303336 (domestic stock)	-	-	-	6608934	484915
GW304673 (town supply)	15.20	8.73	-	6609468	485179
GW300442 (recreation)	27.00	-	2.27	6609323	485414
GW304668 (town supply)	12.00	-		6609665	485698
GW302237 (domestic stock)	22.00	2.50	1.48	6610153	485772
GW030779 (exploration)	0.00	6.50	34.48	6610307	485997



LEGEND

Cadastre

Groundwater Bore

- Domestic
- Domestic Stock
- Exploration
- Irrigation
- Recreation
- Stock
- Town Supply

1:13,339 (at A3)

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Nambucca Shire Council
Bowraville Off-River Storage

Current Groundwater Bore Locations

Job Number	22-14133
Revision	A
Date	24 SEP 2009

Figure 10-4

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Bore ID and Use	Depth (m)	SWL (m)	Yield (L/s)	Northing Coordinates	Easting Coordinates
GW304436 (domestic stock)	36.00	21.00	2.53	6610671	486320
GW300443 (domestic)	27.00	-	1.26	6610518	486377
GW300352 (domestic)	24.40	-	0.55`	6610536	486500
GW030774 (exploration)	11.00	5.90	18.85	6611138	485810
GW039289 (town supply)	12.00	5.80	30.78	6611015	485757
GW053460 (town supply)	11.10	3.30	31.60	6610954	485863
GW053454(town supply)	10.00	4.30	45.00	6610954	485943
GW053455(exploration)	7.90	1.20	33.80	6610861	485890
GW053496(exploration)	14.30	5.90	-	6610800	485996
GW053453(town supply)	16.60	6.10	41.68	6610707	485917
GW053459(town supply)	11.70	4.60	31.60	6610707	485810
GW301930 (domestic stock)	4.00	-	-	6612375	483904
GW066364 (domestic stock)	18.00	6.00	0.38	485568	485568
GW066238 (domestic stock)	21.00	8.00	0.60	6611969	485702
GW302088 (irrigation)	3.00	-	-	6611547	484666
GW301376 (stock)	42.00	6.00	0.63	6611122	484355
GW304540 (domestic stock)	48.00	21.00 21.00	0.13 0.25	6610848	486535
GW300300 (domestic stock)	42.00	12.00	4.55	6610666	487248
GW300549 (domestic)	30.00	-	3.78	6610312	486953
GW302144 (domestic stock)	42.00	12.00	2.27	6610307	487312

Current Recharge Water Sources

Water extracted under the current and proposed groundwater supply schemes originates from the large quantity of precipitation falling in the catchments feeding Nambucca River and South Creek, and directly on the waterways themselves. Given the geography and geology in the region of the current and proposed borefields, recharge water for the alluvial aquifer near Bowraville is almost entirely derived from inflows from the Nambucca River and South Creek, with no significant groundwater recharge to the alluvial aquifer expected from other regional groundwater aquifers. Given the small area of the alluvial aquifer, recharge from infiltrating precipitation is also expected to be minimal compared to the recharge from the local waterways.

Due to the nature of agricultural activities (grazing) minimal irrigation is conducted in the study area, so aquifer recharge by excess irrigation water is expected to be localised and of little

significance to the overall groundwater recharge in the catchments, particularly in light of the low permeability of the soils underlying much of the farmland near the alluvial aquifer.

While no rain data are available for the study area, the proximity of Nambucca River, South Creek, and Bowra Creek to the ocean (the source of much of the moisture that ultimately falls as precipitation) and the limited industrial development in the region suggest that the quality of precipitation falling in the study area is good. This is supported by chemical analyses of water samples, presented in a Piper plot in the Hydroilex 2008 report, indicating that groundwater in the alluvial aquifer is generally of an NaCl type, with low EC and total dissolved solid concentrations. This suggests that the general chemistry of the groundwater in the alluvial aquifer is largely dictated by rainwater quality, with the minor differences in observed water quality due to natural heterogeneity and/or localised interactions between groundwater and surrounding soils/bedrock.

10.2.4 Surface Water / Groundwater Connectivity

Due to the unconfined nature of the alluvial aquifer, shallow groundwater levels, and the connectivity observed between the alluvial aquifer and Nambucca River and South Creek, there is a high degree of surface water and groundwater interaction within the proposed borefield area. While less data are available for the proposed storage area, a comparable degree of connectivity is expected between surface water and shallow groundwater resources.

Precipitation falling in the catchments of Nambucca River and South Creek is highly likely to form run-off, as the headwaters of the catchments are quite steep and the surficial soils downstream are comprised of low-permeability fine-grained sediments. As there is minimal development in the catchments, run-off from roads, buildings, and other man-made structures is not expected to contribute significant quantities to the total run-off in the catchments. During the period of overland flow, surface water may interact with natural or anthropogenic substances on the land surface (dust, soil, fertiliser, contaminants, etc) altering the quality of the run-off water. Some of the run-off may travel far enough to reach tributaries and channels in the catchments, while some may fill depressions in the land surface forming temporary pools as the water infiltrates or evaporates.

The rate of infiltration is variable across the catchment, and also between precipitation events as infiltration rates are controlled by the properties of the local soils such as permeability and antecedent moisture content. Infiltrating water can mix with existing soil moisture in the unsaturated zone, and can react with the various soils it contacts, resulting in changes to water quality. Infiltrating water may ultimately reach the water table and recharge the local aquifer, mixing with the local groundwater and influencing water quality down-gradient.

Precipitation falling in the catchments that feed Nambucca River and South Creek is subject to significant evapotranspiration as precipitation is heaviest during the summer season, and any water on the soil surface or retained in shallow soils is likely to evaporate quite readily. Evaporation leads to an increase in concentration of substances dissolved or suspended in the residual water. However, the replacement of deep-rooting native vegetation with shallower-rooting forage crops (such as lucerne) has decreased the total potential transpiration for the catchments, increasing the potential recharge to the underlying aquifer.

The current groundwater extraction scheme operates as an informal riverbank filtration system, whereby pumping from abstraction bores installed close to the Nambucca River induces river

water to recharge the aquifer through the permeable soils between the river channel and the borefield.

10.3 Impact Assessment

10.3.1 Impacts on Flooding

Construction

Expanded Borefield

The new bores and borefield collection pipeline would traverse the Nambucca River floodplain via trenching (borefield collection pipelines and cabling) and trenchless techniques (Nambucca River crossings). Spoil generated during both trench and trenchless techniques would be backfilled to pre-existing ground levels and appropriately stabilised.

Any excess soil material as a result of the construction process would be reused where possible or adequately disposed. The excavations and construction activities are located within the low erosion risk Nambucca River soil landscape and there is a relatively low risk for soils and sediments to be transported off site during normal flow conditions. However, there is the risk of transport of additional sediment downstream from disturbed sites during flood events. The risk would be exacerbated at times of heavy rainfall and river/ creek flows.

Hence, careful management during the construction phase would be required to ensure that soils are exposed for the shortest time practical and no materials are stockpiled within the influence of flooding. Impacts associated with soil erosion have been further addressed in Chapter 8 – Soils Landform Stability and Erosion Hazard.

Proposed Storage

During construction of the storage, appropriately sized temporary coffer dams would need to be constructed to collect stormwater run-off from storm and flood events whilst the storage embankment is being constructed. The proposed sequencing of works for the storage construction is further detailed in Chapter 4 – Description of the Proposal. Again, careful management during the construction phase would be required to ensure that soils are stabilised as soon as possible and no materials are stockpiled within the influence of flooding.

Operation

Expanded Borefield

The proposed expanded borefield involves construction of 15 additional bores along the Nambucca River and 9 bores along South Creek. The constructed bores would have limited surface expression, involving a concrete bore head and pump housing covered with a steel lid at ground level. The transformers would be placed on poles and connected to the existing power grid via overhead lines. As a result, the constructed bores would not alter localised flood flow hydraulics and are not expected to increase the propensity for the scour of floodplain soils during flood flows.

Proposed Storage

The open channel spillway for the storage would be designed with a width of 16 metres for a maximum peak discharge from the storage during a Probable Maximum Precipitation of 58 m^3/s.

The outlet of the spillway would be located at RL 38.1 m on the right hand bank, discharging through a stilling basin into a gully at the downstream toe, leading back to Bowra Creek. Further impacts as a result of flooding causing dam break are outlined in Chapter 18 – Hazards and Risks.

10.3.2 Water Availability

Expanded Borefield

The proposed borefield design and operation provides for increased abstraction in a cyclical pattern that promotes recovery, while meeting the criteria of alluvium system protection. It has been designed to produce evenness in drawdown, limit migration of saltwater upstream, whilst maintaining practical locations of the bores. The system is planned to have a pumping capacity of up to 40ML/day to the storage in addition to the 17ML/day required for the future Nambucca and District Water Supply demand. Hydroilex (2008) modelling indicated that up to 57ML/day can be extracted from the proposed borefield when the pumps are operated for two 6hr pumping cycles per day.

Pumping in this manner would cause the 1.0 m groundwater head in layer 2 (bottom of the alluvial system) to form-up towards the lower end of the Nambucca River below Lane's Bridge. This is considered to be the 'safety area' to satisfactorily protect the system from the likely impacts of saline intrusion from the Nambucca River Estuary and the effects of increasing sea level change. Simulation results show that the baseflow in the alluvial system remains satisfactory at all times, delivering minimal inflows of the order of 20 ML/day to the Nambucca River Estuary under this cyclic pumping regimen. There are not expected to be any adverse impacts upon downstream existing users or aquatic habitats as the identified Adaptive Management Framework is proposed by which agreed environmental flow rules are considered in borefield management. Further details of the Adaptive Management Framework are outlined in Chapter 4.

There is potential that increased abstraction, without appropriate management, would result in a net decrease of surface water and groundwater discharged downgradient from the expanded borefield, decreasing the amount of water available for meeting environmental and cultural flow requirements downstream from Bowraville. However compliance with the agreed environmental flow rules and implementation of the identified adaptive management framework (AMF) would ensure water is available for meeting environmental and cultural flow requirements downstream from Bowraville. For further details of the Adaptive Management Framework refer to Chapter 4.

Proposed Storage

In order to store some of the groundwater abstracted from the expanded borefield, a storage is proposed, to be situated within the Bowra Creek catchment on land to be acquired by NSC in Viewmont State Forest. It is important to note that the proposed storage would be a transparent system filled by abstracted groundwater only, with no proposed net contributions from the catchment upstream of the storage. To ensure this balance, a volume of water equal to the quantity of surface water entering the storage from the upstream catchment would be

discharged from the storage for durations of several hours twice yearly (during normal flood seasons) to the tailwater receiving environment thereby replenishing surface water and underlying groundwater and reducing any impacts on the existing terrestrial and aquatic ecosystem.

The proposed storage would be situated to the north-east of the expanded borefield, and would have the capacity to store at least 5,500 ML of abstracted groundwater. The creation of an inundation area would have impacts on the hydrology and hydrogeology of the catchment upgradient from the storage, with the stored water causing a rise in groundwater elevations around the perimeter of the inundation area. Shallow groundwater, particularly in regions of fine-grained soils, presents a risk for zones of salinisation forming around the perimeter of the storage.

The storage would also impact the flow regime downgradient from the storage, although the planned water discharges from the storage would help to mitigate these impacts.

10.3.3 Recharge Water Sources

The Proposal does not call for any developments that would affect the recharge regime upstream from the current or proposed borefields, and development projections for the Nambucca River and South Creek catchments predict land use to remain consistent, with no plans for any substantial developments upstream of the proposed borefields. Thus groundwater abstracted from the proposed borefield expansion would continue to be recharged predominantly by flows from Nambucca River and South Creek, with minor contributions from local infiltration through the clay unit overlying the alluvial aquifer.

10.3.4 Climate Change

Variability in precipitation due to both natural cycles and climate change presents the greatest uncertainty regarding long-term water supply for the Proposal. This variability has been accounted for in both the work undertaken within the IWCM Strategy by NSW Water Solutions and Hydroilex (2008). Data from river gauge #205015 on the Nambucca River upstream of the existing borefield indicated that there were no linear relationships between river stage and monthly and daily rainfall.

Sea level rise associated with climate change has the potential to increase sea levels in the Nambucca Heads region by 0.9 m over the next century. Further details on climate change are contained in Chapter 22 – Climate Change and Greenhouse Gas Emissions. This increase in sea level could result in an up-stream advance of the fresh water / brackish water interface in the Nambucca River, driving the interface further inland and closer to the capture zone of the expanded borefield. In this event, the potential for induced saline water recharge of the lower reaches is increased. Consideration of saltwater intrusion has beed taken into account in the design of the expanded borefield.

10.4 Mitigation Measures

10.4.1 Flooding Mitigation Measures

- Works within the floodplain of the Nambucca River and South Creek would not be undertaken during high rainfall seasons.

- Temporary coffer dams are to be designed and constructed to accommodate the 1 in 10 year flood event.

10.4.2 Environmental Flow Measures

Implement the proposed management strategy to a process and logic control (PLC) format as part of the detailed design phase. Issues that would feed into the management strategy are as follows:

- Extraction protocols in accordance with the Nambucca River environmental flow rules and the adaptive management framework following sign-off from relevant government agencies;
- Extraction protocols governing bore water quality parameters;
- Initial filling and normal operation requirements to maintain water quality in the storage; and
- Environmental releases and transparency from the storage.

11 Water Quality

11.1 Introduction

This Chapter identifies the potential water quality impacts associated with the Proposal and the management measures to reduce these impacts. Table 11-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 11-1 Statutory Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Assessment of the impacts of the activity (both construction and operation) on groundwater, including hydrology and geomorphology, water quality and quantity. ◗ Assessment of impact on waterways.	Sections 11.2, 11.3 and 11.3.2 Chapter 10
Department of Environment, Climate Change and Water (DECCW) (formerly DECC and DWE)	◗ Assessment of the impact of the altered flow regime on the health of the upper estuary. Development of a monitoring strategy that would detect changes to in stream vegetation and / or salinity in the upper estuary. ◗ Assessment of the impact of increased groundwater extraction on any known groundwater dependent ecosystem ◗ Assessment of the impact of increased groundwater extraction on the risk of salt water from the estuary intruding into the aquifer during extended drought periods. ◗ Assessment of contamination risk of increased groundwater extraction. ◗ Assessment of impacts on other groundwater users. ◗ *Water;* baseline conditions, assess impacts and describe management and mitigation measures.	Sections 11.2, 11.3 and 11.3.2 Chapter 9 Sections 11.3 and 11.3.2 Sections 11.3 and 11.3.2 Sections 11.2, 11.3 and 11.3.2
Northern Rivers Catchment Management Authority (NRCMA)	◗ *Riverine Management:* it has been identified that the ground water source is highly connected to the Nambucca River surface water system. The CMA recommend the proposal quantify the threats to the groundwater system due to possible changes to the river system. Integrate recommendations emanating from the recent Geomorphic Assessment of Bowraville borefield	Sections 11.2, 11.3 and 11.3.2
NSW Health Department: North Coast Area Health Service (NCAHS)	A water quality policy must address all elements of the framework including: ◗ Undertaking a comprehensive risk assessment of the water supply system. ◗ The design of the system to apply multiple barriers against contamination of the water	

Statutory Authority	EIS Requirements	Where Addressed
	supplied to consumers. ◗ Comprehensive water quality monitoring plan. ◗ Protocol for responding to incidents that threatens (or could threaten) water quality, public health or safety. ◗ Means to investigate and manage complaints of water quality. ◗ Plan to provide reports of water quality to consumers ◗ Process for monitoring and auditing implementation of the Framework *Recreational and Agricultural Considerations:* ◗ Public access for recreational use would be prohibited to ensure high water quality ◗ Livestock would be prohibited from in and around the storage area to ensure no risk of contamination. *Public Health Act* ◗ EIS would need to consider the NSW Drinking Water Monitoring Program ◗ Results need to reported to the NSW Health via internet based NSW Health Drinking Water Database.	

11.2 Existing Conditions

11.2.1 Borefield Testing

Hydroilex Sampling

Samples from monitoring bores MB1 to MB8 were collected by Hydroilex over a three day period in June, and from TB1 to TB3 in September, 2008 with samples from EPB1 and EPB2 collected in January and February, 2009. The water quality parameters from the limited sampling, was seen to vary broadly across each bore and between bores.

The range in water quality as sampled by Hydroilex is summarised in Table 11-2 below.

Table 11-2 Hydroilex Bore Water Quality

		ADWG 2004				
Analytes	Units	Health	Aesthetic	ave	min	max
Total Suspended Solids	mg/L	-	-	15	5.0	58
Turbidity	NTU	-	5.0	23.6	0.5	44
pH	pH units	-	-	5.9	5.5	6.4
Total dissolved solids	mg/L	-	-	176	50	470

Iron - total	mg/L	-	-	2.3	0.02	9.9
Manganese-dissolved	µg/L	500	100	5.2	0.3	13
Aluminium-dissolved	µg/L	-	200	24.7	10	85
Bicarbonate Alk as $CaCO_3$	mg/L	-	-	31.3	13	73
Electrical Conductivity	µS/cm	-	-	202	85	580
Total Kjeldahl Nitrogen	mg/L	-	-	0.3	0.1	0.5
Total Phosphorus	mg/L	-	-	0.2	0.1	0.5

In an endeavour to predict an average water quality from the borefield the sampling results from Monitoring Bore 7 were discarded along with the widely varying results from TB3. An average water quality was then assessed from the remaining results. With the exception of turbidity and phosphorus the results are seen to fall more or less within the Water Quality Guidelines.

Similar testing by Hunter Water Australia in March of 2003 following an extended dry spell produced a water quality as detailed in Table 11-3 below.

Table 11-3 Selected Bowraville Raw Water Quality

Table 2-1 - Selected Bowraville Raw Water Quality Results (March 2003)

Parameter	Unit	Bowraville Raw	ADWG 1996
Alkalinity (as $CaCO_3$)	mg/L	19.8	No value set
Aluminium	mg/L	<0.01	0.2 (Aesthetic)
Calcium	mg/L	3.65	No value set
Chloride	mg/L	21.6	250 (Aesthetic)
Fluoride	mg/L	<0.1	1.5 (Health)
Iron	mg/L	0.01	0.3 (Aesthetic)
pH		6.5	6.5 – 8.5
Magnesium	mg/L	3.34	No value set
Manganese	mg/L	<0.005	0.5 (Health) 0.1 (Aesthetic)
Potassium	Mg/L	1.4	No value set
Sodium	mg/L	12.9	180 (Aesthetic)
Sulfate	mg/L	13.5	500 (Health) 250 (Aesthetic)
TDS	mg/L	65	<500 mg/L is regarded as good quality
Total Hardness (as CaCO3)	mg/L	22.9	200 mg /L as $CaCO_3$ (Aesthetic)
Calcium Hardness (as CaCO3)	mg/L	9.1	
Turbidity	NTU	0.2	5 NTU (Health) <1 NTU desirable for effective disinfection
True Colour	HU	<1.0	15 Hazen Units (Aesthetic)

Ref: Table 2-1 Selected Bowraville RawWater Quality Results (March 2003) - Hunter Water Australia Report March 2003 *"Bowraville Borefield Augmentation – Water Quality Assessment Report D00389"*

The borefield water quality as sampled by Hunter Water was seen to fall within the Drinking Water Guideline values, although the low hardness level and low calcium carbonate levels

indicate an aggressive water that does need post-treatment conditioning (with lime & carbon dioxide).

NSC Sampling

Grab samples of river and borefield water quality collected by NSC in early 2008 and again in early 2009 shows on average an improvement in water turbidity values although nutrient nitrogen and phosphorus values are seen to deteriorate.

Although the turbidity values in the river are seen to exceed the maximum recommended Drinking Water Guideline value of 5 NTU during storm events aquifer is seen to be effective in reducing turbidity to below the Guideline values for storm events of less than one week duration.

A maximum turbidity value of 1.0 NTU is normally recommended for effective disinfection when using chlorine.

A summary of recent grab sampling values collected during variable river flow conditions is detailed in Figure 11-1 and Figure 11-2 below.

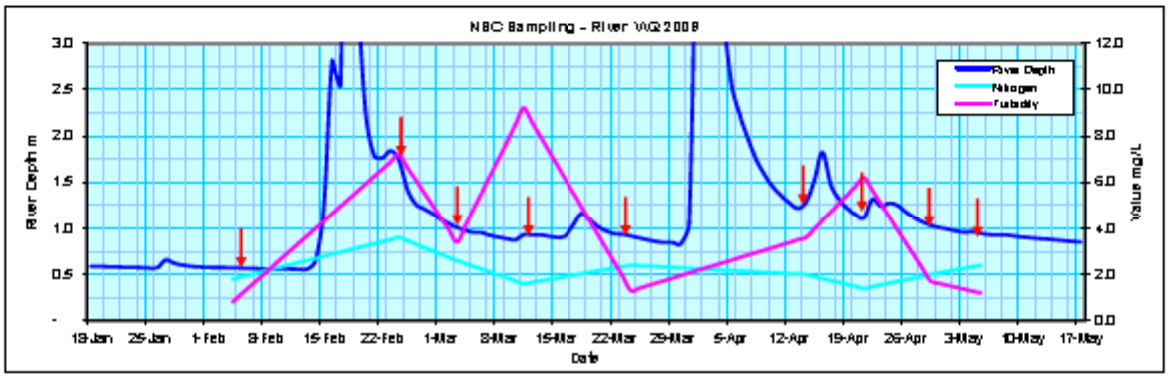


Figure 11-1 Water Quality Sampling – River

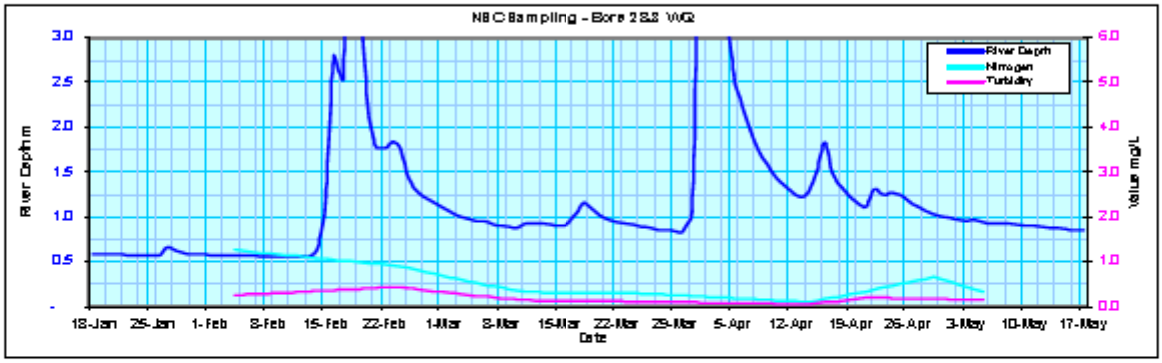


Figure 11-2 Water Quality Sampling – Bores 2 & 8

The recent sampling by NSC provides some indication of the potential improvement in water quality achievable by drawing river water through the aquifer, however the limited number of test samples and inconsistent results limit the ability to predict any trends from these results.

11.2.2 Water Quality Guidelines

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) provide "trigger values" for water quality, that if exceeded would indicate potential environmental problems. Table 11-4 shows the guideline trigger values for south-east Australia for slightly disturbed lowland rivers and freshwater lakes and reservoirs.

Table 11-4 ANZECC /ARMCANZ (2000) Guidelines

	ANZECC/ARMCANZ (2000) Guideline trigger values	
Water Quality Indicator	Lowland Rivers	Freshwater Lakes /Reservoirs
Turbidity	50 NTU	20 NTU
Iron	0.3 mg/L*	0.3 mg/L*
Manganese	1.9 mg/L	1.9 mg/L
Oxidised Nitrogen (NOx)	0.04 mg/L	0.01 mg/L
Ammonia (NH_4)	0.02 mg/L	0.01 mg/L
Total Kjeldahl Nitrogen (TKN)	0.5 mg/L	0.35 mg/L
Filterable Reactive Phosphorus (FRP)	0.02 mg/L	0.005 mg/L
Total Phosphorus (TP)	0.05 mg/L	0.01 mg/L#

Note: * The trigger value given in ANZECC/ARMCANZ (2000) for iron is an interim value due to insufficient data.

The current limit of detection at local laboratories is 0.03 mg/L.

11.2.3 Current Risks to Water Quality

Due to the high degree of connectivity between abstracted water and river water, the greatest source of risk to water quality under the current abstraction scheme is variation in precipitation observed seasonally, and particularly during drought periods. In addition to decreasing water levels in the channels, drought can be associated with a general deterioration of the water quality, particularly water temperature, major element concentrations, and heavy metals concentrations. Such a decline in water quality can also result in eutrophication of the channel, resulting in favourable conditions for algal bloom development.

Conversely, high flood flows in the rivers would result in higher levels of suspended solids in both river waters and neighbouring aquifers. Given the short residence times of groundwater abstracted from the alluvial aquifer, sufficient time and flow distance may not be allowed for beneficial filtration processes within the aquifer to decrease turbidity, resulting in elevated analyte concentrations reported for several samples with high TSS collected by Hydroilex (2008). The short residence time is of particular concern for pathogen removal, with many regulators suggesting an aquifer residence time in excess of 50 days to ensure complete pathogen removal prior to groundwater abstraction. Under the current groundwater abstraction regime, the potential benefits of a river bank filtration approach are likely not being realised because of the proximity of the abstraction bores to the river channel.

While the surficial soils overlying the alluvial aquifer have a low permeability, the shallow depth of groundwater resources in the aquifer makes them vulnerable to impacts from overlying land use. Contamination from agricultural land use (e.g. fertilizers, animal waste, and septic fields)

and urban land use (e.g. spills and leaks) present a risk to surface water and groundwater quality.

Recent studies have indicated that the zone of brackish river water can extend as far upstream as the southern boundary of Bowraville during high, high (so-called "king") tide events. Under the current water abstraction scheme there is a buffer of more than 1.5 km between the up-river freshwater/brackish water interface and the stretch of the river adjacent to the borefield, which is far beyond the capture zone of the nearest abstraction bore. Thus there is very low risk of salt water impacts to the portion of the alluvial aquifer used for groundwater abstraction resulting from pumping-induced salinisation.

Under current conditions, water quality in the Nambucca River and the alluvial aquifer is predominantly determined by natural processes such as rain water quantity and quality, with secondary effects from water/rock interactions and evaporation. Minor, localised variability in observed water quality resulting from land use upstream is possible, but is not reflected in analytical data for groundwater being abstracted under the current water supply scheme. No evidence of salt water intrusion into the alluvial aquifer north of Bowraville is apparent in available data.

11.2.4 Recent Investigations

Investigations by Hydroilex in October 2008 comparing groundwater quality across different bores confirmed a variable water quality from alternative bores and was instrumental in developing the preferred location for the new proposed additional bores.

The location of the new bores was expected to be above the salt intrusion zone and in a part of the aquifer that could produce an improved water quality over that of the river. Hydroilex (2008) also developed a Piper diagram detailing the ionic make-up of water recovered from the various bores as detailed in Figure 11-3.

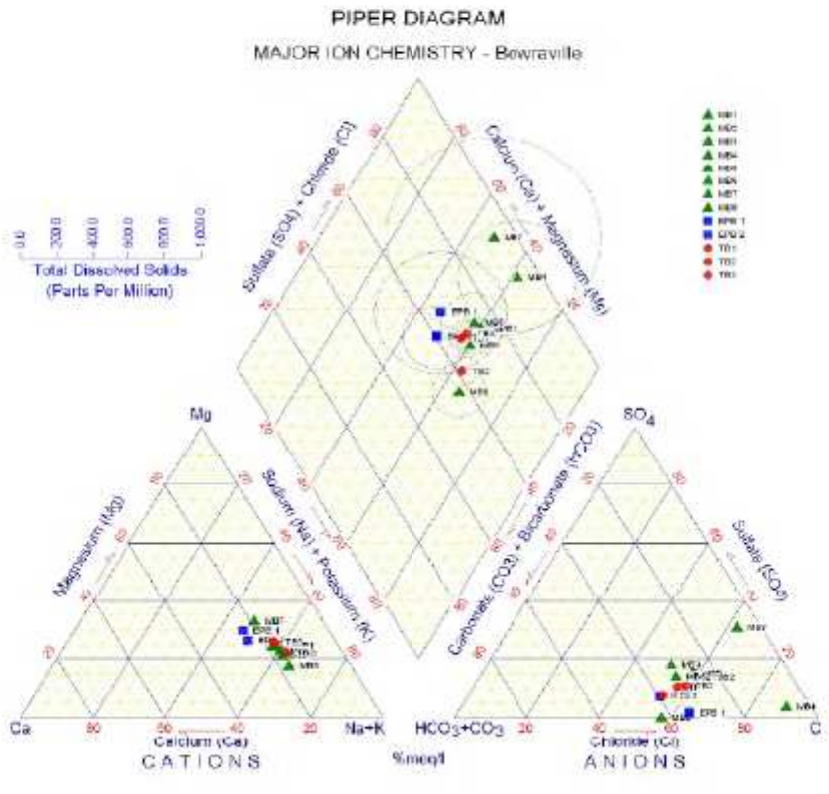


Figure 11-3 Piper Diagram

Modelling (revised early in 2009) was seen to match yield predictions and demonstrated the link between river recharge and the borefield.

11.3 Impact Assessment

11.3.1 Predicted Water Quality

Borefield Water Quality

The requirements for the expanded borefield call for the installation of up to 24 new bores in the alluvial aquifer, increasing the potential borefield yield up to 57 ML/day. A portion of the abstracted groundwater would be diverted to the proposed storage when flow conditions in the river are appropriate.

In addition to increasing the quantity of water abstracted from the Nambucca River reach of the alluvial aquifer, several of the proposed borefield designs call for groundwater abstractions from the South Creek portion of the aquifer which would result in up to 40% of groundwater abstracted being derived from the South Creek catchment. Due to quality differences between Nambucca River and South Creek river water, this may result in a variation in overall abstracted water quality.

The water quality results obtained from sampling and testing of the borefield throughout its development and from the Nambucca River during periods of low and high river flow have indicated a broad range of water qualities that vary substantially depending on the season and the length of dry periods experienced prior to sampling.

Given good weather conditions and a healthy river flow, the water quality available from the borefield is seen to be of an acceptable quality with a "low risk" associated with the need for further treatment.

As seen in Figure 11-1 and Figure 11-2, the borefield aquifer does show an improvement on river water quality, however under severe weather events a number of water quality measures are seen to fall outside of the Drinking Water Guidelines.

Should drought conditions prevail and rainfall again fall below the average for an extended period, then the river water quality could be expected to deteriorate leading to a need to utilise stored water and/or possible future treatment to meet accepted Australian Drinking Water Guideline values.

The proposed borefield design and operation provides for increased abstraction in a cyclical pattern that promotes recovery, while meeting the criteria of alluvium system protection. It has been designed to produce evenness in drawdown, limit migration of the 1.0m head away from the Nambucca River exit, whilst maintaining practical locations of the wells. The system is planned to have a pumping capacity of up to 40ML/day to the storage in addition to the 17ML/day required for the future Nambucca and District Water Supply demand. Hydroilex (2008) modelling indicated that up to 57ML/day can be extracted from the proposed borefield when the pumps are operated for two 6hr pumping cycles per day.

Greater abstraction from the alluvial aquifer would likely result in a drawdown of the watertable within the aquifer, increasing the potential for oxidation and acidification of aquifer soils and groundwater. However, groundwater analytical results do not suggest this is a likely scenario for the alluvial aquifer as moderate levels of dissolved oxygen are currently present in groundwater, redox measurements indicate mildly oxidising conditions in the aquifer, and sulfate concentrations are low in groundwater samples analysed, suggesting that little oxidation of reduced sulfate compounds is occurring despite favourable conditions.

Decreased water levels in the aquifer have the potential to result in a corresponding decrease in the level of water in Nambucca River and South Creek, resulting in decreases in water quality consistent with those caused by droughts (increased element and nutrient concentrations, eutrophication, etc). Furthermore, increased groundwater abstraction rates may decrease the already low residence times of groundwater in the alluvial aquifer, increasing turbidity and increasing the likelihood of pathogens being present in abstracted groundwater, resulting in potential increases to future water treatment costs.

Decreased water levels in the alluvial aquifer combined with the installation of abstraction bores closer to the fresh water / brackish water interface in Nambucca River presents the potential for inducing saline water recharge of the lower reaches of the alluvial aquifer.

In addition to increasing the quantity of water abstracted from the Nambucca River reach of the alluvial aquifer, several of the proposed borefield designs call for groundwater abstractions from the South Creek portion of the aquifer which would result in up to 40% of groundwater abstracted being derived from the South Creek catchment. Due to differences between Nambucca River and South Creek water quality, this may result in a variation in overall abstracted water quality.

Saltwater Intrusion

One of the more comprehensive water quality evaluations was prepared by Water Studies in 2002 who reported the salt-fresh interface as being east of Lanes Bridge and that only in the extreme situation of extended pumping during low river-flow conditions was the interface likely to migrate upstream to the South Creek confluence.

Manly Hydraulics Laboratory in their 2008 study of Salinity Dispersion in the Nambucca River Estuary determined the upper tidal limit (king tide) to be at about Lanes Bridge. If this phenomenon occurred during a low river flow condition then it was considered likely that a saline wedge could be pushed upstream along the base of the aquifer. In such circumstances, continued abstraction form bores close to the river-creek confluence could be affected.

Salt water intrusion can result in long-lasting aesthetic and/or human health concerns, potentially requiring that one or more bores be deactivated for an extended period while natural processes displace the salt water. To minimise any potential saline water recharge of the lower reaches of the alluvial aquifer, a buffer zone has been proposed within which no new bores would be located.

As such and with the proposed bore locations some distance upstream from Lanes Bridge the potential risk of salinity intrusion is considered low.

Simulation results show that the baseflow in the alluvial system remains satisfactory at all times, delivering minimal inflows of the order of 20 ML/day to the Nambucca River Estuary under the proposed cyclic pumping regimen.

Land Use

Land use activities within the extraction area have the potential to contaminate both the river and groundwater. Water quality sampling results for both the river and groundwater suggest that current land uses are not adversely impacting water quality.

Notwithstanding the above, the Bowraville Borefield Well Head Protection Plan developed by Hunter Water in June 2003 would need to be updated to include the expanded borefield and to control land use practices within the well recharge area. Consideration would also be given to including within the draft Nambucca LEP, an overlay provision to ensure land uses do not impact upon the water quality within the expanded borefield (refer to Chapter 21).

Stored Water Quality

With higher quality bore water collected for storage, the turbidity of the stored water would be better than the turbidity of the Nambucca River during a storm event. The turbidity of the stored water may be marginally higher than the levels normally seen from the borefield during normal riverflows, however this marginally increased level of turbidity would be well below the peak turbidity levels that are experienced from the river or borefield during extended flood events.

During low river flow conditions, the "apparent colour" of the stored water would be below that recovered from the borefield due to a larger proportion of the water being transferred to the storage when the river was in a pristine condition. A marginal increase in colour may be seen in the storage following a storm event, however the normal level of colour would remain below that of water sourced from the borefield. The pH of water drawn from the borefield generally satisfies the requirements of the Australian Drinking Water Guidelines. A similar pH can be expected from water contained in the storage as long as algal growth is controlled.

Dispersive Soils

Geotechnical information within the proposed catchment area and the storage is detailed in the Bowraville Off-River Storage Factual Geotechnical Report (Doc#85169) and notes the soil making up the majority of the storage is "moderately" dispersive.

Preliminary settling tests have been conducted on soil samples mixed with water from various locations across the storage. The turbidity of the soil /water mixture was monitored at regular intervals with photos highlighting the change in turbidity over time as the (fully mixed) suspended solids were allowed to settle.

The turbidity of the soil/water mixture (without chemical dosing) remained relatively high for some hours before it was seen to decline. After 30 hours the turbidity of the soil/water mixture was judged to be around 100 NTU. After 48 hours the turbidity was seen to improve to around 5-10 NTU.

Blue Green Algae

The likelihood of an algal bloom is highest during droughts when there is the greatest need to extract water from the storage. Few of the North Coast water supply storages experience toxic or blue-green algal problems including Karangi and Rocky Creek. Armidale does however have potentially toxic blue green algal problems.

Taste and odour are generally caused by the presence of algae in water. There is a higher potential for algal growth in the storage than from contaminated water drawn from the borefield when the Nambucca River is experiencing an algal bloom. The "aggressiveness" of the stored water would (like water drawn from the borefield) need to be adjusted with ongoing treatment with lime and carbon dioxide dosing.

Potential ecological impacts associated with blue-green algal blooms include toxic poisoning of aquatic biota such as waterbirds and fish, and adverse impacts on aquatic vegetation and macroinvertebrates. Further information on the Proposal's impacts on aquatic flora and fauna is contained in Chapter 9.

Computer modelling indicates that the storage would not experience significant water quality issues as long as effective destratification measures are implemented.

If blue-green algae are suspected of being present in the storage or are seen to be on the increase in the normal collected water samples, then the procedures in the Blue-Green Algae Management Protocols would be followed.

The National Health and Medical Research NSC (NHMRC) is presently reviewing a new "*National Protocol for the monitoring of Cyanobecteria and their toxins in surface Fresh Waters*" (Birch et al). This document is due to be published soon. The alert levels in this document may be different from those presently used as listed in the Queensland issued Blue-Green Algae Management Protocols. The National Protocol is expected to be adopted by most water supply authorities.

If elevated algae levels are detected at an early stage in a shallow area of the storage, then using a boom to isolate the problem area and selectively pump-out the algae laden water may need to be considered. For a severe infestation, it may be necessary to obtain approval from the Department of Environment, Climate Change and Water (DECCW) for the use of an appropriate algaecide to kill excess algae.

First Flush Water

With the first flush of water there is a risk that there could be taste and odour problems from any decaying organic matter and from any water that has been caught in the dead-ends of the pipe collection and transfer network. This is expected to be a small quantity of water and can be diluted with other water from coffer dams to reduce any persistent odour problems prior to further treatment at the headworks.

Seepage

The most significant concern to surface water / groundwater interactions posed by the construction of the proposed storage is in relation to the quality of water in the storage, and the potential for stored water to act as a recharge source for aquifers around the inundation area. Seepage of groundwater under the storage can provide a continuous source of water to the downstream receiving environment, and low quality seepage water (low dissolved oxygen, high nutrients, pathogens) can have adverse effects on the ecology of the receiving environment. However, the Proposal has incorporated mitigation measures to minimise the potential for seepage, and given the shallow, impermeable bedrock in the proposed storage area, poor water quality from seepage is not considered to be an issue.

Downstream Water Quality

Reduced flows downstream of the storage have the potential to greatly increase the impacts of runoff and nutrient enrichment of Bowra Creek. Changes in downstream water quality from a water storage typically include increases in water temperature, nutrient load, turbidity, dissolved gases, and concentration of heavy metals and minerals (including those that are naturally occurring). An increased frequency of discharges of water containing toxic algae may affect fish and aquatic invertebrate communities downstream of the storage also.

Cold water pollution may also be an issue for some fauna. While platypuses are well adapted to cold conditions, they require a greater intake of food to regulate their body temperature in cold water and low water temperatures may also affect macroinvertebrate productivity. Furthermore, water temperature is a reproductive cue for fish with breeding occurring at a particular temperature or within a particular range. Many native fish would not breed in colder water.

Low oxygen water from the storage releases can be toxic to benthic macroinvertebrates on which the platypus feeds.

There is also the possibility of an increase in trace metals in the lower levels of the storage and the possibility of these being transferred downstream. A study in Tasmania (Munday et al. 2002), found elevated levels of persistent pesticide residues and PCBs (polychlorinated biphenyls) in platypuses but not at levels which have produced reproductive or immune system depression in other species. It is known, however, that trace metals can affect the reproductive success of fish and can bio-accumulate in macroinvertebrate communities.

The Proposal would include a destratification system, a dual-level offtake and regular seasonal environmental releases to address downstream water quality.

Destratification typically controls blue-green algal blooms in two ways; by deepening the surface mixed layer and reducing the amount of light available to algal cells, and by reducing the amount of dissolved nutrients, especially phosphorus, in the water column. Destratification can

also avoid the discharge of cold water streams from the lower layers of the storage if the storage is stratified during the summer period.

The dual-level offtake tower provides a water quality control measure for water drawn from the storage. Water would generally be drawn from the outlet nearer the surface, where the best quality water is generally available. In the event that the water in the surface layer is contaminated with algae, the destratification system compressor would be turned off and water drawn from a lower level. Temporary stoppage of the air compressor may be effective in suppressing an algal bloom.

To limit the potential for vegetation encroachment and sedimentation within pool environments of Bowra Creek downstream of the storage, it is proposed that maximum capacity outflows of 3.7 m^3/s with durations of several hours be released from the storage twice yearly during normal flood seasons.

11.3.2 Water Quality Risk Assessment

In order to better understand the likely risks associated with future water quality, a preliminary risk assessment was undertaken of the key known risk areas associated with development of the borefield, construction of the storage and a qualified projection of the likely water quality in the river over the next 25 years.

The risks associated with the water quality drawn from the borefield are probably better understood than others and with careful selection of the duty operational bores, the risk of poor quality water can to some degree be mitigated. The water quality in the river is strongly related to river flow conditions, which is directly influenced by future weather events and the likely timing for delivery of any future water treatment facility.

Given good weather conditions and healthy river flows, the water quality available from river or borefield extraction is considered to be of a reasonable quality with a low risk associated with the need for further treatment. However, would drought conditions prevail and rainfall again fall below the annual average for an extended period of time, then the water quality in the river would get progressively worse, leading to a growing need for an increased level of treatment.

It is also considered that the water quality in the storage would vary with time, with the risk of turbidity from dispersive clays on initial filling and the potential for blue-green algae blooms after an extended period of warm water storage. The extended period to initially fill this storage (up to 24 months) would also add to the uncertainty associated with the water quality from the storage.

In view of the above, a preliminary risk assessment was prepared to try and identify the key risk areas associated with delivery of water in conformity with the Australian Water Quality Guidelines, and to try and make a qualified prediction of the likely water quality on initial filling and after an extended period in the storage.

Potential Risks

Likely risks associated with providing increased security of the water distribution system typically include:

- Security of borefield collection system (security of pump operation following flooding, draw-down of the water table (adjacent to each bore or across the borefield, risk of collection pipe failure, river bank erosion, power failure);

- Likely weather conditions leading to high or low river flows – i.e. risk of flooding (and river changing course) or risk of drought (stagnant or toxic water);
- Likely water quality in the river (i.e. high turbidity levels during flooding, nutrient runoff during normal river flows, salinity incursion during low river flows, raised TDS values from miscellaneous bores);
- Likely water quality in the storage – i.e. on initial filling (turbidity from dispersive clays), in summer after extended storage with warm water conditions (blue-green algae blooms), in winter following potential inversion of the storage (inorganic complexes);
- Security of pumped transfer system (pipe or pump failure to or from storage); and
- Miscellaneous other risks.

11.4 Mitigation Measures

Construction of the proposed storage would provide improved security against poor groundwater quality at times of low river flow, however the stored water quality may vary depending on seasonal conditions, the degree of nutrient runoff and the potential dispersive characteristics of the earthen storage. Following the review of numerous reports and investigations, there is reasonable potential for significant algal blooms to occur during warm water storage conditions.

11.4.1 Water Quality Management

In order for the Proposal to meet DECCW water quality risk management framework guidelines, the twelve key elements of the framework would need to be considered. These elements include:

- A commitment to water quality management;
- Assessment of the supply system;
- Preventative measures for quality management;
- Operational procedures and process control;
- Verification of water quality;
- Management of incidents and emergencies;
- Employee awareness and training;
- Community awareness and training;
- Research and development;
- Documentation and reporting;
- Evaluation & audit; and
- Review & continual improvement.

To meet the objectives of the new guidelines, NSC would need to integrate the twelve key elements of the guidelines into a Water Quality Risk Management Plan.

Water Quality Management Plan

A Water Quality Management Plan has been prepared for the Proposal that develops the Water Quality Management Strategies (WQMS) for operation of the storage. The objective of the WQMS is to ensure NSC, as the operational authority of the storage, can extract acceptable quality water from either the borefield or storage, and in turn to maximise the quality of water transferred to the potable water distribution system.

A water quality monitoring program is proposed for implementation during filling and for ongoing operation of the storage. The overall objective is to monitor, maintain and manage water quality generally in the storage during filling and storage and withdrawal operations. The storage is designed for supply of acceptable quality water when water quality from the borefield falls below an acceptable level.

Borefield Monitoring

It is proposed that regular monitoring of the borefields be undertaken to ensure the best quality water is recovered from the best performing bores.

The key parameters that would be monitored regularly from each bore include turbidity, conductivity and pH. Monitoring of nutrient levels in the separate collection headers across the borefield would also be undertaken (which would be in the form of weekly grab samples).

Regular testing of a broad range of parameters from each bore would also be completed on a regular basis to identify any trends in water quality that may be extracted from poorer performing bores. These parameters are detailed in Table 11-5 below.

Table 11-5 Bore Quality Parameters

Parameters		
◗ Sample Time	◗ Sulphate, SO4	◗ Nitrite as N in water
◗ Temperature	◗ Chloride (titratkion)	◗ Nitrate as N in water
◗ Dissolved Oxygen	◗ Arsenic-Dissolved	◗ Ammonia as N in water
◗ Electrical Conductivity	◗ Cadmium-Dissolved	◗ Total Kjeldahl Nitrogen
◗ pH	◗ Chromium-Dissolved	◗ Phosphate as P in water
◗ Redox (ORP)	◗ Copper-Dissolved	◗ Phosphorus Total
◗ Turbidity	◗ Lead-Dissolved	◗ Total suspended solids
◗ Calcium - Dissolved	◗ Mercury-Dissolved	◗ Total dissolved solids
◗ Potassium - Dissolved	◗ Nickel-Dissolved	◗ Iron - dissolved
◗ Sodium - Dissolved	◗ Zinc-Dissolved	◗ Iron - total
◗ Magnesium - Dissolved	◗ Aluminium-Dissolved	◗ Fluoride, F
◗ Bicarbonate as CaCO3	◗ Manganese-Dissolved	◗ Total Cyanide
◗ Carbonate as CaCO3	◗ Sulphide	

Monitoring of Transfer Water Quality

Following the initial filling of the storage, limits on the ongoing quality of water transferred to the storage would need to be set to ensure the best quality water is maintained in the storage. This would require limits on phosphorus, nitrogen and turbidity as a minimum.

Monitoring of Storage Water Quality

It is proposed that regular monitoring of the storage is undertaken to ensure the best quality water is available for when the groundwater quality has deteriorated.

The key parameters that would be monitored include temperature and dissolved oxygen levels (at various locations and depths), turbidity, conductivity, pH and the nutrient parameters of nitrogen and phosphorus. Nutrient monitoring again being in the form of weekly grab samples.

A summary of these parameters is detailed in Table 11-6 below.

Table 11-6 Storage Quality Parameters

Parameters		
◗ Sample Time	◗ Manganese-Dissolved	◗ Phosphate as P in water
◗ Temperature	◗ Sulphide	◗ Phosphorus Total
◗ Dissolved Oxygen	◗ Nitrite as N in water	◗ Total suspended solids
◗ Electrical Conductivity	◗ Nitrate as N in water	◗ Total dissolved solids
◗ pH	◗ Ammonia as N in water	◗ Iron - dissolved
◗ Turbidity	◗ Total Kjeldahl Nitrogen	◗ Iron - total

In regard to long term water quality management, it is proposed that:

- "Exceedance limits" are nominated to mitigate the risks posed by elevated turbidities or salinity from the borefield when pumped transfer from the borefield to the storage would cease. The target criteria for these exceedance limits would be re-assessed after the water quality in the storage has had time to stabilise and operational experience allows further refinement of the quality limits for transfer to the storage and for return of stored water to the distribution system.
- Dispersive clays in the storage would be stabilised with lime or gypsum to mitigate the impact from this material on stored water quality.
- A dual-level off-take would be provided to allow operational flexibility for withdrawal of better quality water for environmental release or for supply of water back to the distribution system.
- Aeration and mixing equipment would be installed to assist destratification of the storage to help mitigate the impact from algal blooms or elevated iron and manganese levels caused by an inversion of the storage. The bubble plume destratification system is proposed as a minimum on the basis of proven effectiveness and reliability in numerous Australian reservoirs. However, a combination of bubble plume and mechanical aeration with a potential energy saving would be considered from a reduced operational period during the lower risk seasons of the year. The capital cost of a bubble plume system is typically lower, however operational costs (power, maintenance, operator visits) are usually greater.

- Sampling of the river water quality by NSC would continue, with additional sampling provided during extreme weather events such as flooding or low-river flows. Water quality monitoring of groundwater inputs into the storage would also be collected regularly (i.e. on a monthly to quarterly basis) to allow improved estimates of current loads into the storage.
- In-storage and withdrawal water quality monitoring would also be undertaken to assess the performance of management strategies and to track the long-term behaviour of the storage.

Determination of longer term trigger values for changing the supply from the borefield to the distribution system or from the storage to the distribution system would be confirmed after the storage has had time to reach a seasonal equilibrium and NSC has the operational experience to ensure acceptable quality water is available for the consumer.

12 Noise and Vibration

The information in this Chapter is taken from 'Bowraville Off-River Storage & Associated Works, Construction and Operational Noise and Vibration Impact Assessment' prepared by GHD, February 2009. An unabridged version of the report is provided in Appendix D, Volume 2.

12.1 Introduction

This assessment has been conducted with consideration to the NSW Department of Environment, Climate Change and Water's (DECC) *New South Wales Construction Noise Guidelines: Draft for consultation,* (August 2008) (CNG), *Industrial Noise Policy* (INP) (EPA, 2000) and *Assessing Vibration: a technical guideline* (February 2006).

Table 12-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 12-1 Statutory Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Likelihood of air, noise or water pollution arising from the development or activity ◗ Analysis of construction impacts including: noise and vibration.	Section 12.4
Department of Environment, Climate Change and Water (DECCW)	Noise and Vibration: a Noise Impact Assessment (NIA) for the proposal must be conducted by a qualified acoustics consultant, and must address baseline conditions, assess impacts and describe management and mitigation measures. The assessment(s) must take into account the following guidelines as relevant: ◗ *Industrial Noise Policy* (EPA, 2000) ◗ *Environmental Criteria for Road Traffic Noise* (EPA, 1999). ◗ *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZECC, 1990).	Sections 12.2, 12.4 and 12.5

12.2 Assessment Methodology and Criteria

12.2.1 Assessment methodology

A noise and vibration assessment was undertaken for the Proposal and took into account the guidelines listed in the Director-General's environmental assessment requirements (where relevant) as follows:

◗ The former Environment Protection Authority (EPA) (2000) *Industrial Noise Policy* (NSW INP) – in regard to potential impacts of the quarry operations on nearby residents.

- The former Environment Protection Authority (EPA) (1999) *Environmental Criteria for Road Traffic Noise* (ECRTN) – in regard to road traffic noise assessment criteria and assessment of barrier heights and noise monitoring and modelling methods.
- The ANZECC (1990) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* – for guidance on airblast overpressure and vibration criteria.

The assessment identified sensitive locations and assessed potential noise and vibration impacts against noise and vibration criteria developed by the DECCW. The methodology for the assessment of noise impacts included quantifying the existing acoustic environment through noise monitoring, establishing project-specific noise criteria, and establishing noise models for the construction and operation phases. The results of the noise models were assessed and recommendations developed to reduce noise impacts where they are predicted to occur. An assessment of potential vibration during construction was also undertaken to determine potential impacts on sensitive receivers and infrastructure.

Noise Monitoring

Long-term unattended noise monitoring was undertaken between 18 September and 26 September 2008. Monitoring was undertaken at four residential properties surrounding the project area. Short-term attended noise monitoring was also undertaken at the same locations. Figure 12-1 shows an aerial image of the noise logger locations and the project site.

12.2.2 Criteria

Construction Noise

This assessment has been undertaken with consideration to the Department of Environment, Climate Change and Water (DECCW) *New South Wales Construction Noise Guidelines: Draft for consultation, August 2008*. The DECC guidelines recommend a qualitative assessment be undertaken for large infrastructure activities.

This guideline recommends standard hours for construction activity as follows:

- Monday to Friday: 7 am to 6 pm;
- Saturday: 8 am to 1 pm; and
- No work on Sundays or Public Holidays.

Construction hours would be limited to between 7 am and 6 pm during weekdays, and the recommended hours on weekends.

The DECCW construction noise guidelines provides noise management levels for construction noise at residential receivers. These management levels are to be calculated based on the adopted rating background level (RBL) at nearby residential locations. Table 12-2 details the adopted construction noise goals for the proposed project.

The lowest measured daytime RBL of 31 dB(A) was recorded at Logger 3 (53 Borefield Road). GHD has conservatively adopted this daytime RBL for all noise receivers surrounding the project area. The lowest measured night time RBL was also adopted from Logger 3 and as previously mentioned, was increased to 30 dB(A) with consideration to the NSW INP.

Table 12-2 NSW DECCW Construction Noise Goals

Time period	Management Level $L_{Aeq(15\,min)}$ dB(A)	Measured RBL L_{A90} (period) dB(A)	Adopted Noise Goal $L_{Aeq\,(15\,min)}$ dB(A)
Recommended standard hours: Monday to Friday: 7 am to 6 pm	Noise affected RBL + 10 dB(A)	31	41
Saturday: 8 am to 1 pm No work on Sundays or Public Holidays	Highly noise affected 75 dB(A)	N/A	75
Outside recommended standard hours	Noise affected RBL + 5 dB(A)	30 (1)	35

(1) The DECCW's NSW INP, states that where the RBL is less than 30 dB(A), then it is set to 30 dB(A).

Based on the proposed construction times, this assessment would be based on the daytime construction noise goal of 41 dB(A) $L_{Aeq\,(15\,minute)}$.

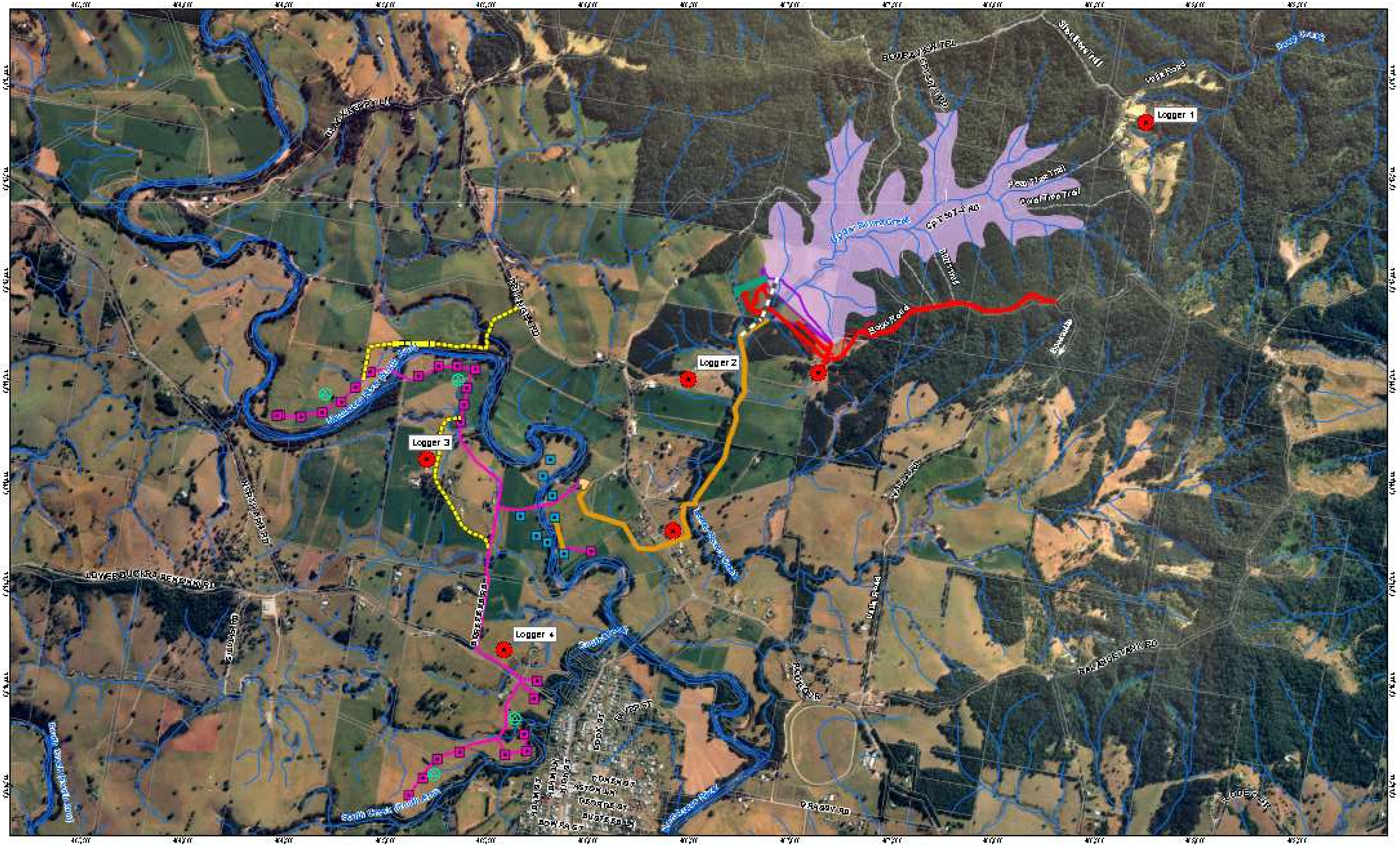
Operational Noise

The operational noise goals have been set with consideration to the NSW INP. The INP guidelines include both Intrusive and Amenity criteria that are designed to protect receivers from noise significantly louder than the background level, and to limit the total noise level from all sources near a receiver.

Intrusive noise limits set by the INP control the relative audibility of operational noise compared to the background level. The Amenity criteria limit the total level of extraneous noise. Both sets of criteria are calculated and the more stringent of the two in each time period applies.

The Amenity criteria are determined based on the overall acoustic characteristics of the receiver area and the existing level of noise, excluding other noises that are uncharacteristic of the usual noise environment. Residential receiver areas are characterised into 'urban', 'suburban', 'rural' or other categories based on land uses and the existing level of noise from industry, commerce, and road traffic.

Rating background noise levels have been taken from Logger 3 (53 Borefield Road), as it was believed that the noise levels recorded at this location were a valid representation of the surrounding areas and were not influenced by traffic noise or other extraneous noise.



1:17,000 (at A3)

0 87.5 175 350 525 700

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND
- Fire Trail
- Creeks
- Cadastre
- Outlet Pipe
- Spillway
- Preliminary Road Design
- Proposed Pipeline Option 7
- Proposed Borefield Collection Pipeline
- Existing Borefield Locations
- Proposed Borefield Locations
- Proposed Borefield Transformers
- Proposed Borefield Access Roads
- Stage 1 Dam Wall
- Stage 1 Inundation Area
- Existing Headworks Area
- Residential Receptors

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Nambucca Shire Council
Bowraville Off River Storage

Job Number	22-14133
Revision	A
Date	07 OCT 2009

Noise Logger Locations

Figure 12-1

27115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E www.ghd.com.au

The project specific noise criteria during operation of the proposed project at residential receivers are provided in Table 12-3.

Table 12-3 Project Specific Noise Levels – Residential Receivers, dB(A)

Criterion	Bowraville Off-River Storage		
	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am
A: Rating Background Level	31 $L_{A90(day)}$	30 (1) $L_{A90(evening)}$	30 (2) $L_{A90(night)}$
B: Intrusiveness Criteria (A +5dB)	36 $L_{Aeq(15\ min)}$	35 $L_{Aeq(15\ min)}$	35 $L_{Aeq(15\ min)}$
C: Rural Amenity Criteria (INP Table 2-1)	50 $L_{Aeq(day)}$	45 $L_{Aeq(evening)}$	40 $L_{Aeq(night)}$
D: Amenity Criteria: (INP Table 2-2 Adjusted)	NA	NA	NA
Project Specific Noise Level (Pg 21 INP)	**36 $L_{Aeq(15\ min)}$**	**35 $L_{Aeq(15\ min)}$**	**35 $L_{Aeq(15\ min)}$**

(1) Nighttime RBL adopted due to high recorded noise levels during the evening period; and

(2) The DECCW's NSW INP, states that where the RBL is less than 30 dB(A), then it is set to 30 dB(A).

The NSW INP requires that the noise level at residences be assessed at the most affected point on or within the residential boundary or, if this is more than 30 m from the residence, at the most-affected point within 30 m of the residence.

Road Traffic Noise Criteria

Due to the potential for the Proposal to create additional traffic levels during the construction phase, road traffic noise criteria may apply. GHD understand that Valla Road would be used as the main access road for the construction of the storage area and embankment.

Road traffic noise criteria are sourced from the DECCW's ECRTN. The ECRTN contains a number of criteria applied to residential receivers near roads, depending on the situation and the road classification. Situation Category 13 in the ECRTN applies to land use developments with potential to create additional traffic on local roads, and as such is applicable to the proposed development.

The ECRTN states that in assessing noise levels at residences, the noise level is to be determined at 1m from the most exposed façade at a height of 1.5m. This criterion includes an allowance for noise reflected from the façade of the building (façade correction). When measuring in a free-field location a correction factor of 2.5 dB(A) would be added to the measured value.

Category 13 of the ECRTN's is provided in Table 12-4.

Table 12-4 ECRTN Road Traffic Noise Criteria L_{Aeq}

Situation	Day (7am – 10pm) dB(A)	Night (10pm – 7am) dB(A)	Where Criteria are Already Exceeded
13. Land use developments with potential to create additional traffic on local roads	$L_{Aeq(1hr)}$ 55	$L_{Aeq(1hr)}$ 50	Where feasible and reasonable, noise levels from existing roads would be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicle; and using barriers and acoustic treatments. In all cases, traffic arising from the development would not lead to an increase in existing noise levels of more than 2 dB.

Sleep Disturbance

The DECCW publication *Noise Guide for Local Government* (NGLG) provides consideration for sleep arousal levels. It states that noise control would be applied with the general intent to protect people from sleep arousal. The DECCW's *ECRTN* provides further clarification on sleep disturbance.

The purpose of sleep arousal guidelines is to address short high-level noise likely to cause awakening during the night time period 10:00 pm to 7:00 am (8:00 am on Sundays and Public Holidays). To achieve this, the $L_{A1(60\ seconds)}$ or L_{Amax} noise level of any specific noise source would not exceed the background noise level (L_{A90}) by more than 15 dB(A) when measured externally 1m from a bedroom window. This criterion takes into account the emergence of noise events but does not directly limit the number of such events or their peak level, which are also found to affect sleep disturbance.

Table 12-5 shows the L_{Amax} noise criteria levels at receiver locations.

Table 12-5 ENCM Sleep Disturbance Criteria L_{Amax} dB(A)

Location	Project-Specific Criteria L_{Amax}
All sensitive receivers	45

Due to the proximity of noise receivers to the proposed site, some nighttime operations may have the potential to exceed the sleep disturbance criteria. Therefore, recommendations for noise control have been made in Section 5 of this report.

Vibration

Vibration during construction activity is expected to primarily originate from haul trucks and heavy machinery during earth moving stages of construction. GHD also understand that blasting may occur during the construction phase.

Human Exposure

Vibration goals during the construction phase were sourced from the DECCW's *Assessing Vibration: a technical guideline*, which is based on guidelines contained in British Standard (BS) 6472–1992, *Evaluation of human exposure to vibration in buildings (1–80 Hz)*.

Intermittent vibration is assessed using the vibration dose value (VDV), fully described in BS 6472 – 1992. Acceptable values of vibration dose are presented in Table 12-6.

Table 12-6 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime [1]		Nighttime [1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas [2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1 Daytime is 7:00 to 22:00 and nighttime is 22:00 to 7:00; and

2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be need to assess intermittent values against the continuous or impulsive criteria for critical areas.

Building Damage

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to the following International Standards and Guidelines:

- British Standard BS7385.2 - 1993 *Evaluation and Measurement for Vibration in Buildings*, Part 2 - Guide to damage levels from ground borne vibration; and
- German Standard DIN 4150-3: 1999-02 Structural Vibration – Part 3: *Effects of vibration on structures*.

BS7385.2 – 1993 is utilised in this case in the assessment of potential building damage resulting from ground borne vibration produced by the proposed construction activity.

The recommended Peak Particle Velocity (PPV) guidelines for the possibility of vibration induced building damage are derived from the minimum vibration levels above which any damage has previously been encountered, and are presented in Table 12-7.

Table 12-7 Transient Vibration Guideline Values for Potential Building - Cosmetic Damage

Building Type	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures. Residential or light commercial type buildings.	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

1 Values referred to are at the base of the building; and

2 For transient vibration effecting unreinforced or light framed structures at frequencies below4 Hz, a maximum displacement of 0.6 mm (zero to peak) would not be exceeded.

Blasting

The DECCW's *Assessing Vibration: a technical guideline* requires that vibration and overpressure from blasting be assessed against the levels in the Australian and New Zealand Environment NSC (ANZEC) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*, 1990.

The recommended maximum level of airblast overpressure during blasting is 115 dB(L) peak. The noise level of 115 dB(L) may be exceeded on up to 5% of the total number of blasts over a period of 12 months though not exceed 120 dB(L).

The recommended maximum level for ground vibration is 5 mm/sec peak particle velocity (ppv). The ppv level of 5 mm/sec may be exceeded on up to 5% of the total number of blasts over a period of 12 months though not exceed 10 mm/sec at any time.

Blasting would generally only be permitted between the hours of 9:00 am and 5:00 pm Monday to Saturday, and would not occur at any time on Sunday or Public Holidays. Blasting would generally only take place once per day.

12.3 Existing Conditions

12.3.1 Noise Receivers

As construction of the Proposal covers a significant area in the vicinity of Bowraville, with a variety of activities, there are a number of residential receivers that may be affected by noise. Noise receivers in the area have been identified as being primarily isolated rural dwellings as well as dwellings within the main township of Bowraville.

12.3.2 Existing Noise Environment

Attended and unattended noise monitoring was conducted by GHD in the area surrounding the proposed storage and borefields. The purpose of noise monitoring was to determine the existing noise levels in the area, which would assist in setting construction and operational noise goals for the Proposal.

An environmental weather station was set-up at one of the noise monitoring locations to capture local weather conditions. The weather station was programmed to record wind speed, wind direction and rainfall on 15-minute intervals for the entire monitoring period.

12.3.3 Noise Monitoring Results

Unattended noise monitoring was undertaken using four Acoustic Research Laboratories (ARL) EL 215 environmental noise loggers. These loggers are capable of measuring continuous sound pressure levels and are able to record L_{A90}, L_{A10}, L_{Aeq} and L_{Amax} noise descriptors. The instruments were programmed to accumulate environmental noise data continuously over sampling periods of 15 minutes for the entire monitoring period.

Prior to deployment, the loggers were calibrated with a sound pressure level of 94 dB at 1kHz using a Bruel and Kjaer Type 4231 sound level Calibrator (serial number 2542101). At completion of the monitoring period, the loggers were retrieved and calibration was rechecked. The data collected by the loggers was downloaded and analysed, and any invalid data removed. Invalid data generally refers to periods of time where average wind speeds were greater than 5 m/s, when rainfall occurred, or for when anomalous noise levels occurred. Table 12-8 displays the detail of each noise logger and Figure 12-5 present a summary of the long-term noise monitoring data.

Table 12-8 Unattended Noise Logger Details

Noise Logger	Logger 1	Logger 2	Logger 3	Logger 4
Monitoring Location	1549 Valla Road	122 Bellingen Road	53 Borefield Road	42 North Arm Road
Logger Serial No.	194803	194539	194637	194688
Measurement Started	18/09/2008 14:00	18/09/2008 15:00	18/09/2008 17:00	18/09/2008 17:30
Measurement Ceased	26/09/2008 08:30	26/09/2008 09:30	26/09/2008 11:00	26/09/2008 11:30
Pre-measurement Calibration	94.2 dB(A)	93.8 dB(A)	93.7 dB(A)	93.6 dB(A)
Freq. Weighting	A	A	A	A
Time response	Fast	Fast	Fast	Fast

Table 12-9 Summary of Noise Monitoring Results

Logger	Background L_{A90} dB(A)			Ambient L_{Aeq} dB(A)		
	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)
Logger 1 dB(A)						
Thursday-18-Sep-08	-	42	29	-	51	49
Friday-19-Sep-08	33	49	34	48	58	50

Saturday-20-Sep-08	33	40	36	47	49	51
Sunday-21-Sep-08	34	45	36	48	53	51
Monday-22-Sep-08	34	43	34	51	52	50
Tuesday-23-Sep-08	32	44	-	48	49	-
Wednesday-24-Sep-08	-	-	-	-	-	-
Thursday-25-Sep-08	-	-	-	-	-	-
RBL and L_{eq} Overall	*33*	*44*	*34*	*48*	*53*	*50*
Logger 2 dB(A)						
Thursday-18-Sep-08	-	36	30	-	39	41
Friday-19-Sep-08	32	37	30	44	40	42
Saturday-20-Sep-08	31	37	35	43	42	-
Sunday-21-Sep-08	32	40	31	52	51	42
Monday-22-Sep-08	33	46	32	44	51	43
Tuesday-23-Sep-08	32	44	34	50	54	46
Wednesday-24-Sep-08	34	35	31	48	43	42
Thursday-25-Sep-08	34	35	29	48	43	42
RBL and L_{eq} Overall	*32*	*37*	*31*	*48*	*48*	*43*
Logger 3 dB(A)						
Thursday-18-Sep-08	-	41	28	-	48	39
Friday-19-Sep-08	31	45	29	42	52	42
Saturday-20-Sep-08	31	43	33	41	51	47
Sunday-21-Sep-08	31	46	29	45	55	42
Monday-22-Sep-08	32	45	29	43	50	45
Tuesday-23-Sep-08	30	45	31	45	53	44
Wednesday-24-Sep-08	31	30	29	42	45	36
Thursday-25-Sep-08	32	35	28	43	46	36
RBL and L_{eq} Overall	31	44	29	43	51	43
Logger 4 dB(A)						
Thursday-18-Sep-08	-	44	28	-	50	42
Friday-19-Sep-08	32	46	28	45	49	44
Saturday-20-Sep-08	31	46	31	45	49	-
Sunday-21-Sep-08	31	47	29	44	51	43
Monday-22-Sep-08	34	50	30	47	53	43

Tuesday-23-Sep-08	33	46	31	49	-	50
Wednesday-24-Sep-08	32	31	28	49	42	41
Thursday-25-Sep-08	35	40	27	48	48	40
RBL and L_{eq} Overall	32	46	29	47	51	46

Figure 12-2 to Figure 12-5 show the location of each logger.

Figure 12-2 Logger 1 - 1549 Valla Road

Figure 12-3 Logger 2 - 122 Bellingen Road

Figure 12-4 Logger 3 - 53 Borefield Road

Figure 12-5 Logger 4 - 42 North Arm Road

Attended noise monitoring was conducted over 15-minute periods at each of the long term monitoring locations. Attended measurements were undertaken using a Bruel and Kjaer 2250 sound level meter (SLM) (serial number 2506887). This SLM is capable of measuring continuous sound pressure levels and is able to record L_{Amin}, L_{A90}, L_{A10}, L_{Amax} and L_{Aeq} noise descriptors. On-site calibration conducted immediately before and after the measurements showed negligible variation. Details of the existing noise environment were also made during these monitoring periods. The results of attended monitoring are shown in Table 12-10.

Table 12-10 15-Minute Attended Noise Monitoring Results

Monitoring Location and Description	$L_{Aeq,\ 15\ minute}$	$L_{A90,\ 15\ minute}$	$L_{A10,\ 15\ minute}$	Comments on Noise Environment
Logger 1 – 1549 Valla Road 26/09/2008 08:15	53	32	45	Typical rural environment with local animals and nearby insects influencing the ambient noise. No traffic or mechanical noise was audible during monitoring.
Logger 2 – 122 Bellingen Road 26/09/2008 09:15	37	30	39	Typical rural environment with local animals and insects influencing the ambient noise. Noise from distant farm animals was audible. Traffic noise on Bellingen Road was barely audible and intermittent in nature.
Logger 3 – 53 Borefield Road 26/09/2008 10:30	46	28	38	Typical rural environment with local animals and insects influencing the ambient noise. Traffic noise on North Arm Road was barely audible and intermittent in nature.
Logger 4 – 42 North Arm Road. 26/09/2008 11:30	41	31	44	Typical rural environment with local animals and insects influencing the ambient noise. Audible but intermittent traffic on North Arm Road was removed from measurements (4 car pass-by's in 15 minutes).

Long-term and attended noise monitoring and site observations indicate the following:

- The ambient noise environment at each of the monitoring locations was influenced by typical rural noises, such as insects, birds and wildlife;
- Background L_{A90} noise levels were generally low during the day and night periods at all logging locations. As per the DECCW NSW Industrial Noise Policy (INP), where the rating background level is less than 30 dB(A), then it is set to 30 dB(A); and
- Monitoring results showed that evening background noise levels were generally higher than the daytime and night time levels. These situations can often arise due to increased insect or bird noise during the evening in the warmer months (or due to temperature inversion conditions during winter). Therefore, in determining the Proposal-specific noise levels, the night time rating background level for each monitoring location would be adopted for the evening time period, with consideration to INP Application Notes.

12.4 Impact Assessment

12.4.1 Construction

Construction Noise Results and Discussion

Construction noise impacts associated with the Proposal were conservatively estimated using the well-known distance attenuation relationship described in Equation (1).

$$SPL = SWL - 20Log(d) + 10Log(Q) - 11 \qquad \text{Equation (1)}$$

Where *d = distance (m) between source and receiver;*

Q = Directivity index (2 for a flat surface);

SPL = sound pressure level at the distance d from the source; and

SWL = sound power level of the source.

Typical noise levels produced by the types of construction plants anticipated to be used were sourced from Australian Standard AS 2436: 1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites* and from GHD's internal database. These represent the loudest construction noise sources expected to be found on site and are summarised in Table 12-11.

Table 12-11 Predicted Plant Item Noise Levels, dB(A)

Plant	Estimated L_{w} dB(A)	Estimated SPL dB(A) at Distance (m)						
		50	100	200	400	600	1200	2400
Crane	104	62	56	50	44	40	34	28
Dozer	105	63	57	51	45	41	35	29
Excavator	100	58	52	46	40	36	30	24
Back Hoe	97	55	49	43	37	33	27	21
Compactor	108	66	60	54	48	44	38	32
Loader	104	62	56	50	44	40	34	28
Roller	102	60	54	48	42	38	32	26
Dump Truck	102	60	54	48	42	38	32	26
Heavy Vehicle	103	61	55	49	43	39	33	27
Compressor	86	44	38	32	26	22	16	10
Concrete Truck	103	61	55	49	43	39	33	27
Concrete Saw	118	76	70	64	58	54	48	42
Chainsaw	111	69	63	57	51	47	41	35
Rock Breaker	120	78	72	66	60	56	50	44
Welding	101	59	53	47	41	37	31	25

The magnitude of off-site noise impact associated with construction would be dependent upon a number of factors:

- The intensity of construction activities;
- The location of construction activities;
- The type of equipment used;
- Existing local noise sources;
- Intervening terrain; and
- The prevailing weather conditions.

In addition, construction machinery would likely move about the study area, variously altering the directivity of the noise source with respect to individual receivers. During any given period, the machinery items to be used in the study area would operate at maximum sound power levels for only brief stages. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Finally, certain types of construction machinery would be present in the study area for only brief periods during construction.

Construction activities would primarily be undertaken between 7 am and 6 pm Monday to Friday, and 7 am to 1 pm Saturdays, and construction noise impacts may exceed the 41 dB(A) construction noise goal at nearby residential receivers based on the conservative estimates made in Table 12-11.

Given the mobile nature of construction activities, it is expected that noise receivers would only be exposed to elevated noise levels for relatively short periods.

Construction Vibration Impacts

General Construction

Vibration impacts discussed in this section essentially focus on potential structural damage to properties in close proximity to the study area and/or potentially affected by construction activities.

Construction vibration may be perceived at times at local sensitive receivers; however, the level of annoyance would depend on individuals. Such issues are practically best managed by site monitoring. Circumstances where vibration monitoring would be undertaken are outlined in the construction-related recommendations.

The distance between the potentially impacted receivers and site construction activities would in most cases be well in excess of 100 metres. However, it is possible that pipeline construction works be carried out at distances closer to residences. Table 12-12 outlines typical vibration levels for different plant activities sourced from the NSW RTA Publication *Environmental Noise Management Manual*.

Table 12-12 Typical Vibration Levels – Construction Equipment

Item	Peak Particle Velocity at 10m (mm/s)
Loader	6-8
15 Tonne Compactor	7-8
Roller	5-6
Dozer	2.5-4
Backhoe	1

Building damage 15 mm/s lower limit is normally not exceeded by general construction activities at distances greater than 10 m.

GHD believe that with the general type of construction operations and the typical separation distance to nearby receivers, vibration impacts from general construction activity would be negligible. However, blasting, if it occurs is expected to generate the most significant vibrations levels and may cause vibration impacts at nearby receivers.

Blasting

Estimations for ground vibration and airblast overpressure during blasting have been made with consideration to Australian Standard AS2187.2–2006 *Explosives – Storage and use – Use of explosives*.

Airblast levels have been estimated using the following cube root scaling formula:

$$P = K_a \left(\frac{R}{Q^{1/3}} \right)^a \qquad \text{Equation (2)}$$

Table 12-13 summarises the constants in Equation (2) and the values that have been assumed to estimate airblast levels in this assessment.

AS2187.2–2000 states that for confined blasthole charges, which would most likely be the case for blasting associated with construction of the proposed off-river storage area, a good estimation may be obtained by using a site exponent (a) of –1.45, with the site constant (K_a) commonly in the range of 10 – 100.

Table 12-13 Airblast Parameters and Assumptions

Parameter	Definition	Assumed Value
P	Pressure (kPa)	N/A
Q	Explosive charge mass (kg)	100 (1)
R	Distance from charge (m)	Range: 200 to 1000 metres
K_a	Site constant	50 (2)
a	Site exponent	-1.45

(1) Charge mass has been calculated based on a typical hole diameter of 89 mm, column height of 13 metres and a charge mass of 7.5 kg/meter (specific gravity 1.2); and

(2) A site constant value (K_a) of 50 has been assumed for the sake of this assessment.

Factors that affect the level of ground vibration arriving at a point from a blast typically include:

- Charge mass fired per hole;
- Distance; and
- Ground transmission characteristics.

As many site factors would effect the transmission of vibration through the ground, the most accurate prediction of ground vibration from a site would be from vibration measurements taken on-site. However, in the absence of such site data, ground vibration levels have been estimated using the following formula:

$$V = K_g \left(\frac{R}{Q^{1/2}} \right)^{-B}$$ Equation (3)

Table 12-14 summarises the constants in Equation (3) and the values that have been assumed to estimate ground vibration levels in this assessment.

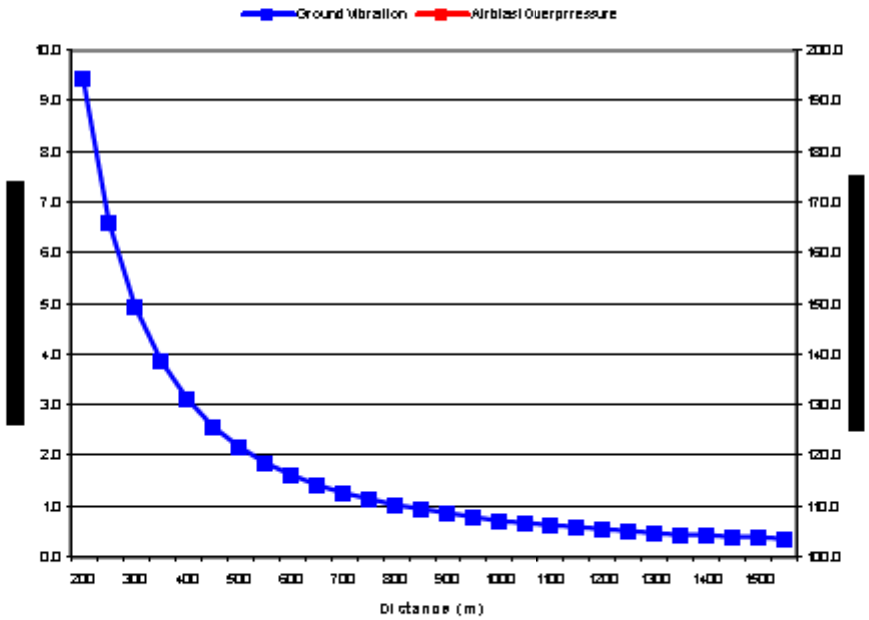
AS2187.2–2000 states that when blasting is carried out to a free face in average field conditions, the mean vector peak particle velocity may be estimated by assuming the values of K_g and B in Table 12-14.

Table 12-14 Ground Vibration Parameters and Assumptions

Parameter	Definition	Assumed Value
V	Ground vibration in vector peak particle velocity (vppv) (m/s)	N/A
R	Distance from charge (m)	Range: 200 to 1000 metres
Q	Maximum charge mass (kg)	100 (1)
K_g, B	Constants related to site and rock properties for estimation purposes	K_g = 1140 B = 1.6

Charge mass has been calculated based on a hole diameter of 89 mm, column height of 13 metres and a charge mass of 7.5 kg/meter (specific gravity 1.2). Figure 12-6 displays a graph of the estimated airblast overpressure and ground vibration levels against the distance from the blast.

Figure 12-6 Airblast and Ground Vibration Predictions



Estimations of airblast overpressure indicates that the recommended peak noise level of 115 dB(L) may be reached at up to 1500 metres from the blast location. However, as attenuation loss from screening of local terrain features has not been taken into account, these estimations are considered to be conservative.

Estimations of ground vibration levels indicates that the 5 mm/sec recommended limit may be reached at up to 300 metres from the blast location.

12.4.2 Operational

Industrial Noise

GHD understand that the sources of noise during the operation of the Proposal would be:

- Proposed borefields and associated pumping stations (headworks); and
- Maintenance and visitor traffic on Valla/ Bobo Roads.

Given the relative isolation of the proposed borefields and the limited number of traffic movements expected during the operation of the Proposal, operational noise modelling has focused on the predicted noise likely to be generated from the proposed headworks building.

For continuous operation of two pumps within the headworks building, predicted contribution based on modelling at the nearest residential boundary would be approximately 12 dB(A) under neutral conditions. Table 12-9 documents the results of the modelling whilst Figure 12-7 illustrates the proximity of the nearest residential dwelling to the existing and proposed headworks building.

Table 12-15 Predicted Noise Modelling

Source	Partial Level Day			
Name	ID	Receiver 1	Receiver 2	Nearest Receiver
Louvre	Louvre	-14.3	-21.3	6.1
Pump house	Roof NE	-12.7	-16.8	4.5
Pump house	Roof SE	-12.5	-16.6	4.5
Pump house	NE Embankment	-16.9	-20.7	3.6
Pump house	SE Embankment	-20.4	-24.3	0
Pump house	SW Embankment	-21.4	-27.8	-2
Pump house	NW Embankment	-24.6	-33.2	-4.8
Roller door	Roll Door	-25.2	-34.9	-6.9
Door 40		-33.7	-43.6	-13.8

Figure 12-7 Operational Noise Assessment

The operational criteria for the Proposal would be 36dB for day & 35dB for evening & night and therefore 12dB would likely be inaudible. The main contributor to the increase in noise would be the proposed non-acoustic louvre (2m x 1m) on southern side of headworks building followed by the corrugated steel roof with insulation/sarking and then the proposed brick embankments of the building. The roller door (sheet steel) is a lower contributor due to its location on the southern side of the building.

Road Traffic Noise

It is expected that road traffic following the construction of the Proposal would primarily occur during daytime hours and would not be of a significant volume. Therefore, it is not expected that road traffic noise from the Proposal would be an issue.

12.5 Mitigation Measures

Mitigation measures have been provided below to assist with noise and vibration control during the construction and operation phases of the Proposal and would be incorporated into a Construction EMP.

12.5.1 Construction

Work Ethics / Community Relations

- All site workers would be sensitised to the potential for noise impacts onto local residents and encouraged to take all practical and reasonable measures to minimise noise during the course of their activities; and
- The site manager (as appropriate) would establish contact with the local residents and communicate the construction program and progress on a regular basis, particularly when noisy activities are planned.

General Recommendations

As far as practicable, the following general noise control measures would be incorporated in the Construction EMP:

- Aim to minimise movements of equipment and personnel during noise sensitive periods, such as night time; and
- Staff arriving or leaving the construction work areas before 7 am or after 6 pm would be made aware of the potential for noise impacts at nearby receivers;
- All work would be kept within the working hours prescribed by the DECCW CNG. This includes trucks not arriving on construction work areas before 7:00 am. Should works out of these hours be needed, the work methods and noise goals of the DECCW's CNG would be considered;
- All equipment used on site would be in good condition and good working order;
- Use equipment, which is fit for the required tasks in terms of power requirements;
- All engine covers would be kept closed while equipment is operating;
- All combustion engine plant, such as generators, compressors and welders would be checked to ensure they produce minimal noise with particular attention to residential grade exhaust silencers;

- Vehicles would be kept properly serviced and fitted with appropriate mufflers. The use of exhaust brakes would be avoided, where practicable;
- Where practical, machines would be operated at low speed or power and would be switched off when not being used rather than left idling for prolonged periods;
- Machines found to produce excessive noise would be removed from the construction work areas or stood down until repairs or modifications can be made; and
- Should blasting be required on construction work areas, the activity would be subject to vibration controls stipulated in the Construction EMP.

12.5.2 Operation

General Recommendations

The following general noise control measures would be incorporated in the design of operational noise sources, such as pumping stations:

- All external noise sources would be located so as to avoid direct line of sight with noise receivers;
- If possible, ventilation or exhaust openings would not face noise receivers;
- Staff arriving or leaving the site for maintenance before 7 am or after 6 pm would be aware of the potential for noise impact at nearby receivers.

Mechanical Plant – General Advice

- Investigate the operational requirements for the mechanical systems and where practical, optimise the required operational time with consideration to potentially noise sensitive time periods, such as night;
- Equipment would be kept properly serviced;
- Where practical, machines would be operated at low speed or power and would be switched off when not being used rather than left idling for prolonged periods;
- Mechanical plant would be fully enclosed to minimise noise propagation; and
- All equipment would be vibration isolated, with consideration to manufacturers requirements.

13 Indigenous Heritage

The information in this Chapter is taken from 'Nambucca District Water Supply Environmental Impact Assessment Cultural Heritage Assessment of Ancillary Areas' prepared by Navin Officer, February 2009. An unabridged version of the report is provided in Appendix D, Volume 2.

13.1 Introduction

This Chapter identifies the potential indigenous heritage impacts associated with the Proposal and the management measures to reduce these impacts. Table 13-1 outlines the Director-General's and other statutory authority requirements and where they have been addressed.

Table 13-1 Statutory Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ The effect of the development or activity on the cultural and heritage significance of the land	Section 13.3.2
Department of Environment, Climate Change and Water (DECCW) (formerly DECC and DWE)	◗ Assessment of the impact of the altered flow regime on Aboriginal cultural values. ◗ DECCW notes the existence of 16-registered Aboriginal sites in the immediate locality. The EIS would need to consider any potential impacts on the traditional aboriginal custodians and any relationship that may exist between these sites and any aboriginal cultural values. ◗ The EIS would also address the development in relation to the requirements of Section 5A of the *EP&A Act*, and determine whether a permit to disturb Aboriginal objects under Part 6, s 87 or whether a licence to destroy, deface or damage Aboriginal objects maybe required under Part 6, s90 of the *National Parks and Wildlife Act*. ◗ The EIS would address and document information requirements set out in DECCW guidelines, include surveys by suitably qualified architects, identify nature and extent of impacts, significance of the sites, actions to mitigate impacts and demonstrate the effective communication with Aboriginal communities.	Sections 13.3 , 13.3.2 and 13.5

13.2 Assessment Methodology

A key aspect of the Aboriginal heritage assessment was consultation with the local Aboriginal community via the establishment of an Aboriginal Liaison Committee. Details of the consultation process are provided in Chapter 6 – Consultation and in the Cultural Heritage Assessment - Appendix D, Volume 2.

The Aboriginal heritage assessment identified known and potential Aboriginal heritage sites and objects and addressed Aboriginal cultural, social heritage and archaeological values. Key tasks undertaken as part of the assessment included:

◗ A review of relevant heritage registers and background literature.

- Consultation with the Bowraville Local Aboriginal Land NSC (BLALC), Elders groups and other knowledge-holders.
- Field survey assisted by nominated Aboriginal representatives.
- Identify material evidence of Aboriginal occupation as revealed by surface artefacts and areas of archaeological potential unassociated with surface artefacts. Potential recordings fall into two broad categories: sites and potential archaeological deposits.
- Assessment of the potential impacts of the Proposal in terms of traditional and contemporary Aboriginal cultural and social values.
- The provision of management recommendations and impact management strategies appropriate to the significance and extent of Aboriginal heritage values.

13.3 Existing Conditions

13.3.1 Regional Context

Tribal and linguistic boundaries, traditional lifestyles, the impact of European settlement, a regional overview and a summary of previous archaeological research in the Nambucca area have been provided in the 2005 report by Navin Officer Heritage Consultant's *Nambucca District Water Supply Storage Dam Site 2B and Ancillary Works Areas Cultural Heritage Assessment* (pp 12-14).

13.3.2 Previous Nambucca District Water Supply Studies

Gorman (1996) undertook a cultural heritage assessment of dam site '2', which included both Options 2a and 2b. No Aboriginal archaeological sites were identified in the course of Gorman's study.

Gorman provided an extensive review of Gumbaingirri ethnohistoric information and some general information on local family affiliations. Gorman also documented information about 'dangerous, mythological and a possible ancestral camping place' (Gorman 1996:34) that was told to her by members of the Aboriginal community.

More rigorous requirements for reporting archaeological assessments were implemented subsequent to Gorman's 1996 assessment (refer NPWS Standards and Guidelines 1997; correspondence: Liam Dagg to NSW Department of Commerce, 13 August 2004). Taking account of this factor, the Department of Commerce commissioned a review and update of the 1996 archaeology study to meet current requirements.

This review was conducted in 2004 by Navin Officer Heritage Consultants and included a review of relevant heritage literature and databases, Aboriginal consultation and field inspections. The scope of the field inspections was defined in part by property access information and the available plans for the Water Supply Project, and thus concentrated on the proposed dam site 2b inundation area, the storage embankment area and access roads. Areas such as the pipeline routes, the pump site and release point on the Nambucca River, and Bowra Creek downstream of the storage were not subject to archaeological survey. These areas were viewed from nearby vantage points and an assessment made of their archaeological sensitivity/potential.

Field survey involved the field team walking most roads and forestry tracks in the inundation area, inspecting the storage embankment area and walking the proposed access road. The Bowra Creek riparian zone was surveyed upstream of the storage embankment for approximately 750 m. Survey in the thickly vegetated upper reaches of Bowra Creek was opportunistic and limited to areas that were accessible.

An Aboriginal Liaison Committee (ALC) was set up in 2007 by the NSW Department of Commerce to facilitate and encourage participation of the local community in the design and construction of the Proposal. No additional sites to those identified in the 2004 field survey have been highlighted by the ALC.

In December 2007, NSC and the Department of Commerce conducted a 'walk-through' of the borefield areas with Aboriginal community elders. This walk-through identified and mapped three areas of significance to the local Aboriginal community in the borefields investigation areas (pers comm Tim Alexander [Dept of Commerce] 2008).

In October 2008, NOHC undertook a desktop review and update of previous cultural heritage assessments undertaken for the Nambucca District Water Supply project. The review defined the further works necessary to meet statutory and policy requirements in relation to the project.

13.3.3 Aboriginal Archaeological Sites

Gorman conducted a field survey within the 1996 'Site 2' dam option, concentrating on creek lines and forestry tracks. She noted that visibility along the creek was 0% and that the gully slopes within the Viewmont State Forest were steep, with vegetation thick to the point of being impenetrable (Gorman 1996:37). Visibility was also poor in the cleared pasture lands where effective survey was limited creek lines, cattle tracks and small discrete ground surface exposures. There is no data in the report that indicates where Gorman actually surveyed. No Aboriginal sites or artefacts were identified in the course of Gorman's 1996 survey.

One possible Aboriginal object (NSW1) was found approximately 50 m from the proposed inundation maximum storage level in the course of the 2004 field surveys. This item, a manuport, was a dark grey/brown, fine-grained volcanic alluvial cobble with a light grey/green patina. (A manuport is an object or fragment of an object carried by human agency to the locality in which it is found, but which may not display any other features of past use). It is not certain that the manuport had an Aboriginal origin, however most non-Aboriginal explanations, such as a hearth stone, road or construction material were largely discounted.

A review of the Department of Environment and Climate Change's Aboriginal Heritage Information Management System (AHIMS) for the 2008 study area indicates that there are no additional Aboriginal sites within the study area.

13.3.4 Sites Identified by Aboriginal Informants

The following sites were identified by local informants to Alice Gorman in 1996. The full verbatim from Gorman's report can be found in the Cultural Heritage Assessment - Appendix D, Volume 2.

- Burial grounds
- Dangerous places
- Ceremonial grounds

- Camping Places

Although it is clear that the landscape around Bowraville contains many areas of significance to the local Aboriginal community, none are located directly on Site 2 [note that in 1996 site 2 included both Options 2A and 2B], and during consultation no concerns were raised about the construction of the dam at this location (Gorman 1996:38-40). As noted in her conclusions, none of the sites/locations would be directly impacted by the proposed dam and associated infrastructure.

An area referred to as 'The Rocks' burial ground near the Nambucca River was identified to the consultants in the course of the 2004 study as being of particular significance to the local Aboriginal community. The site is situated on the Nambucca River approximately one kilometre upstream of Bowraville.

Three areas were identified as a result of the 2007 'walkthrough':

- A corroboree ground on the flat area on the inside of the bend in the Nambucca River on the S-W corner of property no. 13.
- Burial grounds adjacent to the river on both sides - up to 30 m from the edge of the river - as shown hatched on properties 5, 10, 11, 12 and 13.
- A Mythological Area adjacent to South Creek - up to 30m from the edge of the river - as show hatched on properties 24, 25, 26, 27, 28.

Two of these areas, the corroboree and the burial ground are a part of 'The Rocks' area.

13.4 Impact Assessment

13.4.1 Assessment Criteria

The Burra Charter of Australia defines cultural significance as 'aesthetic, historical, scientific or social value for past, present and future generations' (Aust. ICOMOS 1987). The assessment of the cultural significance of a place is based on this definition but often varies in the precise criteria used according to the analytical discipline and the nature of the site, object or place.

In general, Aboriginal archaeological sites are assessed using five potential categories of significance:

- significance to contemporary aboriginal people;
- scientific or archaeological significance;
- aesthetic value;
- representativeness; and
- value as an educational and/or recreational resource.

Many sites would be significant according to several categories and the exact criteria used would vary according to the nature and purpose of the evaluation. Cultural significance is a relative value based on variable references within social and scientific practice. The cultural significance of a place is therefore not a fixed assessment and may vary with changes in knowledge and social perceptions.

Aboriginal significance can be defined as the cultural values of a place held by and manifest within the local and wider contemporary Aboriginal community. Places of significance may be landscape features as well as archaeologically definable traces of past human activity. The significance of a place can be the result of several factors including: continuity of tradition, occupation or action; historical association; custodianship or concern for the protection and maintenance of places; and the value of sites as tangible and meaningful links with the lifestyle and values of community ancestors. Aboriginal cultural significance may or may not parallel the archaeological significance of a site.

Scientific significance can be defined as the present and future research potential of the artefactual material occurring within a place or site. This is also known as archaeological significance.

There are two major criteria used in assessing scientific significance:

1. The potential of a place to provide information, which is of value in scientific analysis and the resolution of potential research questions. Sites may fall into this category because they: contain undisturbed artefactual material, occur within a context which enables the testing of certain propositions, are very old or contain significant time depth, contain large artefactual assemblages or material diversity, have unusual characteristics, are of good preservation, or are a constituent of a larger significant structure such as a site complex.
2. The representativeness of a place. Representativeness is a measure of the degree to which a place is characteristic of other places of its type, content, context or location. Under this criteria a place may be significant because it is very rare or because it provides a characteristic example or reference.

The value of an Aboriginal place as an educational resource is dependent on: the potential for interpretation to a general visitor audience, compatible Aboriginal values, a resistant site fabric, and feasible site access and management resources.

The principal aim of cultural resource management is the conservation of a representative sample of site types and variation from differing social and environmental contexts. Sites with inherently unique features, or which are poorly represented elsewhere in similar environment types, are considered to have relatively high cultural significance.

The cultural significance of a place can be usefully classified according to a comparative scale which combines a relative value with a geographic context. In this way a site can be of low, moderate or high significance within a local, regional or national context. This system provides a means of comparison, between and across places. However it does not necessarily imply that a place with a limited sphere of significance is of lesser value than one of greater reference.

13.4.2 Assessment

The following assessments are made with full reference to the scientific, aesthetic, representative and educational criteria outlined above. Reference to Aboriginal cultural values has also been made where these values have been communicated to the consultants. It would be noted that Aboriginal cultural significance can only be determined by the Aboriginal community, and that confirmation of this significance component is dependent on written submissions by the appropriate representative organisations. The inventory of identified sites and PAD are tabulated in Table 13-2.

Table 13-2 Inventory of Site and PAD Locations and Potential Impact

Recording Type	Recording Code	GDA Reference	Potential Impact
Possible Aboriginal Manuport	NWS1	487396.6612417	Located within 50m of FSL of storage
Aboriginal PAD	NWPAD1	486800.6611480 to 486400.6610690	Proposed transfer pipeline route
Aboriginal burial ground and corroboree area	The Rocks		No impact
Mythological Site	MS		No impact

One possible Aboriginal manuport, one area of potential Archaeological Deposit (PAD) and two areas of Aboriginal cultural value were identified in the study area. These sites are illustrated in Figure 13-1 and have been described below.

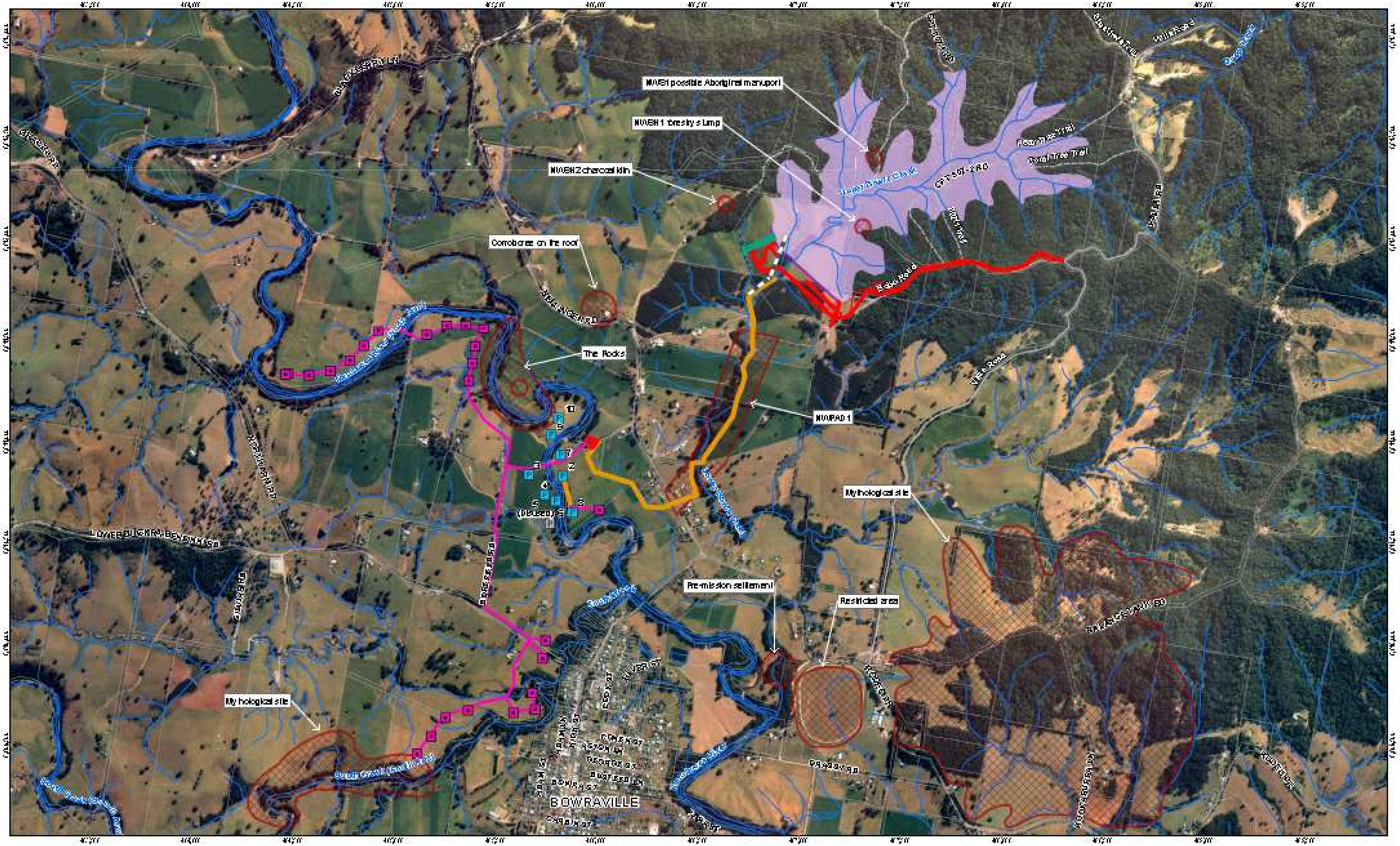
Possible Aboriginal Manuport – Nambucca Water Supply 1 (NWS1)

This item, recorded in 2004, is a dark grey/brown, fine-grained volcanic alluvial cobble with a light grey/green patina. The manuport is located 50 m from the full storage level and as such would not be impacted, however to ensure there is no impact it is proposed to relocate the site near to its find location outside of any potential impact zone.

A manuport is an object or fragment of an object carried by human agency to the locality in which it is found, but which may not display any other features of past use. It is not certain that the manuport has an Aboriginal origin, however most non-Aboriginal explanations, such as a hearth stone, road or construction material can be largely discounted.

There remains a possibility that it represents random loss from heavy machinery, an open vehicle or a tray back. Fred Walker explained that he thought it was likely that the manuport was a broken hatchet head or hand axe. Exposure incidence in the area was 90% and visibility in the exposure was about 95%.

An Aboriginal origin cannot be definitely ascribed to the isolated manuport NWS1, based solely on the archaeological evidence. The Aboriginal representatives present during the survey however were more confident of its origin, based on their own cultural interpretations.



1:17,000 (at A3)

0 87.5 175 350 525 700

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Fire Trail
- Road
- Creeks
- Cadastre
- Cultural Heritage Areas
- Existing Headworks Area
- Outlet Pipe
- Spillway
- Proposed Storage Wall
- Proposed Inundation Area
- Proposed Pipeline Option7 (GHD Preferred)
- Preliminary Road Design
- Proposed Borefield Locations
- Existing Bores
- Disused Bores
- Proposed Borefield Collection Pipeline

GHD — CLIENTS | PEOPLE | PERFORMANCE

Nambucca Shire Council
Bowraville Off-River Storage

Location of Heritage Recordings

Job Number	22-14133
Revision	A
Date	07 OCT 2009

Figure 13-1

2/115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E www.ghd.com.au

Data Source: Nambucca Shire Council: Cadastre & Aerial - 2007; Department of Lands: Topography - 2005. Created by: Gkamvoulias, fmackay, mnorris

Manuports of this nature in disturbed contexts are not usually considered to have archaeological significance based on any of the criteria defined above. However, this item is likely to have a degree of Aboriginal cultural significance based on the interpretations of local Aboriginal community representatives.

Nambucca Water Supply PAD1 (NWSPAD1)

This was recorded in the course of the 2008 field survey. This potential archaeological deposit comprises creek flats and basal slopes associated with Bowra Creek (refer to Figure 13-1).

The proposed transfer pipeline route runs parallel to Bowra Creek and through NWSPAD1 (from the already formed vehicle tracks to Bellingen Road).

Sites of Cultural Value

Two areas of Aboriginal cultural value, the burial ground [the rocks] and corroboree area, and a mythological site, was identified by Aboriginal informants.

The Rocks is located on the Nambucca River and a buffer zone of 30 m either side of the river has been identified by Aboriginal representatives. The mythological site is located on South Creek. The Proposal has taken into account the cultural sites and has been modified such that the proposed borefield and associated collection pipe system is outside the 30 buffer identified by Aboriginal informants.

The Nambucca River has over time been used for various cultural pursuits including swimming, fishing and as a food resource. As environmental flows in the river would be protected as part of the Proposal there would be no impact on this aspect of the study area.

13.5 Mitigation Measures

One possible Aboriginal manuport (NSW1) has been previously identified approximately 50 m from the proposed full storage level in the course of the 2004 survey of the storage area. Site NWS1 would not be inundated when the storage is full. No Aboriginal sites were located in the course of the 2008 survey of ancillary areas.

One area of Potential Archaeological Deposit (NWPAD1) was identified in the course of the 2008 survey. The proposed transfer pipeline traverses the PAD area.

Several areas of cultural significance have been identified by the local Aboriginal community including a burial ground [the rocks] and corroboree area near the Nambucca River and a mythological site near South Creek. Neither would be impacted by the Proposal.

The proposed management measures are outlined below:

- That the possible Aboriginal manuport (NWS1) be re-positioned near to its find location outside of any impact zone by local Aboriginal representatives and archaeologists prior to construction commencing within the storage area.
- As the NWPAD1 is to be impacted by the installation of the transfer pipeline, a program of archaeological subsurface investigation (and Section 87 permit under the NPW Act) would be undertaken with the aim of determining the nature, extent and significance of any subsurface archaeological deposit present within the area.
- To minimise potential delays in construction resulting from the identification of unidentified Aboriginal sites, it is proposed that after initial vegetation clearance within the storage,

Aboriginal representatives and archaeologists would undertake an inspection of the storage area. This would provide an opportunity to locate and collect any sites that may not have been able to be seen during the field surveys. A section 87 permit would be required from DECCW to collect any identified sites.

14 Non-indigenous Heritage

The information in this Chapter is taken from 'Nambucca District Water Supply Environmental Impact Assessment Cultural Heritage Assessment of Ancillary Areas' prepared by Navin Officer, February 2009. An unabridged version of the report is provided in Appendix D, Volume 2.

14.1 Introduction

This Chapter identifies the potential non - indigenous heritage impacts associated with the Proposal and the management measures to reduce these impacts. Table 14-1 outlines the Director-General's requirements and where they have been addressed.

Table 14-1 Statutory Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	The effect of the development or activity on the cultural and heritage significance of the land	Sections 1.2, 1.3, 1.4

14.2 Assessment Methodology

Details of the assessment methodology are provided in the Cultural Heritage Assessment – located in Appendix D. The assessment included the following key tasks:

- Searching listings of the Australian Heritage Commission's (AHC) Register of the National Estate, NSW State Heritage Inventory, National Trust of Australia (NSW), and relevant local and regional environmental planning instruments and heritage studies.
- Reviewing available literature applicable to the study area.
- Field survey.
- Identify historical sites and features (as described below in further detail).
- Preliminary assessment of potential effects resulting from the proposal.
- Providing initial recommendations on the need to avoid, minimise or mitigate any potential effects and the need to undertake further detailed studies.
- Obtaining information on the statutory requirements relating to non-indigenous heritage issues.

Historical sites and features: Historical archaeology refers to the 'post-contact' period and includes: domestic, commercial and industrial sites as well as most maritime sites. It is the study of the past using physical evidence in conjunction with historical sources. The two primary types of places or items that may form part of the terrestrial historical archaeology context include:

- Below ground evidence, including building foundations, occupation deposits, features and artefacts; and above ground evidence, including buildings, works, industrial structures and relics that are intact or ruined; and
- Areas of land that display evidence of human activity or occupation.

Within these broad parameters, an historical archaeological site may include:

- Topographical features and evidence of past environments;
- Evidence of site formation, evolution, redundancy and abandonment (that is, features and materials associated with land reclamation, sequences of structural development, demolition/deconstruction, and renewal);
- Evidence of function and activities according to historical theme/s represented (for example, an industrial site may contain diagnostic evidence of process, products and by-products);
- Evidence associated with domestic occupation including household items and consumables, ornaments, personal effects and toys;
- Evidence of diet including animal and fish bones, and plant residues;
- Evidence of pastimes and occupations including tools of trade and the often fragmentary signatures of these activities and processes;
- Methods of waste disposal and sanitation, including the waste itself which may contain discarded elements from all classes of artefact as well as indicators of diet and pathology; and
- Any surviving physical evidence of the interplay between site environment and people.

The information found in historical archaeological sites is often part of a bigger picture which offers opportunities to compare and contrast results between sites. The most common comparisons are made at the local level, however, due to advances in research and the increasing sophistication and standardisation of methods of data collection, the capacity for wider reference (nationally and, occasionally, internationally) exists and places added emphasis on identification and conservation of historical archaeological resources.

14.3 Existing Conditions

14.3.1 Previous Nambucca District Water Supply Studies

Gorman (1996) undertook a cultural heritage assessment of storage site '2', which included both Options 2a and 2b.

Gorman conducted an historic heritage assessment of Site 2 (Options 2a and 2b) as part of her archaeological assessment. Her study included consultation with local landowners, review of information held at the Eliza and Joseph Newman Folk Museum in Bowraville and some field survey. Gorman was shown the site of a charcoal kiln by landowner, Mr Ussher.

More rigorous requirements for reporting archaeological assessments were implemented subsequent to Gorman's 1996 assessment (refer NPWS Standards and Guidelines 1997; correspondence: Liam Dagg to NSW Department of Commerce, 13 August 2004). Taking account of this factor, the Department of Commerce commissioned a review and update of the 1996 archaeology study to meet current requirements.

This review was conducted in 2004 by Navin Officer Heritage Consultants and included a review of relevant heritage literature and databases, consultation and field inspections. The scope of the field inspections was defined in part by property access information and the available plans for the Water Supply Project, and thus concentrated on the proposed storage site 2b inundation area, the storage embankment area and access roads. Areas such as the

pipeline routes, the pump site and release point on the Nambucca River, and Bowra Creek downstream to the storage were not subject to archaeological survey. These areas were viewed from nearby vantage points and an assessment made of their archaeological sensitivity/potential.

Field survey involved the field team walking most roads and forestry tracks in the inundation area, inspecting the storage embankment area and walking the proposed access road. The Bowra Creek riparian zone was surveyed upstream of the storage embankment for approximately 750 m. Survey in the thickly vegetated upper reaches of Bowra Creek was opportunistic and limited to areas that were accessible.

In October 2008, NOHC undertook a desktop review and update of previous cultural heritage assessments undertaken for the Nambucca District Water Supply project. The review defined the further works necessary to meet statutory and policy requirements in relation to the Proposal.

14.3.2 Sites in and near the Study Area

Two European heritage items were identified in the course of the 2004 field surveys for the Nambucca District Water Supply project. These comprise a forestry tree stump with springboard holes, and the remains of a charcoal kiln (as identified by Gorman in 1996).

14.3.3 Description and assessment of significance of identified sites

Two European heritage items, a forestry tree stump with springboard holes and the remains of a charcoal kiln, were recorded in 2004. No European heritage sites were located in the context of the 2008 field survey. These sites are illustrated in Figure 1-1 in Chapter 13- Indigenous Heritage and have been allocated an identifier in the descriptions below.

The forestry tree stump (NWSH1)

This is located approximately 100 m northeast of the cleared paddock edge of the eastern boundary of portion 152 (Ussher's farm) and within the proposed storage area. This site consists of a large standing tree stump with springboard slots, and a fallen section of the sawn and felled tree trunk (refer to Figure 14-1). The stump is 4.7 m in circumference (at breast height) and is located on the creek (west) side of an overgrown vehicle track that is approximately 100 m northeast of the cleared paddock edge of the eastern boundary of portion 152 (Ussher's farm).

The tree has been felled with a cross-cut saw and cut approximately 2.4 m above the ground. A springboard slot, 16 cm wide, 7 cm high and 12 cm deep is situated 1.6 m above the ground on the eastern face of the stump. Several shallow axe slots occur below this, at 1.4 and 1.5 m above the ground. A step, 60 cm wide and inset 20 cm and 60 cm high has been cut below the shallow axe marks, at 1 m above the ground. Another springboard slot, 16 cm wide, 5 cm high and 6 cm deep has been cut on the southern stump face, approximately 1.7 m above the ground, with a shallow axe mark also placed next to it 40 cm to the left. Some 20 cm above the slot is cut bench, 50 cm wide and 20 cm deep. A long section of now rotten tree trunk is situated 15 m away from the stump.

Figure 14-1 NWSH1 – Forestry stump and felled trunk, with detail of springboard slot.

The charcoal kiln (NWSH2)

This is located on the crest of a spurline shoulder, at the edge of a small forest remnant within dairy farm grasslands to the west (and outside of) the storage area.

The charcoal kiln was operated by Alec Graham during World War II. Charcoal was used to run gas producers that were an alternative source of vehicle fuel during the war. The operation consisted of one earth kiln and one brick lined kiln, dug into the ground next to each other. A fire was lit and the wood put into the earth kiln to burn to charcoal. It was then doused with water, dug out and transferred to the brick kiln, which could attain a higher temperature. Any unburnt wood would be consumed in this kiln and the process finished. After a second dousing the charcoal would be bagged and taken to Macksville for sale (Gorman 1996:40, 41).

The site now comprises a shallow rectangular and elongated earthen pit with approximate dimensions 3.4 m long and 1.2 m wide. Low spoil mounds are located on the eastern side of the pit and cover an area of 3 x 2.6 m. The pit is aligned at right angles to the spurline (318°), and is situated 2 m from a vehicle track that traverses the spurline (refer to Figure 14-2).

The track follows a fence line and cuts off a small bend in a presumably older but better benched track, situated just down slope of the fence line track. The pit is now 55 cm deep but has clearly filled with forest litter and sediment since its abandonment. No evidence for bricks or a former brick lining was evident in or around the pit.

Approximately 70 m southwest along the track from the pit, a small scatter of brick fragments was encountered. These may be traces of the bricks used in the reported brick kiln, and which were presumably later removed and reused. Two of the three fragments appear to be hand moulded sandstock bricks with a coarse aggregate and no frog (10.5 cm wide and 7.7 cm deep). The other fragment is clearly later in age, being machine moulded and with a rectangular frog (7.7 cm deep). If all of these fragments relate to the charcoal kilns, then its suggests that bricks for the kiln were collected from a number of sources, including probable nineteenth century former structures.

Figure 14-2 General view of location of charcoal pit – NWSH2 (right, next to 2 scale), looking southwest

14.4 Impact Assessment

14.4.1 Assessment Criteria

The NSW Heritage Office has defined a methodology and set of criteria for the assessment of cultural heritage significance for items and places, where these do not include Aboriginal heritage from the pre-contact period (NSW Heritage Office & DUAP 1996, NSW Heritage Office 2000). The assessments provided in this report follow the Heritage Office methodology.

The following heritage assessment criteria are those set out for Listing on the State Heritage Register. In many cases items would be significant under only one or two criteria. The State Heritage Register was established under Part 3A of the Heritage Act (as amended in 1999) for listing of items of environmental heritage that are of state heritage significance. Environmental heritage means those places, buildings, works, relics, moveable objects, and precincts, of state or local heritage significance (Section 4, Heritage Act 1977).

An item would be considered to be of State (or local) heritage significance if, in the opinion of the Heritage NSC of NSW, it meets one or more of the following criteria:

Criterion (a) an item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (b) an item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (c) an item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area);

Criterion (d) an item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons;

Criterion (e) an item has potential to yield information that would contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (f) an item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area);

Criterion (g) an item is important in demonstrating the principal characteristics of a class of NSW's

1.1 cultural or natural places; or

1.2 cultural or natural environments (or a class of the local area's)

1.3 cultural or natural places; or

1.4 (cultural or natural environments.)

An item is not to be excluded from the Register on the ground that items with similar characteristics have already been listed on the Register. Only particularly complex items or places would be significant under all criteria.

In using these criteria it is important to assess the values first, then the local or State context in which they may be significant.

Different components of a place may make a different relative contribution to its heritage value. For example, loss of integrity or condition may diminish significance. In some cases it is constructive to note the relative contribution of an item or its components. Table 14-2. provides a guide to ascribing relative value.

Table 14-2 Guide to ascribing relative heritage value

Grading	Justification	Status
Exceptional	Rare or outstanding item of local or State significance. High degree of intactness Item can be interpreted relatively easily.	Fulfils criteria for local or State listing.
High	High degree of original fabric. Demonstrates a key element of the item's significance. Alterations do not detract from significance.	Fulfils criteria for local or State listing.
Moderate	Altered or modified elements.	Fulfils criteria for local or State

Grading	Justification	Status
	Elements with little heritage value, but which contribute to the overall significance of the item.	listing.
Little	Alterations detract from significance. Difficult to interpret.	Does not fulfil criteria for local or State listing.

Grading	Justification	Status
Intrusive	Damaging to the item's heritage significance.	Does not fulfil criteria for local or State listing.

14.4.2 Assessment

Table 14-3 summarises the inventory of site locations and the potential Impact upon them as a result of the Proposal.

Table 14-3 Inventory of Site Locations and Potential Impact

Recording Type	Recording Code	GDA Reference	Potential Impact
forestry stump	NWSH1	487337.6612701	Storage inundation
remains of charcoal kiln	NWHS2	486643.6612172	No impact

Forestry Stump and Felled Trunk - Nambucca Water Supply Historic 1 (NWSH1)

The forestry stump and felled trunk NSWH1 is demonstrative of a past forestry harvesting method no longer practiced. It contains a range of surface features that relate to the technique of manually felling a large tree with axes and a cross cut saw. The site is however in relatively poor condition, with wood rot and termite activity widespread throughout the internal tissues of the stump and felled trunk. The site is also situated in a location poorly suited for public interpretation, being difficult to access and now surrounded by a tree plantation and regrowth. This site is typical of many such stumps, which still remain within the current and former forest areas subject to tree harvesting.

Based on its relatively poor condition, modified context, and lack of rarity, this site is assessed as having little heritage significance and is not considered to fulfil the criteria for local or State listing.

Remains of Charcoal Kiln - Nambucca Water Supply Historic 2 (NWSH2)

The reported charcoal pit NSWH2 has been substantially modified and survives as an archaeological site only, with low ground relief providing the only above ground evidence. Apart from small traces of brick, there are no traces of the reported additional brick kiln. The site is now difficult to interpret and without the aid of oral history, would not be distinguishable from other indeterminate and superficial agricultural ground works. As a consequence, this site is assessed as having little heritage value and is not considered to fulfil the criteria for local or State listing. It would not be affected by the Proposal.

14.4.3 Mitigation Measures

The proposed management measures are discussed below:

- Notification of the intention to impact the forestry stump, site NWSH1, would be provided in writing to the Director of the NSW Heritage Office with a request that a determination be made as to whether the intended impact falls under an existing exemption to section 139 permit provisions.
- No impact can occur until this advice is received and acted upon. This procedure is necessary because this site falls under the definition of a relic (as defined by the *Heritage Act 1977*), but has not been assessed as having local or a greater level of significance.

15 Traffic

The information in this Chapter is taken from 'Bowraville Off-River Storage & Associated Works, Traffic Impact Assessment' prepared by GHD, February 2009. An unabridged version of the report is provided in Appendix F, Volume 2.

15.1 Introduction

This Chapter considers the existing local and regional road network surrounding the study area, assesses the likely traffic generation of the Proposal and determines the impacts during construction and operation.

Table 15-1 outlines the Director-General's requirements and where they have been addressed.

Table 15-1 Statutory Requirements

Statutory Authority	EIS Requirements	Where Addressed
Director-General's requirements (DoP)	◗ Analysis of construction impacts including: road closures and / or traffic diversions and locations and design of any access tracks or roads. ◗ The impact of the development or activity on traffic in the neighbourhood of the development or activity.	Sections 15.2 - 15.4.

15.2 Existing Conditions

The key roads relevant to the Proposal are shown in Figure 15-1 and Figure 15-2.

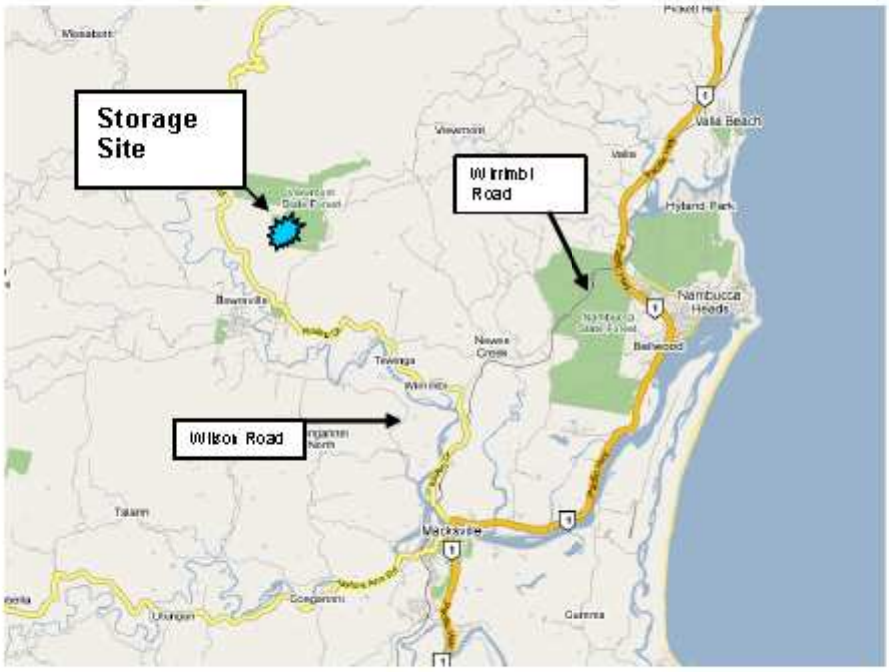


Figure 15-1 Key Regional Access Roads.

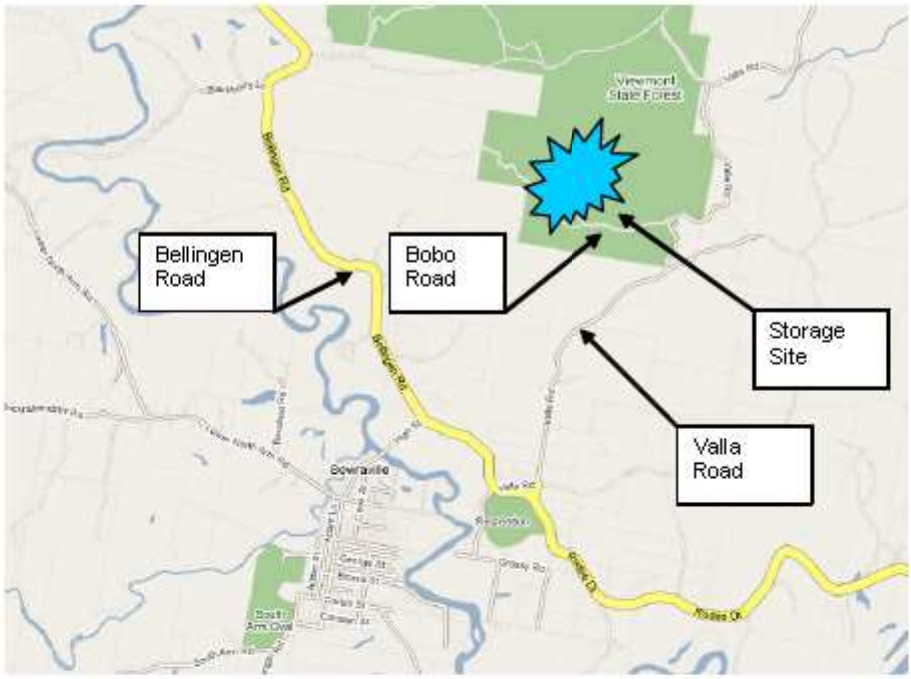


Figure 15-2 Local Access Roads

The available roads to provide access to the borefields and storage site comprise:

- Pacific Highway, linking to major centres north and south along the eastern coastline;
- Wilson Road linking Macksville to Bowraville essentially along the southern side of Nambucca River;

- Rodeo Drive, providing access from the highway to the works area at Bowraville;
- Wirrimbi Road and Old Coast Road providing a link from Rodeo Drive to Nambucca Heads and Pacific Highway; and
- Valla Road providing access to the storage site from Bowraville.

It is anticipated that all major plant and equipment deliveries to the borefield and storage would be brought to the site via the Pacific Highway to North Macksville, then along Rodeo Drive (MR 118) and Valla Road to the storage site.

An alternative route exists between Macksville and Bowraville, being Wilson Road. It is not anticipated that Wilson Road would be used for access to the site, as traffic would need to pass through the commercial and residential centres of both Macksville and Bowraville.

The Pacific Highway is the major east coast link road providing access between coastal centres between Sydney and Brisbane. It carries a high proportion of heavy vehicles through the centre of Macksville and would be the route along which any heavy equipment for construction and operation of the water supply would be brought into the region. The highway is fully funded and maintained by the NSW State Government through the Roads and Traffic Authority.

15.2.1 Rodeo Drive (MR 118)

Rodeo Drive is a two-lane two-way rural road that connects Pacific Highway at Macksville with the Bowraville region. It is classified as a "Regional Road" over its full length.

The road has the following characteristics:

- A circuitous winding alignment for most of the length apart from sections adjacent to the river;
- Most curves not being signposted with advisory speed signs;
- Total length of approximately 12.4 km to Valla Road intersection;
- Two lane, two way sealed pavement with centreline marked full length;
- Approximately 80% of the length is marked with double barrier lines prohibiting overtaking;
- Most road shoulders and verges are thickly grassed which in combination with few guideposts provides poor delineation of the road side limits;
- The pavement is currently in fair to good condition visually with few major failures;
- The bulk of the length is marked with speed de-restriction signs, except for the urban areas at both ends and a section of 70 km/h each side of the Wirrimbi Road intersection. Consequently, the state default speed limit of 100 km/h is generally applicable to the road;
- No signposted load limit for any bridge or culvert;
- Railway overbridge and two underpasses at three locations;
- A number of "curve intersection" and "School Bus Stop Ahead" signs have been installed.

If it is assumed that all traffic passing the count station at Macksville continues to Bowraville then the 2011 AADT of 2,200 translates to 220 vph (vehicles per hour) as the peak hourly count.

Rodeo Drive is the major link road between Macksville and Bowraville. It would be the route used to transport any heavy equipment to the storage site and the associated bore field and transfer facilities etc. It would also be the main route expected to be used by workmen and visitors travelling to and from the site from outside the local area.

The North Coast Railway line crosses Rodeo Drive at 3 locations.

- At 750m from Pacific Highway Rodeo Drive passes beneath a rail overbridge. On the river side there is virtually no road shoulder and there is a hole adjacent to the bridge pier. The narrowing road width is not warned to motorists with advance signs and a number of chevron type width marking signs have been lost. Signage would be rectified to comply with AS 1742. The vertical clearance is 4.6m.
- At 2.85 km a timber overbridge carries Rodeo Drive over the railway. The small radius bends on both sides of the bridge result in long loads crossing the road centreline. There is no signposted load limit, though some non standard advisory signs indicate that caution would be exercised in regard to long loads and that a 10 km/h speed limit would be adhered to. Signage would be rectified to comply with AS 1742.
- At 3.85 km the road descends into a cutting and turns 90^0 under the second rail underpass. The bridge piers are behind the road shoulders. The general arrangement appears to be satisfactory. The vertical clearance is approximately 6.7m. The clearance is not signposted as the height exceeds the highest level requiring signposting, which is 5.0m.

15.2.2 Wilson Road

An alternative route from Macksville to Bowraville is Wilson Road. This route generally follows the southern side of Nambucca River initially through the commercial centre and residential area of Macksville directly to the residential area of Bowraville. Due to the connectivity of the residential areas, it may have a higher traffic count than Rodeo Drive, even though it has a lower road classification status.

From Macksville the route would be via the traffic signal controlled intersection into Embankmentace Street, along the main shopping centre, turn right into Princess Street, then left into McKay Street, cross the railway level crossing before the bridge over Tilly Wouldy Creek, then along Joffre Street, and over the high level bridge over Taylors Arm to the start of Wilson Road.

Crossing of the railway level crossing may prove to be problematic for wide and heavy low loaders with large construction plant. The use of this route would be discouraged for such traffic.

Between Macksville and Bowraville, Wilson Road is constructed as an interurban connector route with a sealed surface, linemarking and some advisory speed signs and curve warning signs for lower than average curve raDI&I. Curves were noted being marked with 45 and 55 km/h advisory signs. The sealed road width was noted as being 6.4m.

The distance to the intersection of Rodeo Dr and High Street at Bowraville from Macksville is almost identical to the distance via Rodeo Drive at approximately 13.5km. However, the use of Wilson Road is not favoured due to the need to pass through the commercial centres of Macksville and Bowraville as well as the surrounding residential areas. There were no load limits noted on any of the bridges on this route.

To the start of Valla Road, the Wilson Road route would be about 1.2km longer than the Rodeo Drive route.

15.2.3 Wirrimbi Road

Wirrimbi Road joins to the Old Coast Road and provides a link from Rodeo Drive at Macksville to Nambucca Heads. It is constructed to a similar standard and alignment as Wilson Road and Rodeo Drive. It would be suitable as an access route to the storage site in conjunction with Old Coast Road to Nambucca Heads.

15.2.4 North Arm Road and Borefield Road

North Arm Road is a secondary link road connecting the town of Bowraville with rural districts to the west and along the southern side of Nambucca River. The road commences at High Street Bowraville and crosses South Creek approximately 100m from High Street.

South Creek Borefield

The South Creek borefield is located south of North Arm Road and on the western side of South Creek. Access to the borefield would be via High Street and then 200m along North Arm Road to the western side of South Creek. This location is within the 50 km/h town speed zone. The zone changes to 100 km/h 180m west of the proposed new access location. Available sight distance from the new access location is 200m easterly to High Street and approximately 280m west. Therefore, the indicated new access location has satisfactory sight distance in both directions. The access location could be easily adjusted by moving the access westward to reduce the access earthworks, without compromising sight distance.

15.2.5 Intersection of North Arm Road with Borefield Road

Access to Borefield A and the west bank components of the existing borefield would be gained via North Arm Road and Borefield Road. At the intersection of North Arm Road and Borefield Road, North Arm Road has a sealed width of 7.0m and is linemarked. Borefield Road is not sealed and has a gravel pavement width of 4.5m to 4.8m. The intersection forms an angle of approximately 67 degrees, which favours the major traffic movements to and from Bowraville. A stock grid 3.2m wide is located at the end of Borefield Road, 370m from North Arm Road. The existing private gravel road beyond the end of Borefield Road continues in a similar form and standard to Borefield Road.

The available sight distance at the intersection of Borefield Road with North Arm Road is approximately 500m easterly toward Bowraville and 178m west, between two vehicles, over a curving crest. The 85th percentile approach speed was assessed at this location at 92 km/h. For the intersection of two existing public roads the desirable ASD with 2.5 sec reaction time, in accordance with the Austroads guide to Intersections at Grade is 170m. The desirable SISD is 215m for the intersection. SISD is the usual minimum design criteria for the intersection of two public roads. Whilst the deficiency is noted, the combination of most turning movements being to and from Bowraville, plus the sufficiency of the ASD, it is considered that the intersection would continue to operate adequately for most routine requirements with small to medium vehicles. For large and heavy loads accessing the borefields via Borefield Road during construction works the construction contractor would assess turning conditions and provide traffic management as required.

15.2.6 Bellingen Road

Bellingen Road is a bitumen sealed two-lane two-way road connecting the towns of Bellingen with Bowraville and surrounding areas. It is also classified as a "Regional Road" over its full length.

Bellingen Road intersects with Rodeo Drive to the south of the site and passes to the west of the storage site. Bellingen Road would be used for access to the headworks, borefield and pipelines that would provide interconnection between the Nambucca River and the storage.

Traffic count data received from NSC indicates that the road has an AADT of 779 in September 2005 at the southern end near Bowraville. Assuming a conservative growth rate of 3% the 2011 AADT would be 931. The count information indicates a considerable reduction in traffic density with increasing distance from Bowraville. At 4.65 km from Bowraville the extrapolated 2011 AADT would be 466. Assuming a linear reduction in traffic with distance from Bowraville would be conservative as there is a concentration of population in the first kilometre however, on this basis the approximate AADT at 2.5 km from Rodeo Dr would be 680.

Comparison of the NSC traffic count data with the historic RTA data does not indicate any obvious inconsistencies.

Access to Headworks from Bellingen Road

Access to the existing headworks is from the western side of Bellingen Road approximately 750m north of High Street. The entry is via a sealed one-way lane adjacent to the western side of No 75 Bellingen Road. The access is just beyond a right hand curve travelling north and is approximately 20m inside the end of the 60 km/h speed zone leaving Bowraville.

It is apparent that a busy dairy business operates approximately 250m further north along Bellingen Road. Flashing lights and additional signage have been installed at the dairy location to assist with traffic management. There is also a "60 km/h AHEAD" warning sign installed approximately 300m west of the speed zone to assist with reducing the speed of approaching traffic. The sign would assist with reducing the approach speed at the headworks entrance.

Advice from NSC is that the access is part ROC and part public lane. The number of vehicles accessing the headworks site on a daily basis would generally be limited to one or two vehicles. Consumable materials are usually delivered on a monthly basis, which would increase the daily movements on those days. On occasions when significant maintenance works are being carried out, the daily movements would increase over the period of works accordingly.

As the access has limited width and appears to provide access to the headworks only it may be reasonable to assess the available sight distance in accordance with AS 2890.1 –2004 Parking Facilities – Off Street Car Parking. For 60 km/h design speed and a domestic driveway the minimum sight distance is 55m. For other access driveways the desirable and minimum sight distances are 83m and 65m respectively. If it is assumed that the approach speed from the west past the dairy is 80 km/h then the desirable Stopping Sight Distance is 111m.

Available sight distances were measured on site. The actual sight distances compared with relevant criteria are summarised in Table 15-2.

Table 15-2 Sight Distances at Headworks Access

Design Speed	Available Sight Distance (m)	Sight Distance for Domestic property (m)	Sight Distance for Other than Domestic Driveways (m)	
	Available	Desirable	Desirable 5s gap	Minimum SSD
60 km/h	190m North SISD 181m North ASD 114m South	55m	83m	65m
80 kmh	190m North SISD 181m North ASD 114m South	95m	111m	105m

Generally the available sight distance to the north considerably exceeds the sight distance requirements for an approach speed of 80 km/h. To the south, where vehicle speeds would not be greater than 60 km/h the sight distance also meets the 80 km/h requirement even though the sight line is restricted by vegetation on the inside of a curve. With minor clearing an extra 30m of sight distance would be attainable. Figure 15-3 shows the headworks access whilst Figure 15-4 illustrates the sight distance towards Bowraville from the access.

Figure 15-3 Access lane to Headworks

Figure 15-4 Headworks access sight line toward Bowraville

Access to Northern Proposed Borefield

The proposed access to the northern proposed borefield is located approximately 1.15km northwest of the headworks access. Sight distances at the access point have been assessed in accordance with AS 2890.1 as for a property access. The access is located within a 100 km/h speed zone. Table 15-3 below is indicative of applicable required sight distances.

Table 15-3 Sight Distances for Level Grade (AS 2890.1:2004)

Design Speed	Sight Distance Requirement other than domestic		Domestic property access
	Desirable	Minimum SSD	
40 km/h	55m	35m	30m
50 km/h	69m	45m	40m
80 km/h	111m	105m	95m
100 km/h	139m	160m	Use adjacent values

The available sight distance from vehicle to vehicle at the access to the southeast exceeds 210m, which is significantly greater than the minimum SSD per AS 2890.

The available sight distance from vehicle to vehicle at the access to the northwest was measured at 113m which is less than the desirable sight distance requirement for the speed zone. However, an assessment of the environmental approach speed produced an 85th percentile approach speed of 81 km/h for which the minimum SSD is 105m. Therefore, the available sight distances in both directions at the proposed access point are considered to be satisfactory for the assessed speed environment under normal conditions with light vehicles. For large and heavy loads accessing the borefield during construction works the construction contractor would assess turning conditions and provide traffic management as required.

At the northern proposed access point Bellingen Road is sealed 5.8m wide, linemarked with barrier lines and has grassed shoulders approximately 1m wide. Entry to the property is over a

stock grid 4m wide and 9m from the edge of the seal. An access to No 188 Bellingen Road is located directly opposite.

15.2.7 Intersection of Valla Road with Rodeo Drive

Valla Road is a secondary rural road used for property access and to access forestry areas. It also connects to the Valla district north of Nambucca Heads. Valla Road intersects with Rodeo Drive 12.4 km from Macksville and 1.1 km before the High Street intersection at Bowraville. Figure 15-5 shows the current condition of the intersection.

Valla Road currently provides the most readily accessible route to the storage site. It forms a T-junction with Rodeo Drive opposite the Bowraville Showground. A photo of the intersection is shown below. The sealed pavement ends just beyond the crest shown in the photo below, 70m from Rodeo Drive. "Turning Trucks" and a "Gravel Road with Loose Surface" signage indicates the conditions that may be encountered further along Valla Road.

Figure 15-5 Current condition of the intersection of Valla Road with Rodeo Drive

The Valla Road intersection is located on a sweeping curve in Rodeo Drive. Characteristics of the intersection are as noted below;

- Angle of intersection of roads approximately 90^0 with the inclusion of a 25m long approach horizontal curve in Valla Road;
- Rodeo Drive grade approximately level;
- Valla Road grade approximately 6% falling to the intersection;
- Rodeo Drive seal width 6.5m with 1.2m to 1.5m shoulder width and centreline painted linemarking;
- Valla Road has no Give Way signage or centreline marking approaching the intersection;
- Valla Road seal width 7.8m with minimal shoulders approximately 25m from the intersection;
- A large sawmill operates from land on the eastern side of Valla Road at the intersection. Primary access appears to be from Balance Tank Road just beyond the crest in Figure 15-5 . The gravel access track on the eastern (right) side of Valla Road in Figure 15-5 appears to

be an occasional exit path. Given the low traffic volume in the area there would seem to be a low probability of traffic interaction by use of the exit.

- Intersection sight board located opposite the Valla Road approach to the intersection. Note that the sight board has been erected inverted;
- The default speed limit of 100 km/h applies to the area of the intersection;
- The Bowraville 60 km/h speed zone commences 220m north west of the intersection along Rodeo Drive;
- There is no intersection lighting provided;
- A 40m long left turn deceleration and turning lane is located in Rodeo Drive on the Bowraville side of the intersection.
- Available sight distance approximately 340m southeast toward Macksville;
- Available sight distance 160m northwest toward Bowraville before being limited by a crest.

The available sight distance of 340m toward Macksville is considerably in excess of the desirable Safe Intersection Sight Distance (SISD) of 253m for a design speed of 100 km/h.

Given that vehicles approaching from Bowraville enter the available sight distance 60m after exiting the 60 km/h urban speed zone, the design approach speed could be considered to be say 80 km/h. For 80 km/h the minimum SISD is 170m and the desirable ASD is 114m.

Therefore, it is considered that the intersection would provide satisfactory access to the storage site via this route for light vehicles. The increased usage of the intersection would warrant the installation of intersection warning signs on both approaches in Rodeo Drive. Figure 15-6, Figure 15-7 and Figure 15-8 illustrate the approaches to the intersection from Valla Road, from Macksville and from Bowraville respectively.

Figure 15-6 Valla Road approach to Rodeo Drive

Figure 15-7 Valla Road intersection sight line toward Macksville

Figure 15-8 Valla Road Intersection sight line toward Bowraville

15.2.8 Valla Road

Valla Road is a narrow two-way gravel road. The pavement is unsealed and has a loose gravel surface and is corrugated in sections. The roadway is not delineated with guideposts and has numerous close trees, which would be hazardous to errant vehicles. There are no curve warning or advisory speed signs in the length from Rodeo Drive to the intersection with the eastern end of Bobo Road, which is 2.5 km from Rodeo Drive.

Standard advisory signage located near Rodeo Drive warns drivers of turning trucks and the gravel road with loose surface. Other signage advises caution due to log trucks using the road.

NSC did not have any traffic count data available for Valla Road however, there are very few houses in the few kilometres at the southern end of Valla Road and it appears that most traffic from the rural enterprises surrounding the northern half of the road would travel via the connection to Pacific Highway which is sealed for approximately 8.2 km. The southern end of Valla Road may have an AADT considerably lower than 200. The peak hourly volume for an AADT of 200 would be 20 vph. A count of dwelling houses in the vicinity located from aerial photography indicates 8 to 10 dwellings may utilise the southern section of Valla Road. Most of these dwellings are located close to Rodeo Drive. Residential dwellings usually generate 8 to 10 vehicle trips per day. Therefore, an assumed AADT of 200 would be conservative.

Advice from NSC is that the use of Valla Road for the cartage of construction materials south of Marriott's Quarry is not permitted. Figure 15-9 shows the typical pavement and roadside conditions along Valla Road.

Figure 15-9 Valla Road - typical view of pavement and roadside conditions

The intersection of Bobo Road with Valla Road has been assessed in the same manner as for Bellingen Road. Characteristics of the intersection are as follows:

- Angle of intersection approximately 90^0 located on the outside of a sweeping bend;
- Valla Road grade approximately 3% rising from the south to the intersection, then level to the north;
- Valla Road gravel pavement width approximately 4.5m with 1.2m to 1.5m shoulder width;
- Available sight distance approximately 55m south limited by the road curvature and a high cutting;
- Available sight distance approximately 85m north before being limited by a curve and cutting.

Turning movements into and out of Bobo Road would be a left turn into the road from Valla Road and a right turn out of Bobo Road into Valla Road.

A potential conflict arising from vehicles turning right out of Bobo Road across the path of vehicles approaching from both directions would be considered. The available sight distance is 55m and 85m. Due to the immediately adjacent curves, the generally winding alignment and the rising southern approach it is considered that the approach speed would not exceed 40 km/h. For 50 km/h the minimum approach sight distance (ASD) is 47m and the desirable ASD is 54m. A safety margin can then be assumed to be available to apply against the longer braking distance applicable for the gravel pavement.

Therefore, it is considered that the intersection would provide satisfactory access to the storage site via this route for light vehicles. The increased usage of the intersection would warrant the installation of intersection warning signs on both approaches in Valla Road.

The use of the Bobo Road to enable heavy vehicles and long loads to access the storage site would require the implementation of traffic control measures during the work period to ensure that conflicts do not arise when the intersection is obstructed by large turning vehicles. It would be expected that the implementation of traffic controls would be an integral part of the worksite Traffic Management Plan for the project. Figure 15-10 and Figure 15-11 illustrate the sight lines available from the Bobo/ Valla Road intersection.

Figure 15-10 Sight line north along Valla Road

Figure 15-11 Sight line south along Valla Road

15.2.9 Bobo Road

Mapping of the area indicates that Bobo Road is aligned approximately east to west and runs between Valla Road and Bellingen Road. It runs approximately through the centre of the storage area, near the storage embankment, and has the potential to be used to access the storage construction area from both the east and west sides. The road is currently used to access adjoining private properties and forestry operations in the Viewmont State Forest. The storage area would be located within the current state forest in an area being purchased by NSC.

The eastern leg of the road, which connects to Valla Road is currently being used to access the storage site for geological and environmental studies of the area. Only the section near Valla Road is currently formed and gravelled for vehicular traffic. A short distance from Valla Road the road condition reverts to an earth track. Inspection of the road indicates that access to a

private property is regularly travelled 1.0 km from Valla Road. The track is typically not less than 3.5m wide, not graded and with no provision for drainage. There are five (5) sharp crests which limit sight distance.

In its current form the track would not be suitable for site access for either workmen or for deliveries of plant and materials. Figure 15-12 shows the current condition of Bobo Road.

It is anticipated the preferred site access would be via this link road from Valla Road. To be suitable for access during construction Bobo Road would need to be upgraded to a 6 metre formation with 3 metre wide bitumen seal. NSC's current standards for such works, as contained in Development Control Plan No 4 – Subdivision, are expected to be suitable for upgrading of the road to suit construction traffic and for the occasional post construction visitors to the storage.

Figure 15-12 Eastern end of Bobo Road looking from Valla Road

Intersection of Ferry Street/ Rodeo Dr with Pacific Highway

Rodeo Drive intersects with Pacific Highway at a T-junction immediately adjacent to the steel truss bridge over the Nambucca River. The speed zoning for both roads in the locality is 50 km/h. Immediately north of the intersection the highway curves through 90^0 to align with the river. The curve has a crash barrier on the outside together with numerous fluorescent CAM's and combination oversize truck tilting and curve advisory speed signs.

The safe intersection site distance (SISD) at the intersection was assessed for a vehicle turning left and right from Rodeo Drive. The available sight distance north was 115m across the chord of the curve and a "filtered" sight distance of 120m was available onto the bridge superstructure to vehicles approaching from Macksville. Some obstruction to the line of sight was presented by bridge railings and guard fencing. For a design speed of 50 km/h the minimum and desirable SISD is 89m and 96m respectively on level approaches. Therefore, the intersection is expected to work satisfactorily from a safety perspective under most traffic conditions. Due to the high traffic volumes encountered on Pacific Highway, especially during holiday periods it is likely that the limited entering opportunity may result in drivers attempting to enter the highway traffic stream when presented with less than recommended gap times.

River and Creek Crossings

There does not appear to be any restriction to access to the storage site, the headworks or any of the existing or proposed borefield areas due to narrow width of bridges or reduced load capacity. The following bridges have been reviewed as part of this assessment:

- Bridge over Nambucca River at Bowraville on High St. A 2 lane timber bridge with wide pedestrian path on the upstream side and timber hand rail on the downstream side.
- Mottleys Bridge over Bowra Creek on Rodeo Drive. A 2 lane concrete decked bridge with W beam guardfence both sides and pedestrian footpath on the upstream side.
- Brouggys Bridge over South Creek on North Arm Road. A low level 2 lane plus pedestrian path bridge with W beam guardfence both sides.
- Unnamed timber bridge over minor creek on North Arm Road approximately 250m west of Brouggys Bridge between South Creek and Borefield Road. Low level timber railing both sides with no pedestrian pathway.

None of the bridges noted above has signposting for narrow width or load limit restrictions.

Signs and Delineation

Previous sections have identified particular deficiencies in signage at certain locations. It was generally found that the standard of signage is consistent with other similar local government areas.

The provision of roadside delineation is also quite varied. More significant roads such as Rodeo Drive, Wilson Road and Bellingen Road have intermittent guideposting, whereas, Valla Road has virtually no guideposting. Again, the situation is probably consistent with other authorities.

There were no locations identified where the linemarking of road centrelines was considered to be incorrect however, a comprehensive audit of linemarking would normally be required to identify such requirements. Generally, sealed roads were linemarked with a centreline in fair condition.

15.2.10 Network Performance

Traffic volume count data is available from the RTA for sites on Pacific Highway at Macksville and also on MR 118, Rodeo Drive at Macksville and at Bowraville. The latest count year is 2004. The count data has been extended to 2011 as the base year assuming a compound annual rate of growth determined from analysis of the historic data. The base year of 2011 is the anticipated year of construction based upon current estimates.

The site descriptions are as follows:

- 09.244 – SH10 Pacific Highway - Macksville at Nambucca River Bridge, 512.6 km (southern side of river).
- 09.231 – SH10 Pacific Highway - Macksville – N of MR 118 Ferry Street, 512.9 km.
- 09.347 - MR No 118 Macksville – Bellingen, Macksville – W of SH10, Pacific Highway, 0.1 km.
- 09.349 – MR No 118 Macksville – Bellingen, Bowraville – S of MR118 (Branch), 13.0 km.
- 09.350 – MR No 118 Macksville – Bellingen, Bowraville – N of MR118, Macksville Road, 13.4 km.

The two sites on Pacific Highway are only 300m apart yet indicate growth rates of 3.1% and 4.2%. The higher growth rate is from a site with almost half the number of count readings and the most recent being taken in 1998. The alternate site has almost twice as many counts and the most recent being in 2004. Consequently, there is doubt over the validity of the higher growth rate. , Adoption of the site with more counts including the most recent counts, results in an extrapolated 2011 annual average daily traffic (AADT) of 21,2200.

The count sites on MR 118 at Bowraville exhibit growth rates of 2.5% and 2.7% and a declining rate of nearly 2% for the site north of High Street (Station 09.350) based upon counts in 1982 and 1986. It is unlikely that the old counts are representative of actual current traffic conditions. Therefore, it has been assumed that all sites near Bowraville have a growth rate of 3% and that the site north of High Street is 67% of the count south of High Street. This action would result in a conservative assessment being made. A summary of the extrapolated 2004 and 2011 base year count AADTs is contained in Table 15-4.

Table 15-4 Traffic Count Stations and Volumes up to 2011

Station	Location	AADT 2004	AADT 2011
09.244 and 09.213	Pacific Highway Macksville	17,140	21,220
09.347	Rodeo Drive Macksville	1,800	2,200
09.349	Bellingen Road south of High Street	1,400	1,700
09.350	Bellingen Road north of High Street	950	1,150

The existing road network performance has been assessed based on known and assumed traffic data at the three (3) key intersections within the study area as listed below:

- Intersection of Rodeo Drive and Valla Road;
- Intersection of Valla Road and Road A; and
- Intersection of Bellingen Road and Road B.

The performance of the intersection of Rodeo Drive (MR118) with Pacific Highway would not be considered further as the traffic contribution to the overall operation of the intersection is considered to be negligible both for the construction and operation phases of the project when considered in relation to the projected volumes on Pacific Highway. Any requirement for upgrading of the intersection is expected to result from natural growth in the region, and would be expected to be fully funded by the RTA. The construction of a bypass of Macksville by the highway may well occur before further highway intersection upgrading occurs.

Road Network

The performance of the existing road network surrounding the development site has been assessed in terms of Level of Service (LOS). The LOS criteria below is based on peak hour flows per direction for urban roads and peak hour flows on two (2) lane two way roads, with

design speed of 100 km/h, for rural roads as defined in RTA's Guide to Traffic Generating Developments and detailed in Table 15-5 and Table 15-6 respectively.

Table 15-5 Urban road peak hour flows per direction

Level of Service	One Lane (vpd)
A	200
B	380
C	600
D	900
E	1400

Source: RTA Guide to Traffic Generating Developments, October 2002, Version 2.2

Table 15-6 Peak hour flow on two (2) lane rural road (vph)

Level of Service	Veh/hr
B	530
C	870
D	1410
E	2290

Source: RTA Guide to Traffic Generating Developments, October 2002, Version 2.2 Table 4.5

The LOS criteria in Table 15-6 is based on the following assumptions:

- Design speed of 100 kph;
- Terrain level with 20% no overtaking;
- An average of 15% heavy vehicles;
- 3.7 metre traffic lane widths; and
- 60/40 directional split of traffic.

Assuming that the peak hourly two way flow is 10% of the AADT then it is clear that current traffic density is well short of the hourly counts in the two tables above.

On Rodeo Drive at Valla Road the sum of local traffic plus peak construction traffic is unlikely to be higher than 170 + 72 = 242 vph. The peak hourly site generated traffic has been taken as being for the example the first hour of work each day when 60 staff arrive, there are 2 support trips and 10 material delivery trips. At other times during the day the site generated traffic could be as low as 5 to 10 vph.

On Bellingen Road the sum of local traffic plus peak construction traffic may be 115 + 72 = 187 vph at Bowraville. Both peak volumes are 45% to 35% of the limiting volume for LOS B for a 2 lane rural road in accordance with the criteria above.

The number of vehicles expected to access the site during the construction phase would increase marginally at times when materials are being imported to site. Such co-incidence of operations is expected to occur for less than perhaps 50% of the construction period. At these times heavy vehicles may account for up to 15% of the peak traffic volume.

The current level of service for the key roads surrounding the site, being Rodeo Drive, Bellingen Road and Valla Road are expected to remain at LOS A to B for the foreseeable future.

Intersection Performance

The three (3) key intersections surrounding the site were investigated, based on the anticipated volumes in year in 2011 and 2021.

The expected traffic volumes on local roads during years 2011 and 2021 resulting from current activities in the area and anticipated natural growth are given in Table 15-7 below.

Table 15-7 Traffic Flows

	Estimated Traffic 2011 (vph)	Estimated Traffic 2021 (vph)
Rodeo Drive at Valla Road	170	230
Valla Road at Bobo Road	< 20	< 27
Bellingen Road at Bobo Road	68	91

The traffic loading on the intersections with construction traffic is expected to be in accordance with the flows indicated below.

Table 15-8 Intersection Traffic Flows

	Estimated Traffic 2011 (vph)	Estimated Traffic 2011 (vph) plus Construction	Estimated Traffic 2021 (vph)
Rodeo Drive	170	242	230
Valla Road	20	92	27
Valla Road	20	92	27
Link Road	0	72	5#
Bellingen Road	68	140	91
Link Road	0	72	5#

Nominal Allowance for maintenance and tourism.

Comparison of Table 15-8 with Table 15-9 below confirms that a detailed analysis of each of the intersections is unnecessary due to the low flow volumes expected even with construction traffic included.

15.2.11 Intersection Capacity

The intersecting traffic volumes at Rodeo Drive and Valla Road and Bellingen Road at full development in 2021 are estimated to be:

- 2300 vpd Rodeo Drive and 270 vpd Valla Road. This corresponds to a two-way peak flow of about 230 vph and 27 vph.
- 910 vpd Bellingen Road. This corresponds to a two-way peak flow of about 91 vph.

For these low combinations of flows, the busier roads can comfortably absorb the minor road traffic at a good level of service. These combinations of flows are well below the threshold values where intersection capacity analysis is normally required as shown below.

Table 15-9 Intersection Volumes below which Capacity Analysis is Unnecessary

Type of Road	Light Cross & Turning Volumes Maximum Design Hour Volumes vehicles per hour (two way)		
Two lane major road	400	500	650
Cross road	250	200	100
Four lane major road	1,000	1,500	2,000
Cross road	100	50	25

Source: Austroads Part 2, Table 8.1 Roadway Capacity

15.2.12 Existing Crash History

The RTA has provided crash history for the period beginning July 2003 to June 2008 for the following roads;

- Pacific Highway within the Nambucca Shire;
- MR 118 Macksville to Bellingen which includes Ferry Street, Rodeo Drive and Bellingen Road and;
- Full length of Valla Road.

A plan of recorded crashes is provided in Appendix C for each of the road sections noted above. The five-year crash history provided by the RTA has been reviewed to identify any features which may be relevant to this study. The review has been performed for:

- Intersection of Rodeo Drive/Ferry Street and Pacific Highway;
- The length of Rodeo Drive from Pacific Highway to Valla Road;
- Intersection of Rodeo Drive and Valla Road;

A general review of the available crash data indicated no obvious anomalies which would warrant further investigation of the crash data that may point to particular road characteristics that would warrant further attention or corrective actions.

The Crash data is provided in Appendix C, and is summarised in Table 15-10.

Table 15-10 Crash Analysis Summary

Location	No. of injury crashes	No. of non injury crashes	Total number of crashes	Total number of injuries	Majority of crashes
Intersection of Pac Highway & Rodeo Drive	5	2	7	6	Includes all crashes in the vicinity of the intersection, both in lane and turning types.
Rodeo Drive from Pac Highway to High St Bowraville	15	12	27	17	60% of all crashes were associated with off road on curve types.
Intersection of Valla Road & Rodeo Drive	0	0	0	0	No crashes recorded in the database.
Bellingen Road from High St to Blackberry Lane	1	1	2	1	The injury crash was an off-road on-curve in close proximity to Bobo Road intersection.
Valla Road full length	2	3	5	3	60% single vehicle off-road types, 40% 2 vehicle head-on type.

The key points relating to each of the above locations are:

- The high proportion of single vehicle off road on curve type crashes is indicative of the winding hilly terrain and the general lack of adequate delineation of the road alignment;
- No crashes were recorded at the intersection of Rodeo Drive and Valla Road;
- The crashes recorded in the vicinity of Rodeo Drive and Pacific Highway are not unexpected given the high traffic density at particular times. It does not indicate a particular problem in this area when considered in relation to the highway nearby;
- The map of crashes on MR118 indicates a number of groups of crash sites predominating. This appears to indicate that site specific local factors may be influencing the crash data;
- None of the key intersections investigated in this report figured in the crash statistics apart from Rodeo Drive and Pacific Highway;
- There were no recorded crashes involving pedal cyclists with Pacific Highway excluded.

15.2.13 Public Transport

Public bus services in the area are provided by Busways North Coast Pty Ltd. Busways operates from a depot at Macksville.

The Busways timetable indicates that 2 morning and 2 evening buses follow a loop route utilising both Wilson Drive and Rodeo Drive between Macksville and Bowraville on weekdays. They then continue on to Nambucca Heads and Coffs Harbour. A service also operates along Bellingen Road as far as Tallowood School 2.2 km from High Street.

15.2.14 School Bus Services

Schools in the Bowraville area are:

- Bowraville Central School – 19 High Street Bowraville;
- Gumbangirri Preschool – Bowraville;
- John Paul College – 2 Carbin Street Bowraville, and
- Tallowood School – 220 Bellingen Road, Bowraville.

Bowraville Central School also operates a school farm off the end of Borefield Road from North Arm Road.

School bus services use Rodeo Drive and Bellingen Road in order to access pick up and drop off locations at strategic intervals. There is no school bus traffic along Valla Road. Parents drive their children along Valla Road to a pick up point on Rodeo Drive.

Services are provided by Baldwins Bus Service from their premises at 53 Borefield Road and Chezmar Bus Services.

The project is not expected to have any significant impact on public transport services in the area.

15.2.15 Pedestrians and Cyclists

All of the roads surrounding the storage site and associated with the bore field are outside the urban area of Bowraville. Consequently, they do not provide footpaths for pedestrians.

None of the roads provide either on road or off road cycleways. Both pedestrians and cyclists must share the road pavement or verge with motor vehicles and other road users.

It is considered that the absence of specific facilities is appropriate given the expected low demand for services and the limited ability of NSC to provide such facilities.

15.2.16 Parking

There is a potential for parked workers' vehicles to create an access nuisance to local residents and motorists if there is not adequate provision for parking within each works site area. NSC can require all construction workers and operational vehicles to be accommodated within the works site by the inclusion of an appropriate condition in the Development Approval.

Preliminary design details have been prepared for a recreation area and on site parking and turning area as part of public facilities, which may be constructed for the completed public viewing area. The indicative recreation area is approximately 120m x 25m and is expected to be more than sufficient for expected demand for construction parking. In addition a separate parking and turning area would provide 14 parking spaces on completion of construction.

15.3 Impact Assessment

15.3.1 Construction Impacts

A Traffic Impact Assessment for a development proposal normally is focussed on the ongoing impact of the additional traffic generation due to the development in concert with the natural growth of traffic in the locality after 10 years of operation. In this case it is difficult to quantify the

long term impacts as they are expected to be extremely low in comparison with the current background traffic and the natural growth of local traffic indicated to occur in the next 10 years. Therefore, this report has emphasised the possible construction impacts in order to fully appreciate the potential short term impacts.

Large construction equipment would be used on site. Any oversize loads would require travel permits and escorts in accordance with the current permit system. Such transport movements are expected to work quite satisfactorily outside of the development approval system applying to the construction of the storage and the borefield enhancement etc.

Most materials to be delivered to the Proposal site and for construction of pipelines and the borefields are expected to be delivered in a range of trucks up to semi-trailer size or truck and dog combinations. Such vehicles can be adequately catered for by the existing road network.

If all construction access is to be via Valla Road then the estimated current AADT at Bobo Road intersection may increase from say 200 to 390. Whilst this is a relatively significant impact over the current base, as the base traffic is extremely low the potential adverse impact on other motorists or surrounding properties is also quite small.

In regard to the potential impact upon Rodeo Drive, assuming that all traffic travels east of Valla Road then the AADT (2011) may increase from 1,700 to 1,890. This is an increase of 11%. By comparison, if the natural traffic growth in the area is 3% then natural growth would produce a similar increase without the construction traffic in 3 years.

It is clear then, that the construction period impacts for Rodeo Drive are relatively low in comparison with existing traffic levels and equate to relatively short periods of natural traffic growth. The construction impact for Bellingen Road and North Arm Road is more pronounced as the existing traffic levels are much lower.

A large proportion of the overall works would take place in areas away from public roads. Activities which may impinge on the availability of public roads for use by other motorists would include:

- Construction of the transfer pipeline, either by underboring or trenching, from the headworks to the storage site across Bellingen Road, and;
- Crossing of North Arm Road, either by underboring or trenching, for the borefield collection pipeline.

Both of these activities would require the implementation of approved Traffic Management Plans for the safe working of the construction activities whilst under traffic. As mentioned previously, the movement of oversize construction plant on public roads would also require the implementation of traffic management procedures which would impinge on the availability of the public thoroughfare.

15.3.2 Operational Impacts

Activities that are anticipated once the Proposal becomes operational would include:

- Maintenance of pumps and pumping facilities associated with each individual borefield pump station.
- Maintenance of the borefield headworks facilities.

- Maintenance of the rising main and delivery main connecting the headworks with the storage.
- Routine maintenance works associated with the Proposal.
- Security inspections of the facilities.

It is expected that the storage would not be available for recreational usage in order to protect water quality. A viewing area would be provided for public access, but visitor numbers would be expected to be very low and the scenic value is not expected to be high.

In terms of daily traffic movements associated with the range of activities listed above, there may be 0 to 6 per day and the frequency of days may be irregular. Therefore, operational impacts are difficult to quantify but relatively insignificant.

15.4 Mitigation Measures

It is proposed that the following mitigation measures be adopted as part of the Proposal:

- That a comprehensive traffic management plan be prepared and submitted to the consent authority for approval detailing construction period transport activities, site access, parking and stockpile areas for the duration of the works.
- That MR 118 Rodeo Drive from Macksville to Bowraville would be the principal access route to the site from Pacific Highway and from areas to the south of Macksville.
- That the route from Nambucca Heads via Old Coast Road and Wirrimbi Road with an alternate route for heavy vehicles via Siding Road, to the Proposal site is an acceptable access route, subject to the development of an acceptable Traffic Management Plan.
- That if Wirrimbi Road is used as a materials supply route, that the signposted load ratings of the rail bridge be confirmed for the particular class of vehicle to be used.
- That the rail bridge and approaches on Siding Road be signposted in accordance with AS 1742.2.
- The design of the existing headworks access road to Bellingen Road would be upgraded to current standards.
- That the section of Bobo Road off Valla Road be used for access to the storage site, and be upgraded to a 6 metre formation with 3 metre wide bitumen seal.
- That vehicular access to Lot 2 DP 1076377 be maintained as part of any changes to road status and access routes associated with the acquisition of the storage site area by NSC.
- That NSC undertakes improvements to the delineation and signposting of the two railway crossings on MR 118.
- That the unsealed length of Valla Road be regularly maintained during the course of the works in accordance with a Traffic Management Plan including dust control, maintenance and intervention strategy approved by NSC.

16 Visual Amenity

16.1 Introduction

This Chapter reviews the existing visual character of the study area and its surrounds, the expected impacts of the Proposal on the existing visual character of nearby existing residences and publicly accessible locations such as local roads in the vicinity of the Proposal.

The visual assessment considered the following:

- Assessment of the existing visual amenity of the surrounding area, taking into account current land use patterns;
- The sensitivity of the landscape to alteration by the proposal;
- The visual character and extent of the Proposal; and
- Viewer sensitivity to alteration of the environment by the proposal.

In addition to assessing potential views from affected properties to the Proposal, this Chapter makes recommendations to mitigate any potential visual impacts.

16.1.1 Methodology

A qualitative assessment of visual impact has been undertaken for the Proposal. The visual impact of the Proposal has been primarily evaluated on the basis of the following visual management objectives:

- To protect and maintain the landscape character;
- To assess the visual impact where the Proposal is visible from the key viewpoints or a primary road;
- To maintain existing good quality native vegetation where possible; and
- To ensure existing vegetation removal and construction is undertaken carefully to minimise visual impact.

Therefore the following process has been adopted for the visual assessment of the Proposal:

Understanding the Proposal

The visual assessment involved the review of relevant documentation for the Proposal. Documentation reviewed included design plans, elevations, the location of associated roads, borefields, power supply and other built elements.

Landscape Character

The landscape character was identified in a desktop and field assessment and the viewing experience of each character was confirmed. The landscape character was assessed by describing the components of the existing landscape in detail such as its topography, land use, vegetation, water form, settlement patterns and other features. The landscape character is relevant to human interaction and experience as there is a high degree of certainty that some landscapes are valued more highly than others, for example National Parks.

Once the character is defined, an assessment can then be made of the overall effect which the Proposal would have on the character and value of the landscape. The extent to which a

landscape can absorb change varies with: the existing land use; the pattern and scale of the landscape; the visual enclosure and distribution of visual receptors; the scope for mitigation which would be in character with the existing landscape; and the value placed on the landscape.

Defining the Visual Catchment – Viewshed Analysis Tool

Visual impacts relate to changes in views experienced by people in the landscape. To define the visual catchment, the extent of visibility of the Proposal has also been assessed and takes into account local screening from vegetation and the surrounding topography. This has been undertaken using a viewshed analysis.

Viewshed Analysis is a tool performed using *3D analyst* in ArcGIS that calculates visible areas from an observation point. A view shed is useful in determining how visible objects might be as the shape of a terrain surface affects what parts of the surface an observer standing at a given point can see. This is calculated from a set of user-defined parameters such as height of observer, height of target, extent of the viewing area and a contour surface. In this case the visual baseline included 20 points along the top of the storage embankment. The degree to which the storage can viewed from any particular location is ranked according to the number of the 20 points that can be seen along the storage.

The view shed analysis would be interpreted as a conceptual approach only for large infrastructure such as storage embankments, and is best complemented by ground truthing. It would be noted that the viewshed analysis undertaken for the Proposal considered only the impacts of the storage embankment and not the potential impacts of the proposed access roads, borefields and associated transformers. These issues wee considered separately.

Site Analysis

The view-shed analysis identified any properties or public locations likely to have views affected by the Proposal. These locations have been illustrated on a map including the study area and surrounds. Photographs from the properties identified in the previous stage as having views potentially affected by the Proposal would be utilised to illustrate the potential impacts.

Visual Analysis

The landscape character, view shed and site analysis were used to determine the visual impacts of the Proposal on affected public locations and properties. The extent of the impact was assessed objectively according to the sensitivity of the receptor, taking into account any mitigation measures.

To measure the potential impact on each view to the Proposal, standard desirable outcomes were used. The following desirable outcomes were used to provide a standard against which to measure the potential impact for each possible view to the Proposal. These desirable outcomes represent a best-case scenario, where there is minimal visual impact. The desirable outcomes are as follows:

1. The Proposal would not be viewed with the sky as a backdrop.
2. The Proposal would not interrupt the view from any public location or nearby property to any landscape feature.
3. The Proposal would not detract from the visual amenity of an important visual or cultural element or landscape.