Appendix B

Water Quality Monitoring Program and Management Plan

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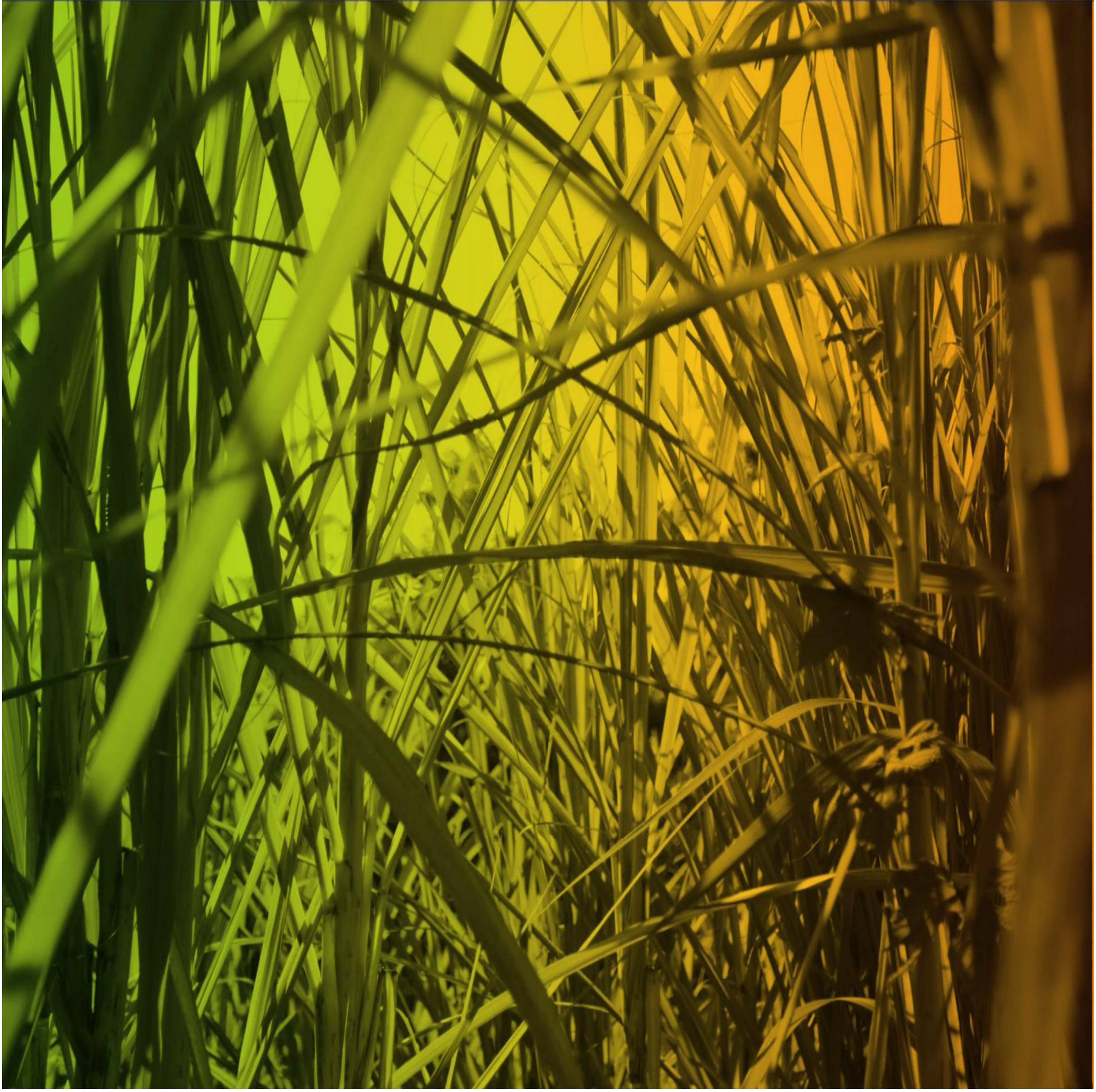
Armidale Regional Landfill Facility

Water Quality Monitoring Program and Management Plan



Armidale Regional Landfill Facility

Water Quality Monitoring Program and Management Plan

Prepared for

Armidale Dumaresq Council

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1.0 Introduction

Armidale Dumaresq Council is currently seeking project approval from the Minister of Planning to construct and operate a new landfill waste facility. This monitoring program and management plan has been developed for inclusion within the project's Environmental Assessment (EA) and Landfill Environmental Management Plan (LEMP) as required by the Department of Environment, Water, Heritage, and the Arts (DEWHA), and specifically addresses the following matters:

1. A detailed monitoring program for ground and surface water quality on the site and key areas adjacent to the perimeter of the site and at appropriate locations downstream of the Gara River; and
2. A management plan that identifies the potential impacts on the heritage values of the downstream Gondwanan Rainforests of Australia World Heritage Area (GRAWHA).

This plan has been developed in accordance with the specific objectives described by DEWHA, which include the following:

- Identify and describe the values of the GRAWHA with a particular focus on ecological areas that would be most vulnerable to impacts from the proposed construction and operation of the landfill site;
- Identify mitigation measures for the control of air and water borne weed propagules onsite;
- Identify measures to minimise and control the spread of invasive weed species downstream of the site in cooperation with adjacent landowners, state agencies and the World Heritage Area place managers; and
- Incorporate the detailed ground and surface water monitoring program.

The ground and surface water monitoring program aims to:

- Describe the surface and ground water baseline condition of the Landfill Site and surrounding areas;
- Identify appropriate assessment criteria and critical water quality values with particular regard to the GRAWHA;
- Identify appropriate monitoring parameters and frequencies of sampling;
- Identify remedial actions to be taken in the event of exceedances of assessment criteria or observable threats to environmental water quality;
- Identify parties responsible for undertaking remedial actions; and
- Outline the period of review of the plan and the process for evaluation and amendment of the plan.

The monitoring program and management plan applies to both the period of construction and the ongoing operation of the landfill.

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2.0 Oxley Wild Rivers National Park (GRAWHA)

2.1 Background

The proposed landfill facility is located approximately 4 km north north-west of Oxley Wild Rivers National Park and 1 km (at its closest point) west of the Gara River which flows into the park. Oxley Wild Rivers National Park forms part of the Gondwana Rainforests of Australia World Heritage Area (GRAWHA).

Pursuant to the EPBC Act, the proximity of the World Heritage Area (Oxley Wild Rivers National Park) to the proposed landfill facility requires that an assessment of matters of National Environmental Significance (NES) be undertaken. This assessment has been completed as a component of the Flora and Fauna Impact Assessment prepared for the project (EA Systems 2009).

In addition to the flora and fauna assessment conducted by EA Systems (2009) DEWHA required that the values of GRAWHA be identified and described in more detail. To this end, consultation was undertaken to ensure the methods proposed met with DEWHA's[1] expectations. A further objective was to determine whether any additional studies or research publications were available given the paucity in literature relevant to this area (refer **Section 2.1.1**).

Field investigations were conducted on the 1st and 2nd December 2009, which included inspection and collection of qualitative observations from both upstream sites to the proposed landfill facility and downstream areas within the Oxley Wild Rivers National Park, as follows:

- Gara River, upstream of the proposed landfill site;
- Commissioners Waters and its tributary, upstream of the proposed landfill site;
- Downstream of the Commissioners Waters confluence at Blue Hole (at the commencement of Oxley Wild Rivers National Park); and
- Downstream of the Gara River weir and upstream of Creek confluence with Gara River (within Oxley Wild Rivers National Park).

During site visits to Gara Gorge conducted on the 2nd December 2009, additional consultation was undertaken with DECCW – NPWS personnel[2] present on site at the time.

2.1.1 Literature Review

Literature in relation to the GRAWHA, in particular that relevant to Oxley Wild Rivers National Park, is relatively limited. Literature and web based information reviewed includes the following:

- Department of Environment and Heritage (2000). Strategic Overview for Management of World Heritage Central Eastern Rainforest Reserves of Australia / CERRA.
- Environment Australia, NSW National Parks and Wildlife Service and Queensland Parks and Wildlife Service (2003). Report on the State of Conservation of the Central Eastern Rainforest Reserves of Australia / CERRA
- Department of Environment, Water, Heritage and Arts (DEWHA):
  - Australian Heritage Database (website)
  - World Heritage Listing Information (website)
  - Gondwana Rainforests of Australia fact sheet (website)
- NSW Department of Environment and Conservation:
  - Oxley Wild Rivers National Park Plan of Management (National Parks and Wildlife Services 2005)
  - World Heritage and Associated Natural Values of Central Eastern Rainforest Reserves of Australia / CERRA (National Parks and Wildlife Service 2004)
- EA Systems (2009). Flora and Fauna Assessment – Proposed New Armidale Landfill Facility

Information obtained from these sources are summarised in the following sections.

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[1] Pat Kelly and Jonathon Teasdale, DEWHA, Canberra (Attachment 1)

[2] Matt Ryan and George Monroe, NWPS, Armidale

2.1.2 Inscription of Australian Rainforests as World Heritage Areas

In recognition of the importance of rainforests as part of the nation's natural heritage, a suite of rainforest national parks and nature reserves within New South Wales were nominated for inclusion on the World Heritage List in 1985. These areas were inscribed in 1986 as the *Australian East Coast Subtropical and Temperate Rainforest Parks World Heritage Site*.

Significant areas of rainforest in southern Queensland and additional areas in northern New South Wales were listed in 1994 as the *Central Eastern Rainforest Reserves (Australia) World Heritage Site*. Collectively the Australian East Coast Subtropical and Temperate Rainforest Parks World Heritage Site and the Central Eastern Rainforest Reserves of Australia (CERRA) World Heritage Site have been referred to as the Gondwana Rainforests of Australia World Heritage Area (GRAWHA) since 2007.

The inscription of the GRAWHA is due to their outstanding natural universal values, specifically:

- As an outstanding example representing major stages of the earth's evolutionary history;
- As an outstanding example representing significant ongoing geological processes and biological evolution; and
- Containing important and significant habitats for the in situ conservation of biological diversity.

The evolution of new species is encouraged by the natural separation and isolation of rainforest stands. Many plants and animals found in the GRAWHA are locally restricted to a few sites or occur in widely separated populations.

Although the inscribed rainforests cover only about 0.3 per cent of Australia, they contain about half of all Australian plant families and about a third of Australia's mammal and bird species. The GRAWHA have an extremely high conservation value and provide habitat for more than 200 rare or threatened plant and animal species. The distributional limits of several species and many centres of species diversity occur in GRAWHA properties.

2.1.3 Oxley Wild Rivers National Park

The Oxley Wild Rivers National Park was listed in 1994 (as a component of CERRA), and at the time encompassed 93,220 hectares. Additions to the reserve system in later years have substantially increased this area. In 2004, the NSW National Parks and Wildlife Service (NPWS) estimated the final reserve system to be potentially 285,000 in extent, although as at 2005 a figure of 142,332 ha was reported (NPWS 2005).

The GRAWHA comprises 8 distinct groupings of parks and reserves distributed between Newcastle and Brisbane, with the Oxley Wild Rivers National Park is a component of the Hastings – Macleay Group. This group includes an example of the Great Escarpment, with a sharp break between the plateau and the escarpment shown in the gulfs and gorges of the upper Macleay. Steep hillslopes and deep valleys with a complex drainage pattern cover most of the area east of the Great Escarpment.

Oxley Wild Rivers National Park is part of a broad contiguous belt of relatively undisturbed forested land along the Great Escarpment. Adjacent lands on the tablelands have largely been cleared for grazing but large areas of native vegetation remain in the east, under both public and private ownership.

Westward erosion of the tablelands by the Macleay River system has created the spectacular gorges of the Oxley Wild Rivers National Park area – including Gara Gorge, which is fed by the Gara River and its tributaries from the north, and Powers Creek from the west. Small areas of alluvial landforms occur along the valley floors but are uncommon until the Macleay River flows out of the upper gorges, a significant distance downstream of Gara Gorge, and are therefore not considered further.

The main section of the Oxley Wild Rivers National Park is large but with a long and convoluted boundary, while some areas are isolated and considered very small. Core areas of the park are largely managed as wilderness or remote areas, with visitor facilities concentrated at existing gorge rim locations on the edges of the park – such as those facilities provided at Gara Gorge.

Gara Gorge is that part of the Oxley Wild Rivers National Park which is in closest proximity to the proposed landfill site and where the Gara River first enters the Park (

Figure 2-1). Gara Gorge is a popular picnicking area for Armidale residents with the existing facilities reported as often full. Facilities at the gorge include two areas accessible by road, these being Blue Hole and Threlfall. Both locations provide car and coach parking, picnic areas, gas barbeques, reticulated potable water, interpretation displays, toilets, and walking trails.

2.1.4 Values

The significance of the dry rainforest within Oxley Wild Rivers National Park is the principal reason the Park was incorporated into World Heritage listing in 1994.

The relatively dry environments of much of Oxley Wild Rivers National Park have given rise to the extensive development of woodland on steep slopes with north to westerly aspects and to grassy open forest on sheltered aspects. Grassy open forests also extend onto the plateau and along river terraces. Dry rainforest is widely dispersed on slopes and gullies, while shrub lands occur along cliff edges where the soil is too shallow and unstable for trees.

Plant communities of the gorge rim have to contend with the continual and rapid loss of water, soils and nutrients down slope. They show the following special vegetation features:

- A considerable structural and floristic diversity;
- The presence of a number of unusual plant communities, most of which are restricted to gorge rim areas; and
- A large number of plants that are rare, threatened or have unusual distributions.

The immediate or fringing area of the park in the vicinity of Gara Gorge is impacted by typical edge effects and encroachment and infestations of pasture grasses and other introduced species. However, the abundance, density and species richness of native grasses, sedges, herbs, and forbs increases substantially as the topography descends onto the slopes. Native grasses are particularly abundant as is the diversity of native flowering herbs.

EA Systems (2009) provide comprehensive lists and significance assessment of all threatened or otherwise significant flora, fauna, and ecological communities prepared for the environmental assessment of the proposed landfill facility. Listings, and significance assessments, include known and potentially occurring threatened species within 20 km of the proposed landfill site, which includes Gara Gorge and a large portion of the north western section of the Oxley Wild Rivers National Park.

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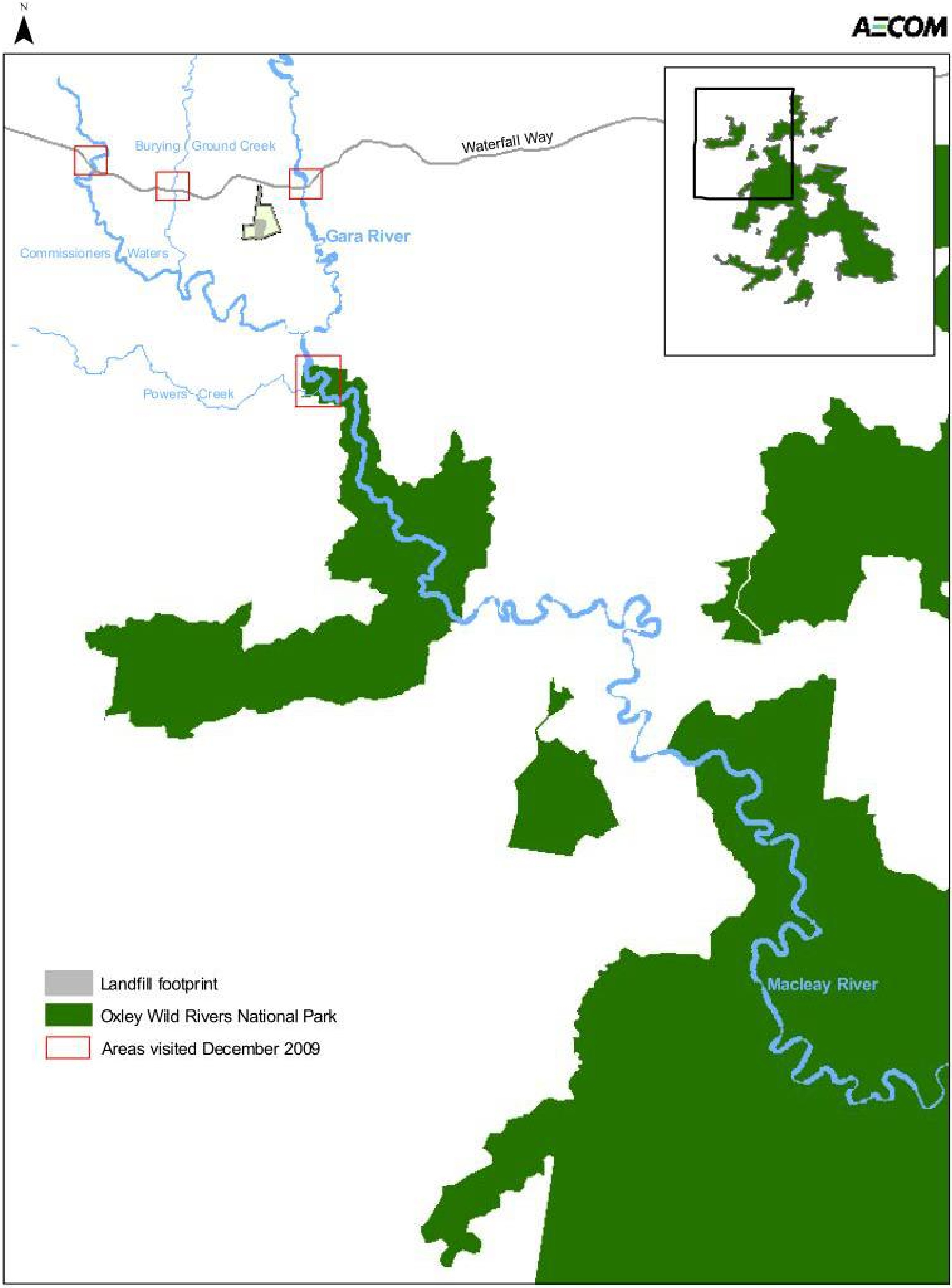

ARMIDALE DUMARESQ COUNCIL - ARMIDALE REGIONAL LANDFILL

OXLEY WILD RIVERS NATIONAL PARK

Source: ASR (2006), Map Data (2008), Natural Resources Atlas NSW (2009)

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Fig. **2.1**

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2.1.5 Existing Threats and Issues

2.1.5.1 Introduced Plant Species

Over 60 introduced plant species have been recorded in the Oxley Wild Rivers National Park. They are usually associated with disturbed sites, particularly those areas adjacent to cultivated pastures on the tablelands and grazed river such as Blue Hole and Threfall at Gara Gorge.

Terrestrial weed species observed within the areas of Blue Hole and the Threfall trail which extends for approximately 5 km around the rim of the gorge, include Blackberry (*Rubus fruticosus*), Sweet Briar (*Rosa rubiginosa*), *Lantana camara* (*Lantana*), Hawthorn (*Crataegus mongyna*), and a range of pastoral grasses, with Spear thistle (*Cirsium vulgare*) and Bathurst Burr (*Xanthium spinosum*) found on many of the river flats and banks and associated tributaries entering the park.

NPWS rangers[3] indicated that the most problematic weeds requiring ongoing management are Blackberry, Willows, Chilean Needlegrass, African Lovegrass, and Serrated Tussock Grass).

EA Systems (2009) have identified the need to undertake targeted monitoring and weed control within the proposed landfill site, in order to manage the potential for exotic grasses such as Coolatai Grass (*Hyparrhenia hirta*), African Lovegrass (*Eragrostis curvula*), Serrated Tussock (*Nassella trichotoma*) and Chilean Needlegrass (*Nassella neesiana*) – which may spread into the landfill site from the Waterfall Way access route.

Such monitoring and mitigation measures will assist in reducing any potential spread of weeds to the Oxley Wild Rivers Park, but only from a very small proportion of the overall weed sources within the greater catchment area.

The major aquatic weeds transported into the site via the Gara River system (including its tributaries Commissioners Waters and Burying Ground Creek) are Willow species (predominantly Weeping Willow *Salix babylonica*). Willows are widespread through the study area, and are evident within Gara River until its confluence with Powers Creek.

Umbrella Sedge (*Cyperus eragrostis*) is also commonly found throughout the Gara River and its tributaries. Although not considered a serious weed, this species does have the capacity to gradually overrun areas which would otherwise be occupied by native sedges, rushes or semi-aquatic grasses.

2.1.5.2 Weed Management

As required by DEWHA the project LEMP is to identify both:

- Mitigation measures for the control of air and water borne weed propagules onsite; and
- Measures to minimise and control the spread of invasive weed species downstream of the site in cooperation with adjacent landowners, state agencies and the World Heritage Area place managers.

EA Systems (2009) have concluded that it is unlikely that weeds will spread from landfill waste placed in the operational pits nor from rehabilitated pit areas over time as green (garden) waste will not be processed at the site. The potential introduction and spread of weeds from the landfill site is more likely to be associated with soil disturbance and earthworks during the reconstruction and rehabilitation phases of the landfill operation.

Control of weed growth, and /or transport of weed propagules off-site (via air, water, vehicular and wildlife dispersal mechanisms) will be managed by the following measures:

- Security (chain wire) fencing will be erected around the landfill site to enclose the landfill, landfill amenities, leachate and stormwater ponds. Vehicle entry will be via the site gate, which will be locked outside of operating hours to prevent public access.
- Installation of wheel wash facilities to prevent spread of weed propagules from vehicular movement into and out of the landfill facility, with runoff contained and weed propagules in wash down effluent controlled;
- Control of existing on-site weed infestations prior to construction;
- Targeted monitoring and weed control in areas subject to soil disturbance, within drainage lines and access routes;

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[3] Matt Ryan and George Monroe, NWPS, Armidale

- Importation of any topsoil and plant materials to the site will be subject to strict specifications which ensure that weeds, disease and other undesirable materials are not introduced to rehabilitation and landscape areas;
- Tertiary surface water controls including clean stormwater (perimeter) diversion drains, leachate pond, a sedimentation basin and a dry basin of sufficient capacity to contain all surface water on site, and therefore water borne weed propagules;
- Progressive revegetation of landfill cells, and following final capping of the landfill site;
- Establishment of "offset" or compensatory areas of vegetation within approximately 60 ha of the site outside of landfilling operations. An Offset Management Plan has been prepared by EA Systems (2010) and includes measures such as:
    - fencing and removal of stock,
    - weed and pest control,
    - revegetation and rehabilitation,
    - two year maintenance period,
    - five year weed control period, and
    - monitoring and reporting.
- Contractors (bushland regenerators, landscape contractors) or Council personnel engaged to undertake offset management and landscape maintenance of the landfill operational area will be required to:
    - prepare a maintenance program for approval by Council's Operation Manager, and amend it as required until approved
    - keep a Maintenance Logbook, recording when and what maintenance work has been done, what materials (e.g. herbicides) have been used, and what weed species have been controlled.
- Monitoring results and maintenance records will be incorporated into reporting requirements as outlined within the project's LEMP;
- Regular liaison with DECCW (NPWS Armidale personnel responsible for weed control within Gara Gorge) shall be conducted in order to:
    - Provide each party with updated information regarding existing weed and pest issues being managed on site, and those being managed within the Oxley Wild Rivers National Park,
    - Share knowledge and lessons learnt or new developments in weed control techniques, and
    - Collaborate, in conjunction with landowners of properties in between the site and Gara Gorge, for the development of a Willow control program in the Gara River and its tributaries (Commissioners Waters and Burying Ground Creek)

2.1.5.3 Water Quality

The quality of water is the second most existing concern that impacts on the ecological integrity of Oxley Wild Rivers National Park. Water quality monitoring reported by (NSW NPWS, 2005) has found poor water quality to be characteristic of streams such as the Gara River on the tablelands upstream of Oxley Wild Rivers National Park. These same rivers, however, were much cleaner downstream of the Park, indicating that the relatively undisturbed environments of the Park contributed to removal of excess nutrients (NSW NPWS, 2005).

Additional issues identified include the following:

- The New England Highway, Oxley Highway and Waterfall Way cross the headwaters of most of the major streams that flow into Oxley Wild Rivers National Park at points close to the park boundaries. A vehicle accident involving a chemical or fuel spill would also pose a major threat to water quality.
- Armidale's Sewage Treatment Plant discharges to Commissioners Waters with high concentrations of Phosphates continuously detected in water quality monitoring.
- Algal blooms in the vicinity of Blue Hole are a common occurrence during periods of low flows (pers.comm. Matt Ryan and George Monroe, NWPS, Armidale, 2009).

A review of water quality data is provided in **Section 3.2.2**.

2.1.5.4 Flooding

Concern has been raised in relation to potential contaminants entering the waterways of Oxley Wild Rivers National Park during flood events.

Runoff from the proposed landfill site falls to the north towards a tributary of the Gara River. The proposed landfill is located within the upper reaches of the catchment. No flood studies have been conducted in this area. Instead, calculations using Manning's equation were used to estimate the 100 year Average Recurrence Interval (ARI) flow and the 100 year flood level in these creeks. The results of these calculations indicate that the proposed landfill site is well outside the extent of the 100 year floodplain.

The design for the landfill, leachate pond, sedimentation basin and dry basin incorporates adequate freeboard to contain 100 year ARI flows, on site, without further containment or storage actions needing to be implemented.

Events larger than the 100 year event would be relatively catastrophic for the local area. Washing out of leachate water from the landfill site during events larger than this are likely to be undetectable in comparison to widespread erosion, sediment and debris mobilisation, and influx of contaminants from other point sources (e.g. Armidale STP, and toilet facilities within the Gara Gorge's day facilities).

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3.0 Surface Water and Groundwater Water Quality

3.1 Background Review

A background review has been conducted to establish the appropriateness of baseline data available for current surface and ground water quality. The review assessed both current surface and ground water monitoring program and available historical data, including:

- Currently established ground water monitoring network and surface water sampling locations;
- Local hydro-geological conditions; and
- Available surface and ground water data.

3.2 Surface Water

3.2.1.1 Catchment Areas

The proposed landfill site is situated within the Gara River catchment, a major catchment within the local region that covers an area of 41,486 ha, and a sub-catchment of the Macleay River. The Gara River originates approximately 45 km north of the proposed landfill site and flows from north to south, to the east of the proposed landfill site. The minimum or straight line distance between the Gara River and the proposed landfill site is 1.06 km. The River descends into a Gara Gorge approximately 4.3 km south-south-east of the proposed landfill site, within the Oxley Wild Rivers National Park. The riverbed distance between the closest point to the proposed landfill site and the Oxley Wild Rivers National Park is 8.8 km.

Tributaries of the Gara River (upstream of the Oxley Wild Rivers National Park) include Commissioners Waters, Burying Ground Creek, and a number of minor drainage lines (Figure 3-1).

Commissioners Waters is located approximately 1.6 km south of the proposed landfill site, and flows into the Gara River approximately 800 m upstream of the Oxley Wild Rivers National Park. Burying Ground Creek enters Commissioners Waters approximately 2 km west of the site. Runoff from the proposed landfill site does not flow to Commissioners Waters or its tributary Burying Ground Creek.

Runoff from the proposed landfill site runs into the Gara River via two unnamed intermittent creeks which have a combined catchment area of 370 ha. These creeks flow onto the site from the west and south west for approximately 200 m before merging to form a single gully that intermittently flows a further 1300 m to the east before joining the Gara River at the north-western corner of the proposed landfill site.

Both drainage lines are regulated by several farm dams, two of which are located within the boundaries of the proposed landfill site and its associated buffer zones.

Land use within the region is predominantly agricultural, with some residential, commercial and industrial areas concentrated around the major urban centres of Guyra and Armidale.

The *Southern New England Tablelands Region State of the Environment Report 2004* (and *Supplementary* report, 2004/05) identifies the Gara River as a “stressed sub-catchment”, exhibiting signs of poor water quality. It also shows signs of “high hydrologic and environmental stress”, including:

- Eutrophication (due to high nutrient content); and
- Poor river structure (stream bank erosion and poor riparian habitat).

The *Stressed Rivers Assessment Report 1998*, produced by the former Department of Land and Water Conservation (DLWC), gave the Gara River the highest overall stress classification, indicating that water extraction within the region contributes to the River’s environmental stress. Flows within the River are impacted both by the Guyra Shire Council Dams and the Malpas Dam, all of which are close to Guyra.

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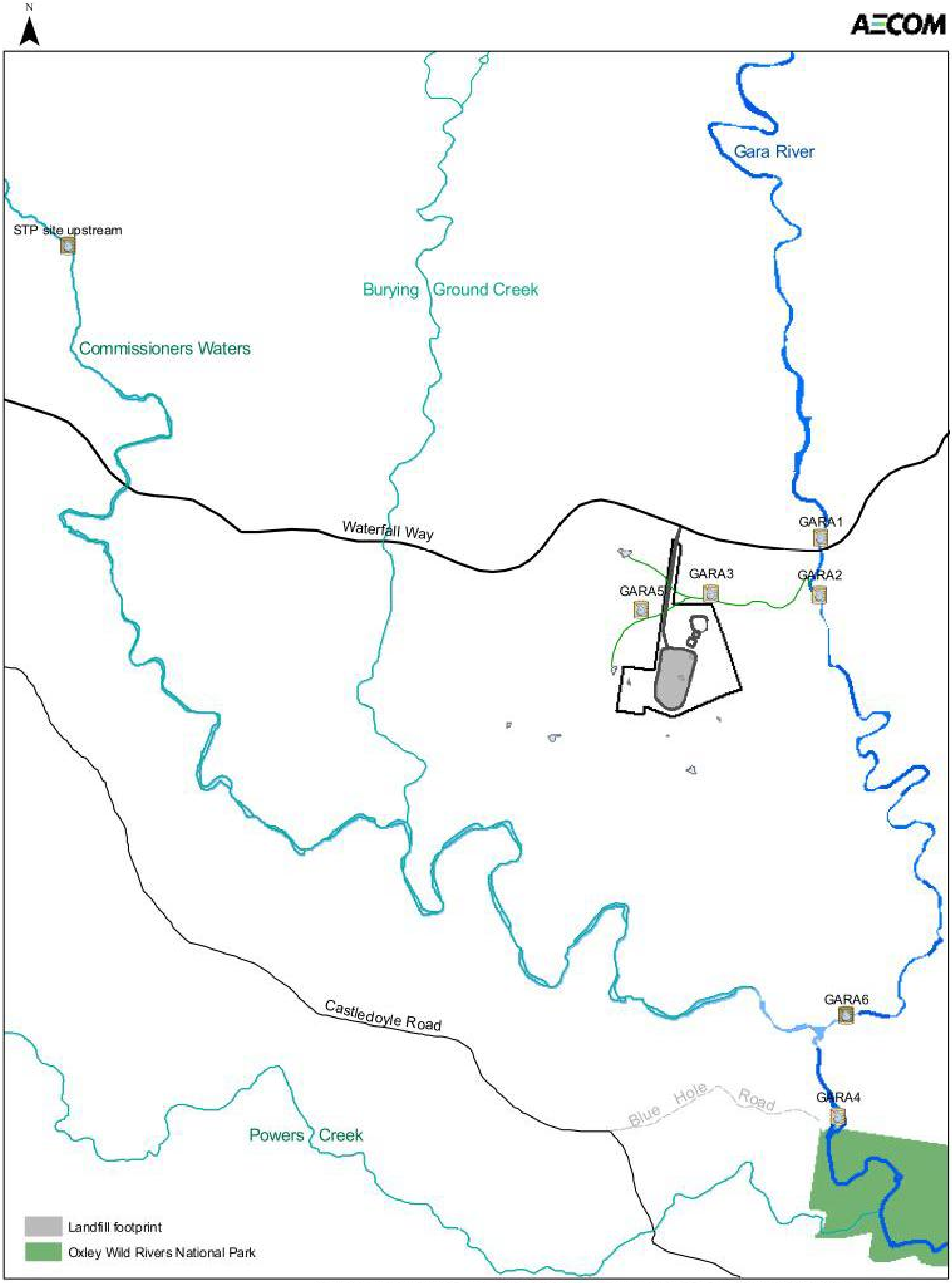

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SURFACE WATER & MONITORING LOCATIONS

Source: ASR (2006), Map Data (2008), Natural Resources Atlas NSW (2009)

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Fig. **3.1**

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3.2.2 Data Review

Surface water sampling is currently undertaken at three sites on the Gara River (GARA1, GARA2 and GARA4) and two sites on the gully running through the proposed landfill site (GARA3 and GARA5) (

Figure 3-1).

GARA5 has generally been dry at the time of sampling while GARA3 has often had low flow with resulting elevated salinity and degraded water quality parameters. The river sites GARA1, GARA2 and GARA4 share similar water quality parameters and elevated nutrient concentrations reflecting the nature of the surrounding landuse. GARA4, located downstream of the confluence of Commissioners Waters at Blue Water Hole has consistently shown higher total phosphorous (TP) concentrations mainly in the form of filterable reactive phosphate (FRP).

Monitoring of three creeks, Dumaresq Creek, Tilbuster Creek and Commissioners Waters, in the vicinity of the Council’s sewage treatment plant (STP) was undertaken on a three monthly basis from July 2005 to April 2009. Dumaresq Creek and Tilbuster Creek were monitored upstream while Commissioners Waters was monitored downstream of the STP discharge point.

A review of the STP monitoring data identified a significant increase in nutrients in Commissioners Waters downstream from the STP discharge point. Mean total nitrogen (TN) concentrations of 0.25 mg/L and 0.44 mg/L were recorded in Dumaresq and Tilbuster Creeks respectively, while downstream of the discharge, in Commissioners Waters, mean TN concentration was 1.32 mg/L. Similarly, mean TP concentrations of 0.17 mg/L and 0.20 mg/L were recorded in Dumaresq and Tilbuster Creeks respectively, while downstream of the discharge, in Commissioners Waters, mean TP concentration was 1.65 mg/L.

3.3 Groundwater

3.3.1 Groundwater Investigations

Hydro-geological investigations were conducted by EA Systems (2005) and RCA (2006-2007) to:

- Establish the current hydro-geological conditions across the site; and
- Determine the potential impact from the project.

EA Systems drilled and logged five bore holes, into which five piezometers were installed to monitor groundwater movement. Groundwater monitoring was then carried out from November through to December 2005. While no standing groundwater was detected during the shallow soil drilling investigation, the soil profile had evidence of transient sub-surface flow within the shallower soils. No groundwater was detected in any of the bore holes during the piezometer monitoring period.

Subsequent to the above investigation, RCA conducted hydro-geological studies in October 2006, which included the drilling of 10 bores in depths ranging from 1.0 m to18.0 m, with groundwater monitoring wells installed in 5 bores (two in rock, and three in soil) (**Error! Reference source not found.**).

Groundwater samples were collected from the wells in rock (BH4 and BH5) as well as from an existing groundwater bore on a neighbouring property to the west of the landfill site. No standing groundwater was encountered in any of the bores in soil.

During March 2007, RCA conducted further groundwater investigation in the study site, installing seven groundwater monitoring wells into the bedrock aquifer, including BH4 and BH5 from earlier investigations. Standing groundwater was encountered in all bores.

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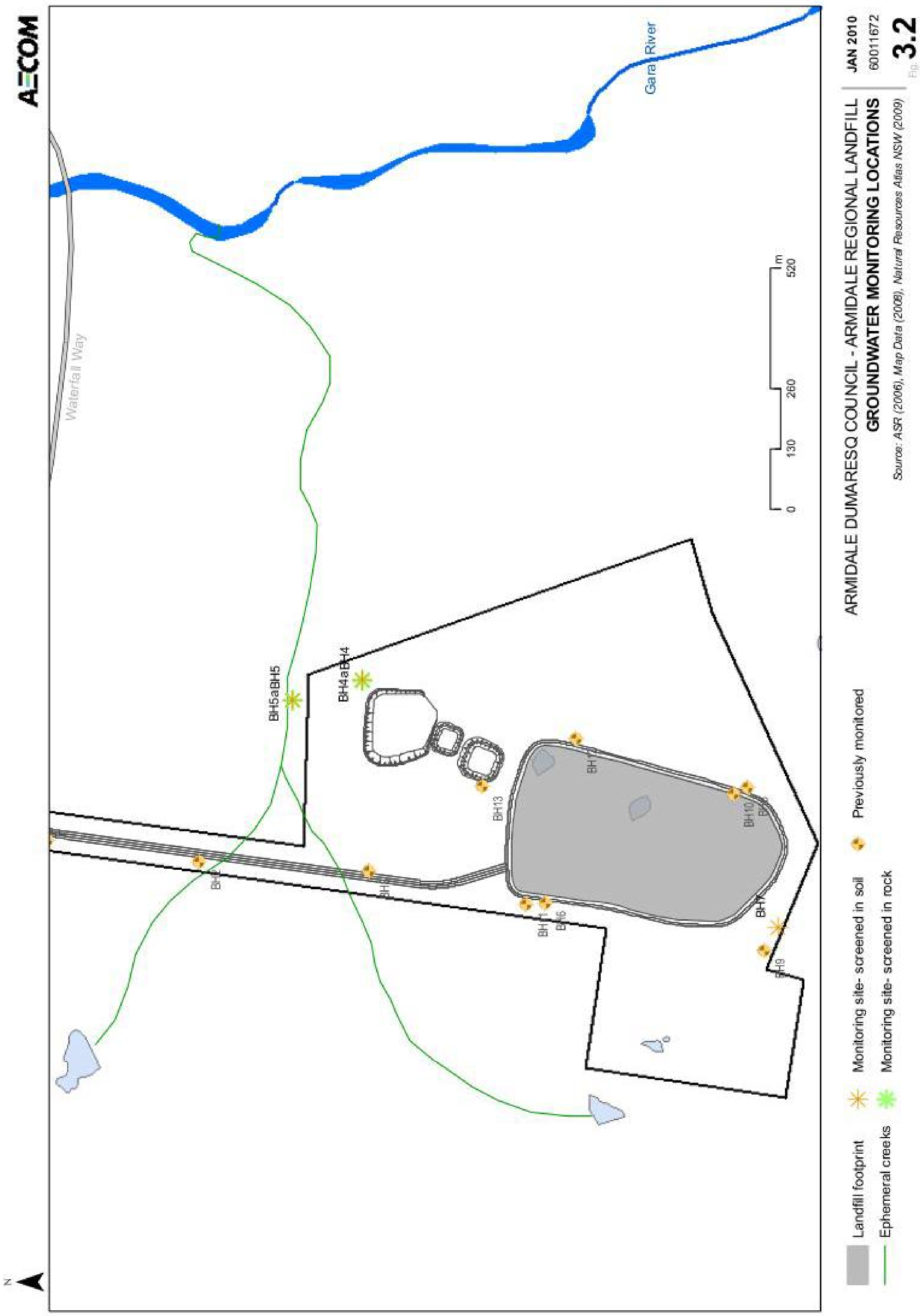

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GROUNDWATER MONITORING LOCATIONS

Source: ASR (2006), Map Data (2008), Natural Resources Atlas NSW (2009)

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Fig. 3.2

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3.3.2 Hydro-geological Conditions

RCA (2007) divided the site’s topography into two distinct sections:

- The southern or upper section which is steep and heavily vegetated, and
- The northern or lower section which is more gently sloping and consists of open paddock and defined by a ridge running eastwest at the northern extremity.

Groundwater in the upper or southern section of the site was generally assumed to be toward the north-north east, whereas in the lower or northern section of the site flow was assumed to be more directly north-east. Collectively groundwater is considered to be leaving the site in a predominantly north easterly flow direction, towards the Gara River. Summer extraction demand in the Gara River is reported as regularly exceeding available flows in November (DNR 2006), indicating that minimal recharge from groundwater inflows is likely to be occurring.

Groundwater sampling results indicate that the aquifer in the southern or upper section of the site, which is contained within the ridgeline, is predominantly a chloride water type. In the lower or northern section of the site, the flatter topography means that the water is more likely to be influenced by influx of other water types from up gradient or south-west of the site. All groundwater sampled in this section of the site was predominantly a bicarbonate water type, except for the water in well BH5, which was a sulphate water type.

BH5 well is closest to the toe of the ridge at the northern extremity of the site. RCA (2007) observed a significantly lower recovery rate in BH5 than the other wells on the site following purging, and purged groundwater appeared more turbid. This was attributed to a layer of mudstone found immediately above the level of the argillite in BH5, which was not identified in the other bores. The topography in the well’s vicinity also suggests that groundwater flows in the opposite direction to the general groundwater.

As a result, RCA (2007) considers it likely that the water sampled from BH5 is representative of, or is being impacted upon, by a separate aquifer to that of the majority of the site, flowing from the north back toward the low point of the site in the vicinity of BH4. Based on the limited number of wells in this section of the site, groundwater flow direction could not be accurately interpolated. However, the estimation of groundwater flow direction, based on the available data and the observed topography, is considered to give a valid representation of the flow direction in the northern section of the site.

Groundwater passing through the argillite bedrock is expected to have higher dissolved solids than water discharging from the sandstone or highly weathered argillite layers. Results from analysis of groundwater sampling for ammonia, chloride, sulphate, chloroform, phenols, and total organic carbon are summarised below:

- The ammonia concentration in BH5 was slightly greater (<109%) than the National Health and Nutrition Research Council (NHNRC) and National Resource Management Ministerial Council (NRMMC) 2004 drinking water guidelines. The overall concentration of ammonia across the aquifers encountered could be considered as low, given the high potential for solubility.
- The relatively high concentrations of major ions (chloride and sulphate) detected in groundwater on the site is considered likely to be as a result of the long residence time of the groundwater within the predominantly argillite bedrock, and the solubility of the chemical constituents of the rock.
- Chloroform was detected in very low concentrations in two (2) wells, BH9 and BH11. The wells are on opposite sides of the site and do not have the same geochemical characterisation. Despite the potential source of the chloroform being unknown, the chloroform detected is not considered significant given the low concentrations.
- Phenols have been detected in BH5. However, the concentrations detected do not exceed the site guidelines and are falling. No likely source of phenols was observed in the vicinity of BH5. Contamination of the well due to drilling is not considered to be a likely source as the phenols were detected over several months and the bore has been subjected to repeated rigorous development.
- The Total Organic Carbon concentrations detected in all wells is considered relatively low except for BH5. The TOC concentration in BH5 has risen markedly (740%) from 2006 to 2007 with no apparent reason for this rise observed.

3.4 Conclusion

The available surface water data for the Gara River and Commissioners Waters identifies the likely impact of the Council STP discharge on the water quality at Blue Hole (GARA4). In order to better quantify the impact of the STP discharge on the water quality of the Gara River an additional sampling site upstream of the confluence of the Gara River and Commissioners Waters is recommended. Given the nature of STP discharges it is also recommended to add microbiological indicators to the surface water analytical suite. Other analytical parameters considered necessary to monitor the impacts of the landfill construction and operation, and the contribution of the catchment environment, include:

- Total Suspended Solids (TSS)
- Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn)
- Volatile organic compounds (VOC) and semi-volatile organic compound (SVOC)
- Organochlorine (OC) and organophosphorous (OP) pesticides
- Nutrients - total nitrogen (TN), total kjledahl nitrogen (TKN), nitrite (NO_2), nitrate (NO_3), total phosphorous (TP) and filterable reactive phosphorous (TRP).
- Major cations and anions

Limited background data is available with respect to potential landfill contaminants in groundwater. Chloroform and phenols have been detected in the groundwater beneath the site, albeit in concentrations only marginally above detection limits. Continued monitoring of VOCs and SVOCs will provide a baseline to assess impacts from the proposed landfill construction and operation. Ammonia (NH3) has been identified at concentrations close to nominated regulatory guidelines. Monitoring of total nitrogen (TN) and ammonia (NH3) is recommended along with a suite of heavy metals (refer **Section 4.0**. Monitoring Program).

4.0 Monitoring Program

4.1 General Requirements

The general requirement of monitoring procedures described by this program is to maintain the integrity of the monitoring program over time. The procedures and approaches, described in the following sections are required to:

- Conduct a technically defendable water quality monitoring program that complies with established standards, scientific monitoring protocols and reporting frameworks, in accordance with the data quality objectives detailed in **Section 5.1** of this document;
- Establish baseline physical, chemical and biological properties of groundwater and surface water at the Site;
- Establish baseline hydraulic characteristics of surface water and groundwater at the Site
- Monitor representative physical, chemical and biological parameters, which will provide an indication of trends in ecosystem health and assist with identifying the causes and effects of pollution;
- Efficiently manage surface water and groundwater sampling data, so as to provide easy access and interpretation for future analysis and reporting, establishing trends and reporting anomalies; and
- Ensure Occupational Health and Safety risks, associated with implementation of the program, are identified and mitigated.

4.2 Groundwater Monitoring Program

4.2.1 Purpose

Routine groundwater sampling is required at the landfill site to monitor existing groundwater contamination, identify new groundwater contamination and to demonstrate continuing groundwater quality.

4.2.2 Groundwater Monitoring Well Sampling Methodology

Prior to the sampling of groundwater, standing water levels (SWL) should be measured. Where phase separated hydrocarbon PSH is suspected, an interface probe should be used to measure the apparent thickness of the layer.

Low flow sampling or micro-purge sampling should be used to sample all groundwater monitoring wells. The technique generally utilises an air driven bladder pump, but other methods may be used provided effective decontamination can be achieved. The advantage of the bladder is that it can be discarded after each sample location thus minimising the opportunity for cross-contamination.

Low flow sampling is a technique designed to minimise the hydraulic stress on the aquifer during purging and sampling. This is done by using an adjustable rate pump to remove water from the screened zone at a rate that will cause minimal drawdown of the water level in the well. Drawdown is measured in the well concurrent with pumping using a water level meter. Low flow sampling does not require a specific flow rate or purge volume.

In practical terms, allowable drawdown should never exceed the distance between the top of the well screen and the pump intake, which is normally positioned near the mid-point of the screen. To provide a safety factor, drawdown should generally not exceed 25 % of this distance to ensure that no water stored in the casing prior to purging is drawn down into the pump intake and collected as part of the sample. Typically, flow rates during purging in the order of 0.1 to 0.5 L/min are used; however, this is dependent on site-specific and well-specific factors.

Pumping water levels in the monitoring well and water-quality indicator parameters should be monitored during pumping. Water quality parameters including pH, temperature, electrical conductivity (EC), dissolved oxygen (DO) and oxidation-reduction potential (ORP) will be measured using calibrated equipment. Stabilising water quality parameters indicate that purging is complete and sampling can begin, as detailed in Table 4-1. Field parameter measuring equipment will be calibrated as required and calibration certificates and records retained.

Table 4-1. Criteria for Defining Stabilisation of Water Quality Parameters

Parameter	Stabilisation Criterion
pH	± 0.2 pH units
Electrical Conductivity	± 3% of reading
Dissolved Oxygen	± 10% of reading or ± 0.2 mg/L, whichever is greater
Eh	± 20 mV

A sample can be collected after the water level and measured field parameters stabilise over three consecutive readings taken three to five minutes apart. For in-line flow-through cells, the frequency of the measurements should be based on the time required to completely evacuate one volume of the cell to ensure that independent measurements are made. It is important to know the manufacturer's recommendations for the amount of time required to completely evacuate the cell to allow individual sensors being used to measure field parameters (e.g. dissolved oxygen) to stabilize and to ensure that representative data is collected.

Though not a chemical parameter, turbidity can be indicative of stress and disturbance resulting from pumping. Turbidity should be as low as possible when sampling is undertaken. The stabilisation criterion for turbidity is ± 10 % of the preceding reading or ± 1.0 NTU, whichever is greater.

The flow cell should be disconnected or bypassed during sample collection. Sampling should be completed at a rate where aeration and turbulent filling is minimised, typically less than 0.5 L/min. Generally samples for the most sensitive parameters (e.g. VOCs) and those of greatest interest at the site should be collected first. Samples for analytes that require filtration should be collected last (e.g. heavy metals).

Low-flow purging and sampling can be used to collect samples for all aqueous-phase contaminants and naturally occurring analytes, including volatile and semivolatile organic compounds (VOCs and SVOCs), metals and other inorganics, pesticides, PCBs, other organic compounds, radionuclides and microbiological constituents.

Further detail on low-flow sampling can be obtained from:

- The US EPA publication "Low-flow (minimal draw down) groundwater sampling procedures" (US EPA 1996); and
- The ASTM standard D 6771-02 "Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations" (ASTM 2002).

During the groundwater sampling, field observations, field parameters (when stabilisation parameters as specified in Table 4-1 are met) and photographs should be recorded. Table 4-2 lists the parameters to be recorded.

Table 4-2: Groundwater Monitoring Field Parameters

Type	Parameter
Bore Description	Unique sample location identifier
	GPS coordinates (WGS 84, decimal degrees)
Bore Description	Photographic Record
	Sample appearance (colour/odour/clarity/visible sheen – if any)
	Bore details (Total Depth, Screen level)
Field Measurement	Time and date
	pH
	Oxidation Reduction Potential
	Electrical Conductivity
	Dissolved Oxygen
	Turbidity
	Water Temperature
	Standing Water Level

4.2.3 Sampling Locations

The groundwater monitoring program will be conducted at the locations detailed in Table 4-3 and shown in Error! Reference source not found.Figure 3-2.

Table 4-3: Groundwater Monitoring Locations

Monitoring Well ID	Description	Position (MGA94 Zone 56)		RL (m, AHD)
		Easting	Northing	
BH4	Screened in rock	383691.47	6619577.55	954.11
BH4a	Screened in soil	383693.19	6619577.72	953.96
BH5a	Screened in soil	383649.85	6619727.47	953.05
BH5	Screened in rock	383650.96	6619727.59	953.13
BH7	Screened in soil	383158.60	6618681.95	1010.58

RL = reduced level
AHD = Australian Height Datum

Sampling should be undertaken in accordance with the DQOs outlined in **Section 5.1**. Demonstration of the DQOs will require the collection of:

- One field duplicate sample for every ten primary samples collected;
- One rinsate blank for each day of sampling; and
- A trip blank for each esky dispatched to the laboratory.

Non-routine sampling may be required in response to environmental incidents or as a result of subsequent environmental investigations at the site. Table 4-3 provides the locations that should be monitored as part of the program. This list should be reviewed and updated when additional monitoring wells are installed.

4.2.4 Sample Frequency and Analytical Regime

Table 4-4 describes the groundwater sample frequency and laboratory analytical suite for ongoing groundwater monitoring at the site.

Table 4-4: Groundwater Sample Frequency and Analytical Regime

Location	Frequency	Laboratory Analytical
BH4	Quarterly	Field parameters Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) TN, NH_3 VOC, SVOC
BH4a	Quarterly	Field parameters Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) TN, NH_3 VOC, SVOC
BH5a	Quarterly	Field parameters Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) TN, NH_3 VOC, SVOC
BH5	Quarterly	Field parameters Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) TN, NH_3 VOC, SVOC

Location	Frequency	Laboratory Analytical
BH7	Quarterly	Field parameters Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) TN, NH_3 VOC, SVOC

4.3 Surface Water Monitoring

4.3.1 Purpose

The purpose of the surface water monitoring program is to capture an accurate “picture” of both: surface water quality; and environmental factors influencing or associated with the surface water quality at the time of sampling.

4.3.2 Sampling Methodology

The surface water samples should be collected using a grab sampler or by direct filling into the sample bottle. Ideally, containers for volatile organics should be filled directly from the water body by placing the container below the surface of the water (typically 0.25–0.5 m depth). If this is not practical measures should be taken to minimise potential volatile loss. Care should be taken to minimise aeration. Surface water samples to be analysed for dissolved metals will need to be filtered in the field prior to filling appropriate containers.

During sampling, field parameters, such as pH, dissolved oxygen (DO), electrical conductivity (EC), oxidation-reduction potential (ORP), turbidity and water temperature will be measured using calibrated equipment. Each sample will be visually observed and a description of the colour, turbidity, odour and any visible sheen will be recorded in the field notes (refer to Table 4-5).

Field parameter measuring equipment will be calibrated as required and calibration certificates and records retained.

Table 4-5: Surface Water Monitoring Field Parameters

Type	Parameter
Field Observation	Unique sample location identifier
	GPS coordinates (WGS 84, decimal degrees)
	Photographic Record
	Water body description
	Weather conditions
	Flood level indicator reading (if applicable)
	Estimated flow rate
	Substrate type
	Water colour, light penetration, odour, presence of scum or sheen etc.
	Fish and aquatic flora and fauna observations
	Evidence of bank stability/erosion and feral animal activity
Field Measurement	Time and date
	pH
	Oxidation Reduction Potential
	Electrical Conductivity
	Dissolved Oxygen
	Turbidity
	Water Temperature
	Depth of water sample taken from

Sampling should be undertaken in accordance with the Data Quality Objectives (DQO)s outlined in **Section 5.1**. Demonstration of the DQOs will require the collection of:

- One field duplicate sample for every ten primary samples collected;
- One rinsate blank for each day of sampling; and
- A trip blank for each esky dispatched to the laboratory.

4.3.3 Sampling Locations

The surface water monitoring program will be conducted at the locations detailed in Table 4-6, and as shown in Figure 3-1. It should be noted that the recommended sample locations include one additional location when compared to previous surface water monitoring programs. The additional location is recommended to monitor possible impacts on the Gara River associated with the Armidale Sewage Treatment Plant (STP).

Table 4-6: Surface Water Sampling Locations

Site	Sample Site Description	GPS Position	
		Easting	Northing
GARA1	Located on Gara River, upstream of the confluence of the landfill site and the Gara River, North of the Waterfall Way/Gara River road bridge. This site is not influenced by run-off originating from the landfill.	384760.65	6620315.70
GARA2	Located on the Gara River immediately downstream of the confluence of the landfill site and the Gara River. This site represents the first monitoring location on the Gara River where potential impact from the landfill facilities might be detected.	384756.70	6619754.60
GARA3	Located on the landfill site gully immediately downstream of the facility.	383733.31	6619782.26
GARA4	Located on the Gara River, at the Blue Water Hole (downstream of both landfill facility, and Commissioners Water including potential impacts from STP).	385029.34	6614635.65
GARA5	Located on the landfill site gully upstream of the landfill facility.	383029.97	6619624.20
GARA6	Additional monitoring site located immediately upstream of the confluence of Commissioners Waters and Gara River.	3851013.54	6615724.24

4.3.4 Sample Frequency and Analytical Regime

Table 4-7 describes the sampling frequency and the laboratory analytical suite for ongoing surface water monitoring program at the Site.

As above, one additional monitoring site has been added to the surface water monitoring program to consider possible impacts associated with the STP. As such, it has been recommended that the previous analytical suite be increased to include microbiological analytes (i.e. E.Coli and *Enterococci*).

Table 4-7: Surface Water Analytical Suite

Location	**Frequency**	**Laboratory Analytical Suite**
GARA1	Quarterly	Field parameters Total Suspended Solids Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) VOC, SVOC OC and OP pesticides Nutrients (TN, TKN, NO_2, NO_3, TP, TRP) Cations and anions Total coliforms, *E.coli, Enterococci* spp
GARA2	Quarterly	Field parameters Total Suspended Solids Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) VOC, SVOC OC and OP pesticides Nutrients (TN, TKN, NO_2, NO_3, TP, TRP) Cations and anions Total coliforms, *E.coli, Enterococci* spp
GARA3	Quarterly	Field parameters Total Suspended Solids Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) VOC, SVOC OC and OP pesticides Nutrients (TN, TKN, NO_2, NO_3, TP, TRP) Cations and anions Total coliforms, *E.coli, Enterococci* spp
GARA4	Quarterly	Field parameters Total Suspended Solids Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) VOC, SVOC OC and OP pesticides Nutrients (TN, TKN, NO_2, NO_3, TP, TRP) Cations and anions Total coliforms, *E.coli, Enterococci* spp

Location	Frequency	Laboratory Analytical Suite
GARA5	Quarterly	Field parameters Total Suspended Solids Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) VOC, SVOC OC and OP pesticides Nutrients (TN, TKN, NO_2, NO_3, TP, TRP) Cations and anions Total coliforms, *E.coli, Enterococci* spp
GARA6	Quarterly	Field parameters Total Suspended Solids Heavy metals (As, Cr, Cd, Cu, Hg, Pb, Ni, Se, Zn) VOC, SVOC OC and OP pesticides Nutrients (TN, TKN, NO_2, NO_3, TP, TRP) Cations and anions Total coliforms, *E.coli, Enterococci* spp

4.4 Additional Requirements

4.4.1 Sample Preservation, Packaging and Shipping

Procedures for containing and preserving groundwater and surface water samples are as follows.

- The type and size of containers and preservatives used for water samples varies based on the type of analysis to be performed. Samples will be placed and stored in laboratory-supplied sample containers.
- Filtering of groundwater and extraction bore samples to 0.45 μm for metals analysis will be conducted using disposable filters prior to preservation (i.e. placement within the preserved laboratory supplied sample bottle).
- All water samples will be placed in a cooler with ice to maintain samples at $<4^{o}$C prior to analysis.
- Holding times for water samples vary according to the type of analysis that is to be performed. In general, holding times for common types of analyses are as follows:
  - samples to be analysed for faecal coliforms can be held a maximum of 1-2 days
  - samples to be analysed for ferrous iron can be held a maximum of 24 hours
  - samples to be analysed for VOCs can be held a maximum of 14 days
  - samples to be analysed for other organic chemicals (including TPH, PAHs and Phenols) can be held a maximum of 7 days until extraction, and then for 40 days until analysis
  - samples to be analysed for metals (except mercury) can be held a maximum of 6 months.
- Samples will be labelled with specific details including:
  - date and time of sample collection
  - project number
  - name(s) of sampler
  - sample identification number
  - sample preservatives used.

4.4.2 Chain of Custody (COC) Protocols

Samples collected in the field must be able to be tracked from the time of collection until the analytical laboratory receives them. To document sample possession, Chain of Custody (COC) procedures shall be followed.

COC records shall include the following information:

- Project number
- Name(s) of sampler
- Time and date of sample collection
- Sample type (i.e. water, soil or sediment)
- Number and type of sample containers (including preservatives used)
- Sample identification number
- Receiving analytical laboratory
- Required analyses
- Contact details for questions regarding sample analysis
- Names, dates, times and signatures documenting all changes in sample possession from:
    - the person collecting the samples in the field; to the –
    - courier transporting the samples to the laboratory; to the -
    - analytical laboratory.

COC records will accompany samples at all times once the samples are collected. When transferring possession of the samples, the individuals relinquishing and receiving the samples will sign, date, and note the time of transfer on the COC record.

4.4.3 Decontamination

Field personnel are responsible for ensuring that all field equipment is decontaminated prior to use for the collection of samples as required by the GSWMP. Decontamination is performed to eliminate the possibility of cross-contamination from previous projects or between sampling locations. In general, decontamination consists of either: a high pressure, hot water wash (steam-cleaning); or, a non-phosphate detergent solution (Decon 90, or Alconox) wash followed by deionized, distilled, or clean water rinse(s).

The decontamination procedures must be performed before initial use of any equipment for sample collection and after each subsequent use.

Decontamination procedures that must be utilised during sampling are as follows:

- Prior to collection of each sample, all sampling and measurement field equipment (e.g. water quality meters etc) will be hand washed with a mixture of water and phosphate free detergent. This will be followed by a double potable water rinse. Where possible, equipment will be wiped with disposable paper towel prior to, and after, decontamination as above.
- The air discharge line, fluid line and internal air bladder used in the low flow purging and sampling system will be replaced between groundwater monitoring wells (i.e. dedicated equipment).
- Following completion of sampling and decontamination of sampling equipment (as described above), one rinsate blank sample (from an item of sampling equipment i.e. water quality meter) will be collected per day of sampling by running laboratory supplied distilled water over the selected item and decanting directly into the sample bottle.

4.5 Data Management and Reporting

Reporting will be required at the completion of each monitoring program. The objectives of the report will be to: interpret the analytical results received; identify any compliance issues; trigger implementation of contingency plan (as described by **Section 7.0**); and, recommend any additional or modified management measures that might be required.

The specific reporting requirements for the GSWMP are as follows.

- Verbally report to Armidale Dumaresq Council’s Operations Manager any trigger level exceedances of the contaminants of concern within 24 hours of obtaining results from the laboratory.
- Provide a progress report to Armidale Dumaresq Council within two weeks of receipt of laboratory results from each sampling event (ie. Quarterly, annually).
- Provide an annual summary report to Armidale Dumaresq Council within two weeks of the completion of each calendar year.

4.5.1 Verbal Reporting

All trigger level exceedances will be reported verbally to the Armidale Dumaresq Council's Operations Manager. The purpose of the verbal reporting is to enable identification of and proactive management of any changed conditions (for example a leaking pipe or tank) which might have contributed to the trigger level exceedance.

All verbal reporting, including any agreed actions, shall be confirmed in writing by e-mail.

4.5.2 Progress Reporting

Progress reports will be prepared upon completion of each sampling event. Progress reports will include, as minimum requirements:

- The locations of all groundwater monitoring wells and surface water sample sites sampled as part of the sampling event;
- A description of the sampling methodology used and, in particular, any departures from the requirements of this GSWMP;
- Descriptions of all samples collected, including measured field parameters, in accordance with the GSWMP;
- Tabulated comparison of analytical results from the subject sampling event with the trigger levels recommended by the GSWMP and with historical sampling results;
- Identification of any trigger level exceedances, sample data anomolies or sample data trends and provision of an explanation (for example changed conditions such as a leaking pipe or a spill event);
- Assessment of the quality of data obtained and achievement of the Data Quality Objectives recommended by the GSWMP;
- Recommendation of management actions, including but not limited to triggering of the Contingency Plan described by **Section 7.0**; and
- Recommendations (if any) for modification of the GSWMP.

4.5.3 Annual Summary Reporting

Annual summary reports will be prepared upon the conclusion of each calendar year. Annual summary reports will include, as minimum requirements:

- A summary of all groundwater and surface water samples collected during the preceding year;
- Tabulated comparison of analytical results from the subject sampling event with the trigger levels recommended by the GSWMP and with historical sampling results;
- Summary of any trigger level exceedances, sample data anomolies or sample data trends and provision of an explanation (for example changed conditions such as a leaking pipe or a spill event);
- Summary of recommended management actions, including but not limited to triggering of the Contingency Plan described by **Section 7.0**;
- Summary of Contingency measures implemented in accordance with **Section 7.0** (if any); and
- Summary of recommendations (if any) for modification of the GSWMP.

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5.0 Quality Assurance/Quality Control

5.1 Data Quality Objectives

The National Environmental Protection Measure (NEPM, Schedule B[2]) *Guideline on Data Collection, Sample Design and Reporting* (1999), specifies that the nature and quality of the data produced in an investigation will be determined by the Data Quality Objectives (DQOs). As referenced by the NEPM, the DQO process is detailed in the US EPA *Guidance for the Data Quality Objectives Process* (1994), EPA QA/G-4 (EPA 600R96055). The US EPA defines the process as:

> *'a strategic planning approach based on the Scientific Method that is used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect'.*

The process of establishing appropriate DQOs is defined by the USEPA according to the following seven steps (**Table 5-1**).

Table 5-1: DQO Steps

Step	Data Quality Objective
1	**State the problem** – define the problem to be addressed, identify the planning team, examine budget and schedule.
2	**Identify the decision** – outline the decision, the study question and alternative actions.
3	**Identify inputs to the decision** – present parameters and inputs for decision, including information sources, basis for trigger/guideline levels, sampling and analysis methodology, etc.
4	**Define the study boundaries** – present spatial and temporal limits for study, sample characteristics and decision making units.
5	**Develop a decision rule** – define a statistical parameter, specify trigger/guideline levels and develop argument for action.
6	**Specify limits on decision errors** – set acceptable limits for decision errors relative to potential consequences such as health, budget, social or environmental impacts.
7	**Optimise the design for obtaining data** – develop an effective sampling and analysis plan that meets resource and performance criteria.

In the context of the GSWMP adoption of the DQO process is considered critical to obtaining relevant data for interpretation and development and implementation of associated management or mitigation measures. The DQO process was considered in the development of the GSWMP and to address QA/QC measures to be adopted during the program.

The approach adopted relative to the seven steps presented above is discussed below.

5.1.1 Step 1 - State the Problem to be Resolved

The problems to be addressed are whether:

- Any potential groundwater or surface water contamination issues are present
- The site mitigation measures are performing adequately
- Any contamination or performance issues can be effectively managed and what measures can be taken to reduce associated impacts.

5.1.2 Step 2 - Identify the Decision to be Made

The decision identification component of the DQO process represents the key issues that need to be reviewed / considered in order to resolve the problems identified in Step 1. These issues include:

- Are contaminant concentrations above background levels?
- Do the concentrations identified exceed the relevant regulatory guidelines / trigger levels?
- Has the extent of any groundwater/surface water contamination been identified?
- Are the current groundwater surface/water monitoring results representative of historical results?
- Should management controls, such as groundwater exclusion zones, be established?
- Do the contaminant concentrations adversely impact upon human health or the environment for the identified receptors of concern?
- Is the landfill performing within industry accepted performance criteria?
- Is the investigation approach scientifically suitable and defensible?

5.1.3 Step 3 - Identify Inputs to the Decision

To allow assessment of the data against the objectives listed above, various inputs are considered. The following list presents various inputs considered.

- Relevant regulatory guidelines / trigger levels;
- Landfill performance criteria;
- Aesthetic impacts (odours, sheen, etc);
- Identification of the contaminants of interest for each area, based on previous investigation data;
- The known distribution of surface water / groundwater contamination at and surrounding the site; and
- The previously recorded concentrations of contaminants relative to the trigger levels.

5.1.4 Step 4 - Define the Boundaries of the Investigation

The spatial boundaries (geographical limits) applied for data collection and decision making in the investigations are defined as follows:

- The extent of the sampling locations surrounding the Site; and
- The groundwater aquifer to a depth of approximately 60 mBGL

5.1.5 Step 5 - Develop a Decision Rule

Based upon the relevance of all of the data collected, the decision rule for the program is to assess:

- The representativeness of current and historic analytical data;
- Whether the current groundwater and/or surface water controls (if any) are adequate; and
- Whether previous conclusions regarding risk to Armidale Dumaresq Council are still accurate/relevant.

5.1.6 Step 6 - Specify Limits on Decision Errors

A decision error in the context of the decision rule presented above would lead to either underestimation or overestimation of the risk level associated with a particular area. Decision errors may include:

- Limitations based on inaccurate/inadequate data from previous investigations;
- Errors in the GSWMP;
- Data not representative of site conditions; and
- Inadequate data quality (refer to Section 5.3).

5.1.7 Step 7 - Optimise the Design for Obtaining Data

The methodology presented represents a program which is designed to meet the objectives of the GSWMP and also to achieve the nominated DQOs. Optimisation of the data collection process will be achieved by:

- Targeted sampling based on historical and anecdotal evidence.

The investigation will be carried out in a manner and to a level of accuracy and confidence presented in the NEPM documentation.

5.2 QA/QC Data Assessment

5.2.1 Field QA/QC

All work completed on the site will be conducted in accordance with standard environmental sampling protocols. The essential elements of the QA/QC program are presented in Table 5-2 below.

Table 5-2: Essential Elements of the Field QA/QC Program

Action	Description
Use of Experienced Personnel	Field work will be undertaken by trained engineers/scientists with previous experience in contaminated site assessment, field sampling techniques and health and safety issues.
Record Keeping	Full records of all field activities including water monitoring data and sample collection will be maintained on standard field logging sheets.
Sample Collection	New nitrile gloves will be worn during water sampling, and replaced between each sample collection.
Sample Labelling	A unique sample number will be used for each sample to clearly specify the sample origin (site/well number and date), preservation standards and analytical requirements.
Chain of Custody	Chain of Custody procedures are required for all sample transfers. Custody sheets should list sample numbers; date of collection and analyses required and be signed by each person transferring and accepting custody.
Sample Storage	The collected water samples will be transferred to approved sampling containers with appropriate preservation as required and then placed in cool storage prior to transfer to a NATA accredited laboratory.
Decontamination	All equipment used in the sampling process will be decontaminated using a phosphate free detergent, followed by rinsing with de-ionised water, prior to mobilisation and between sampling locations to reduce the risks of cross contamination.

Field Duplicates

In addition to the primary samples, quality control field duplicate (intra-laboratory duplicates) and triplicate (inter-laboratory) samples will be collected to assess aspects of field protocols and laboratory performance and to classify the validity of the laboratory data. Field duplicates will be collected in general accordance with AS 4482.1-2005 guidelines (Standards Australia 2005).

A relative percentage difference (RPD) analysis of primary and duplicate / triplicate samples is used to measure the representativeness and/or precision of duplicate samples. The RPD is calculated from the absolute difference between results of the duplicate pair divided by the mean value of the duplicate pair.

RPD (%) = 100 x (D1-D2) / ((D1+D2) / 2)

where: D1 = primary sample analysis
D2 = duplicate sample analysis

AS 4482.1-2005 states that the typical RPD which can be expected from acceptable field duplicates is < ± 30-50% of the mean concentration of the analyte, where the results are greater than ten times the limit of reporting (LOR).

Rinsate Blanks

One rinsate blank will be collected in the field each day during the collection of water samples to assess the effectiveness of decontamination procedures. Rinsate blanks are prepared by passing laboratory supplied deionised water over the sampling equipment after decontamination procedures had been completed.

Trip Blanks

Trip blank samples will be submitted during the sampling event to assess whether any cross-contamination has occurred between samples en route to the laboratory within the coolers. Trip blank samples are supplied by the laboratory in appropriately preserved containers and contain laboratory grade deionised water.

5.2.2 Laboratory QA/QC

The laboratory used in the investigations will be National Association of Testing Authorities (NATA) approved for the analyses required. Quality assurance procedures adopted by the analytical laboratory will include analysis of blanks, duplicates, laboratory control samples, matrix spikes and surrogate spikes (for organics).

A description of the laboratory's minimum quality assurance procedures is presented in Table 5-3 below.

Table 5-3: Description of Laboratory Quality Assurance procedures

QA Procedure	Description
Laboratory Blanks and Controls (refer to Table 5-5)	The quality control term Method/Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Frequency of QC samples 1 in 20.
Laboratory Duplicates (refer to Table 5-5)	The quality control term Laboratory Duplicate refers to an intra laboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity. Relative percentage differences (RPDs) are used to assess precision. Frequency of QC samples 1 in 10.
Matrix Spikes (refer to Table 5-5)	The quality control term Matrix Spike (MS) refers to an intra laboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. The samples undergo the same extraction and analysis procedures and the results are used to assess the method precision and bias. Spike recoveries are reported as a percent recovery. Frequency of QC samples 1 in 20.
Surrogate Spikes (refer to Table 5-5)	The quality control term Surrogate Spike refers to a compound added to a sample aliquot in known amounts before extraction and analysis. The compound should be similar in composition and behaviour to the target analyte but not naturally occurring in the sample. A surrogate is used to monitor the method performance for analysis of organic compounds. Spike recoveries are reported as a percent recovery.

All samples will be received by the laboratory in appropriately pre-treated and preserved containers and within specified holding times.

5.3 Assessment of Data Quality

Based on the outcomes of the DQO process the quality of the data collected in accordance with the GSWMP should be assessed according to a range of factors including:

- documentation and data completeness
- data comparability, representativeness and precision and accuracy for sampling and analysis.

The relevant evaluation criteria for each of these issues are presented in **Table 5-4** below.

Table 5-4: DQO Evaluation

DQO	Evaluation Criteria
Documentation Completeness	Site conditions properly described
	Investigation area properly described
	Understanding of site history and chemicals of interest presented
	Sampling locations properly described and accurately located
Data Completeness	Samples tested for appropriate chemicals of interest
	Completion of field records, chain of custody forms, laboratory sample receipt and test certificates from NATA registered laboratories.
	Consideration of key receptors of interest
	Remediation strategies assessed and preferred selection based upon site specific factors
Data Comparability	Appropriate sampling techniques, sample storage and transportation of samples used
	Selection of NATA certified laboratory using NEPM testing procedures
	Intra-laboratory duplicate samples (refer to Table 5-5)
	Inter-laboratory duplicate samples (refer to Table 5-5)
Data Representativeness	Collection of representative samples (and adequate numbers) from each location
	Use of properly trained and qualified field personnel
	Assessment of the RPD for laboratory and field duplicate samples (refer to Table 5-5)
	Assessment of the analytical results for laboratory quality control samples
	Collection and assessment of rinsate blanks (refer to Table 5-5)

Table 5-5: Acceptance Criteria for Data Quality Indicators Water Analysis

Data Quality Indicator	Acceptance Criteria
Rinsate blanks	Less than the laboratory LOR
Intra laboratory field duplicates (1) (3)	Relative Percent Difference (RPD) less than ± 30 to 50%
Laboratory duplicates (2) (3)	RPD less than: 20% for high level laboratory duplicates (i.e. >20 x LOR) 50% for medium level laboratory duplicates (i.e. 10 to 20 x LOR)
Matrix spikes (3) (4)	Recoveries between 70-130% of the theoretical recovery
Method blanks	Less than the laboratory LOR
Laboratory control samples (5)	Recoveries between 70-130%.
Surrogate spikes	See Note 6

1. Potential exceptions to this criteria may occur where sample variation or heterogeneity, rather than poor laboratory performance, is accountable for the poor reproducibility, or where the results are close to the LOR. This typical RPD range is obtained from AS 4482.1-2005 *Guide to the investigation and sampling of sites with potentially contaminated soil*.

2. If the results are close to the LOR, then higher results will be accepted.

3. Criteria for sample duplicate and matrix spike results assume no sample heterogeneity. If samples are found to be heterogeneous with respect to a particular analyte the above criteria does not apply.

4. Assumes that samples are homogeneous and the background analyte level is less than 20% of the spike level (refer to USEPA Method 8000B). Note that there is no requirement for matrix spikes to pass as certain matrices may preclude recovery of spiked compounds. In this case data will be accepted if LCS data meets the acceptance criteria.

5. 80% of the compounds tested must fall within the control limits. Control limits are dynamic and vary for individual tests as per USEPA Method 8000B.

6. Recoveries for surrogates are test dependent and are based on USEPA Method SW846. Control limits are dynamic and vary for individual tests but are within the criteria described in USEPA Method SW846.

6.0 Investigation Trigger Levels

6.1 Surface and Groundwater Acceptance Criteria

Surface water and groundwater analytical results will generally be compared to the ANZECC (2000) *Guidelines for Fresh and Marine Water Quality*. As groundwater and surface water discharges to freshwater aquatic ecosystems, the freshwater ecosystems guidelines have been adopted. Gara River is an ephemeral waterway and subject to significant periodic flows. These flows result in high erosion, sediment transport and disturbance to the creek and surrounding area. Given the dynamic nature of the receiving waters, the 95% level of species protection will be adopted for the GSWMP (where laboratory techniques can be quantified to these limits). The 99% species protection criteria will be used for chemicals that bioaccumulate (e.g. PCBs, OC pesticides and some heavy metals including mercury).

For some of analytes, the analytical program may not be able to achieve the ANZECC (2000) 95% criteria, as the criteria are significantly below laboratory limits of reporting. Notwithstanding, the proposed analytical program is sufficient to achieve the nominated DQOs, which is focused on the monitoring of groundwater and surface water quality against background data and appropriate trigger levels.

The ANZECC (2000) guidelines relate to receiving surface water bodies, and not to the groundwater directly beneath the Site. If ANZECC (2000) or other suitable criteria is not available for an analyte, AECOM propose to use the laboratory limit of reporting (LOR) and background concentrations (where available) as a guide for identifying the presence of a contaminant. Table T2 in the Tables Section of this document provide ANZECC (2000) trigger levels / acceptance criteria to be applied to the selected indicators for the surface and groundwater monitoring program.

ANZECC (2000) provides comprehensive information and procedures for setting more specific water quality targets tailored for unique conditions for a range of pollutants or indicators and may be used to further customise water quality targets for local conditions. These targets, provided by Department of the Environment, Water, Heritage and the Arts through the website Water Quality Targets Online, simplify the task of setting water quality targets when preparing regional plans.

The targets are provided for a set of indicators to be applied to individual environmental values. Indicators for water quality include:

- Nutrients (Nitrogen and Phosphorus)
- Salinity
- Turbidity & Suspended Solids
- River condition, including Biological Indicators (when established)

For water, the following environmental values may require protection:

- Aquatic ecosystems
- Primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);:
- Recreation and aesthetics
- Drinking Water

Table T1 in the Tables Section of this document provides water quality targets to be applied to the selected indicators and environmental values for the surface and groundwater monitoring program.

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7.0 Contingency Plan

7.1 Groundwater and Surface Water

This contingency plan outlines the measures to be taken in response to:

- An exceedance of the specified trigger levels described in **Section 6.0**; and/or
- An exceedance of historically reported analysis results.

The contingency measures to be taken in the event groundwater and/or surface water monitoring results exceed either the trigger levels or historically reported results (as applicable) are described following.

7.1.1 Repeat Sampling

A repeat sample will be collected from the same location at which the exceedance was reported. The sample will be collected as soon as possible following receipt of the elevated result to minimise differences in site conditions which might occur over time.

In addition, repeat samples should also be collected upstream / hydraulic gradient and downstream / hydraulic gradient of the subject sample location.

The objectives of the repeat sampling event are to:

- Validate the reported result and demonstrate that the result, and the observed exceedance(s), can be replicated;
- Define the spatial extent of the observed impact; and
- Assist in defining the source of the observed impact.

In the event that repeat sampling does not validate the original result, consideration will be given to:

- Whether the original result was anomalous; or
- Whether the monitoring frequency should be increased to provide for detection of temporal variations not otherwise detected by the current program.

In the event that repeat sampling does validate the original result, a conceptual site model and risk assessment will be undertaken as described by **Section 7.1.2**.

7.1.2 Conceptual Site Model and Risk Assessment

A conceptual site model should be developed considering:

- Potential sources of the identified contamination – including changes in site conditions and activities which could have resulted in the observed impact;
- Potential pathways from the potential source to the observed impact and from the observed impact to potential receptors; and
- Potential receptors of the observed impact.

Should an increase in risk to Armidale Dumaresq Council be identified, consideration will be given in initiation of corrective action as described by **Section 7.1.3**.

Should no increase in risk to Armidale Dumaresq Council be identified, consideration will be given to increasing the frequency of monitoring at the subject location such that any future changes are detected in a timely fashion and proactively managed.

7.1.3 Corrective Action

Depending on the outcomes of the preceding repeat sampling and risk assessment, corrective actions may be warranted. Corrective Actions may include:

- Modification of the existing monitoring program
- Implementation of management or remediation strategies, as appropriate.

The requirement of corrective action will take into consideration: the degree of trigger value exceedance; nature of the contaminant; and, available historical data. In the case of significant exceedances, potentially resulting from spills or leaking infrastructure, immediate management or remediation responses to mitigate the impacts should be considered.

The selected response is particularly important to surface water exceedances at a site boundary sampling location because of the potential to impact off-site receptors.

Monitoring Program Modification

The purpose of any modification to the monitoring program would be to:

- Refine the conceptual site model prepared in respect of the identified impact, including identification of the contamination source;
- Refine the assessment of risk to Armidale Dumaresq Council related to the identified impact;
- Enable design of appropriate management or remediation measures (if warranted); and
- Identify what parameters may be affecting the analytical results (e.g. an increasing water table that encounters soil contamination not previously affecting groundwater quality).

Modifications to the monitoring program might include:

- Inclusion of additional monitoring well/sampling locations,
- Amending the analytes being assessed,
- Lowering the laboratory detection limits (through collection of additional sample, modification of analysis methodology),
- Increasing the frequency of sample collection.

Management Strategies

The purpose of any management or remediation strategies that might be considered would be to reduce the risk to Armidale Dumaresq Council represented by the observed impact. To this end, management or remediation strategies might include:

- Modification of current work practices or provision of improved waste management facilities to minimise the future risk of spills and impact to surface water or groundwater;
- Active remediation, such as removal of the primary contaminant source (for example a leaking UST) and secondary source (for example impacted soil surrounding the removed UST);
- Institutional controls, such as fencing, establishment of a groundwater exclusion zone, or implementation of a site management plan, to limit access to identified impact.

8.0 Frequency of Review

The GSWMP should be reviewed at least annually. The annual review is required to assess the suitability of the current monitoring program in light of the data obtained during the year and any changes to the scope or setting that may have occurred.

The review should take into account the information presented in the progress and annual summary reports (refer to **Section 4.5**) and assess all relevant information to the GSWMP including but not limited to:

- Historical analytical data
- Changes in land use
- Changes in extraction water use (where applicable)
- Changes in water use (e.g. for recreational activities)
- Changes in guideline criteria
- Outcomes of new environmental assessments
- New contamination issues.

The GSWMP would need to be modified to reflect any variation in sampling frequency, addition of new sampling locations or variation in the analytical regime for example, from a new contamination issue being identified on site).

The GSWMP should be viewed as a live document and updated as necessary, noting that revision of the GSWMP may result in the monitoring regime increasing or decreasing.

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9.0 References

ANZECC. 1992. *Australia and New Zealand guidelines for the assessment and management of contaminated sites.* Australia and New Zealand Environment and Conservation Council and Medical Research Council. January 1992.

ASTM. 2002. *Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations*, ASTM D 6771-02.

Department of Environment and Heritage. 2000. *Strategic Overview for management of World Heritage Central Eastern Rainforest Reserves of Australia / CERRA.* Canberra. 53pp. November 2000.

Department of the Environment, Water, Heritage and the Arts. Australian Heritage Database [Accessed November 2008] http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105135

Department of the Environment, Water, Heritage and the Arts. Gondwana Rainforests of Australia [Accessed November 2008] http://www.environment.gov.au/heritage/places/world/gondwana/index

Department of the Environment, Water, Heritage and the Arts. Water Quality Targets On-line, http://www.environment.gov.au/water/publications/quality/targets-online/map.php

EA Systems. 2009. *Flora and Fauna Assessment – Proposed New Armidale Landfill Facility*. Report prepared for AECOM Australia, December 2009.

Environment Australia, NSW National Parks and Wildlife Service and Queensland Parks and Wildlife Service. 2003. *Australian National Periodic Report. Report on the State of Conservation of the Central Eastern Rainforest Reserves of Australia*. Periodic Report 2002 Section II. 20pp.

National Environment Protection Council (NEPC), 1999. *National Environment Protection (Assessment of Site Contamination) Measure*. December 1999.

NSW Department of Environment and Conservation - National Parks and Wildlife Service. 2005. *Oxley Wild Rivers National Park, Oxley Wild Rivers State Conservation Area, Cunnawarra National Park and Georges Creek Nature Reserve Plan of Management.* 69pp. June 2005.

NSW Department of Environment and Conservation. 2004. *World Heritage and Associated Natural Values of Central Eastern Rainforest Reserves of Australia / CERRA*. National Parks and Wildlife Service, originally published June 2003, revised 2004

NSW Department of Natural Resources. 2006. *Macro Water Planning Process – Macleay River Catchment Area* – Unregulated Water Sources, March 2006.

RCA Australia. 2007. *Hydrological Investigation – Proposed Armidale Landfill*. Report for Maunsell Australia Ltd. August 2007.

USEPA. 1994. *Guidance for the Data Quality Objectives Process*. EPA QA/G-4.

US EPA. 1996. *Low-flow (minimal draw down) groundwater sampling procedures*. EPA Ground Water Issue, April 1996.

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Tables

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Table T1: Water Quality Targets - New South Wales / Rivers Upland (µg/L)

Indicator (µg/L)	Environmental Value					
	Aquatic Ecosystem Protection	**Recreation**	**Drinking Water**	**Livestock Drinking Water**	**Irrigation (long term targets)**	**Aquaculture**
Total Nitrogen (µg/L as N)	250				5,000	
Nitrogen Oxides (NO_x) (µg/L as N)	15					
Nitrate (µg/L as N)		44,300* (primary contact)	50,000** (health)	400,000 (health)		50,000
Nitrite (µg/L as N)		3,280** (primary contact)	3,000** (health)	30,000 (health)		100
Ammonia (µg/L as N)		10 (primary contact)	500 (aesthetic)			20 (pH>8.0)
Total Phosphorus (µg/L as P)	20					
Filterable Reactive Phosphate (FRP) (µg/L as P)	15				50	
Phosphates (µg/L as P)						100
Turbidity (NTU)	2-25***	>1.6 m Secchi depth (primary contact)	5 (aesthetic)	6,000^^^		40 mg/L TSS^
Salinity (µS/cm)	30-350^^					4,500
Sodium (µg/L)		300,000 (primary contact)	180,000 (aesthetic)		115,000$^{\#}$	
Chloride (µg/L)		400,000 (primary contact)	250,000 (aesthetic)		175,000$^{\#}$	

Notes:

Nitrogen (total nitrogen, ammonia, NOx, nitrate, nitrate) values as µg/L N, except:

* Nitrate as µg/L $N0_3$

** Nitrite as µg/L $N0_2$

*** High turbidity values apply to high flows

^ TSS – Total Suspended Solids

^^ Low values in Highlands; High values in NSW

^^^ Beef cattle, No effect (see Water Quality Targets On-line for other receptors)

$^{\#}$ Prevention of foliar Injury – most sensitive species

Table T2: ANZECC trigger values for freshwater 95% level of protection for slight to moderately disturbed systems (µg/L)

Chemical	Trigger values for freshwater (µg/L)
METALS & METALLOIDS	
Aluminium (pH>6.5)	55
Aluminium (pH<6.5)	0.8
Antimony	9
Arsenic (As III)	24
Arsenic (As V)	13
Beryllium	0.13
Bismuth	0.7
Boron	370
Cadmium	0.2
Chromium (Cr III)	3.3
Chromium (Cr VI)	1
Cobalt	2.8
Copper	1.4
Gallium	18
Iron	300
Lanthanum	0.04
Lead	3.4
Manganese	1900
Mercury (inorganic)	0.06
Mercury (methyl)	ID
Molybdenum	34
Nickel	11
Selenium (Total)	5
Selenium (Se IV)	11
Silver	0.05
Thallium	0.03
Tin (inorganic,Sn IV)	3
Tributyltin (as µg/L Sn)	0.002
Uranium	0.5
Vanadium	6
Zinc	8
NON-METALLIC INORGANICS	
Ammonia	900

Chemical	Trigger values for freshwater (µg/L)
Chlorine	3
Cyanide	7
Nitrate	700
Hydrogen sulfide	1
ORGANIC ALCOHOLS	
Ethanol	1400
Ethylene glycol	330
Isopropyl alcohol	4200
CHLORINATED ALKANES	
Chloromethanes	
Dichloromethane	4000
Chloroform	370
Carbon tetrachloride	240
Chloroethanes	
1,2-dichloroethane	1900
1,1,1-trichloroethane	270
1,1,2-trichloroethane	6500
1,1,2,2-tetrachloroethane	400
Pentachloroethane	80
Hexachloroethane	290
Chloropropanes	
1,1-dichloropropane	500
1,2-dichloropropane	900
1,3-dichloropropane	1100
CHLORINATED ALKENES	
Chloroethylene	100
1,1-dichloroethylene	700
1,1,2-trichloroethylene	330
1,1,2,2-tetrachloroethylene	70
3-chloropropene	3
1,3-dichloropropene	0.1
ANILINES	
Aniline	8
2,4-dichloroaniline	7
2,5-dichloroaniline	3
3,4-dichloroaniline	3

Chemical	Trigger values for freshwater (µg/L)
3,5-dichloroaniline	1
Benzidine	2.5
Dichlorobenzidine	0.5
AROMATIC HYDROCARBONS	
Benzene	950
Toluene	180
Ethylbenzene	80
o-xylene	350
m-xylene	75
p-xylene	200
m+p-xylene	ID
Cumene (*i*-propyl benzene)	30
Polycyclic Aromatic Hydrocarbons	
Naphthalene	16
Anthracene	0.4
Phenanthrene	2
Fluoranthene	1.4
Benzo(a)pyrene	0.2
Nitrobenzenes	
Nitrobenzene	550
1,2-dinitrobenzene	0.6
1,3-dinitrobenzene	13
1,4-dinitrobenzene	0.6
1,3,5-trinitrobenzene	4
1-methoxy-2-nitrobenzene	130
1-methoxy-4-nitrobenzene	16
1-chloro-2-nitrobenzene	15
1-chloro-3-nitrobenzene	12
1-chloro-4-nitrobenzene	1
1-chloro-2,4-dinitrobenzene	4
1,2-dichloro-3-nitrobenzene	15
1,3-dichloro-5-nitrobenzene	3
1,4-dichloro-2-nitrobenzene	10
2,4-dichloro-2-nitrobenzene	12
1,2,4,5-tetrachloro-3-nitrobenzene	0.3
1,5-dichloro-2,4-dinitrobenzene	0.03

Chemical	Trigger values for freshwater (µg/L)
1,3,5-trichloro-2,4-dinitrobenzene	0.2
1-fluoro-4-nitrobenzene	28
Nitrotoluenes	
2-nitrotoluene	110
3-nitrotoluene	75
4-nitrotoluene	120
2,3-dinitrotoluene	0.3
2,4-dinitrotoluene	16
2,4,6-trinitrotoluene	140
1,2-dimethyl-3-nitrobenzene	4
1,2-dimethyl-4-nitrobenzene	16
4-chloro-3-nitrotoluene	1.5
Chlorobenzenes and Chloronaphthalenes	
Monochlorobenzene	55
1,2-dichlorobenzene	160
1,3-dichlorobenzene	260
1,4-dichlorobenzene	60
1,2,3-trichlorobenzene	3
1,2,4-trichlorobenzene	85
1,3,5-trichlorobenzene	8
1,2,3,4-tetrachlorobenzene	2
1,2,3,5-tetrachlorobenzene	3
1,2,4,5-tetrachlorobenzene	5
Pentachlorobenzene	1.5
Hexachlorobenzene	0.05
1-chloronaphthalene	1.6
Polychlorinated Biphenyls (PCBs) & Dioxins	
Capacitor 21	0.002
Aroclor 1016	0.001
Aroclor 1221	1
Aroclor 1232	0.3
Aroclor 1242	0.3
Aroclor 1248	0.03
Aroclor 1254	0.01
Aroclor 1260	25
Aroclor 1262	50

Chemical	Trigger values for freshwater (µg/L)
Aroclor 1268	50
2,3,4’-trichlorobiphenyl	0.07
4,4’-dichlorobiphenyl	0.1
2,2’,4,5,5’-pentachloro-1,1’-biphenylB	0.2
2,4,6,2’,4’,6’-hexachlorobiphenyl	0.15
Total PCBs	ID
2,3,7,8-TCDD	0.00001
PHENOLS and XYLENOLS	
Phenol	320
2,4-dimethylphenol	2
Nonylphenol	0.1
2-chlorophenol	340
3-chlorophenol	4.5
4-chlorophenol	220
2,3-dichlorophenol	31
2,4-dichlorophenol	120
2,5-dichlorophenol	3
2,6-dichlorophenol	34
3,4-dichlorophenol	2
3,5-dichlorophenol	4
2,3,4-trichlorophenol	1
2,3,5-trichlorophenol	2
2,3,6-trichlorophenol	2
2,4,5-trichlorophenol	0.5
2,4,6-trichlorophenol	3
2,3,4,5-tetrachlorophenol	0.2
2,3,4,6-tetrachlorophenol	10
2,3,5,6-tetrachlorophenol	0.2
Pentachlorophenol	3.6
Nitrophenols	
2-nitrophenol	2
3-nitrophenol	1
4-nitrophenol	58
2,4-dinitrophenol	45
2,4,6-trinitrophenol	250
ORGANIC SULFUR COMPOUNDS	

Chemical	Trigger values for freshwater (µg/L)
Carbon disulfide	20
Isopropyl disulfide	8
n-propyl sulfide	20
Propyl disulfide	3
Tert-butyl sulfide	30
Phenyl disulfide	0.1
Bis(dimethylthiocarbamyl)sulfide	10
Bis(diethylthiocarbamyl)disulfide	1
2-methoxy-4H-1,3,2-benzodioxaphosphorium-2-sulfide	2
Xanthates	
Potassium amyl xanthate	0.5
Potassium ethyl xanthate	0.05
Potassium hexyl xanthate	500
Potassium isopropyl xanthate	15
Sodium ethyl xanthate	0.05
Sodium isobutyl xanthate	5
Sodium isopropyl xanthate	0.05
Sodium sec-butyl xanthate	5
PHTHALATES	
Dimethylphthalate	3700
Diethylphthalate	1000
Dibutylphthalate	9.9
Di(2-ethylhexyl)phthalate	1
MISCELLANEOUS INDUSTRIAL CHEMICALS	
Acetonitrile	160
Acrylonitrile	8
Poly(acrylonitrile-co-butadiene-costyrene)	530
Dimethylformamide	1000
1,2-diphenylhydrazine	2
Diphenylnitrosamine	6
Hexachlorobutadiene	0.04
Hexachlorocyclopentadiene	0.05
Isophorone	120
ORGANOCHLORINE PESTICIDES	
Aldrin	0.001
Chlordane	0.03

Chemical	Trigger values for freshwater (µg/L)
DDE	0.03
DDT	0.006
Dicofol	0.5
Dieldrin	0.01
Endosulfan	0.03
Endosulfan alpha	0.0002
Endosulfan beta	0.007
Endrin	0.01
Heptachlor	0.01
Lindane	0.2
Methoxychlor	0.005
Mirex	0.04
Toxaphene	0.1
ORGANOPHOSPHORUS PESTICIDES	
Azinphos methyl	0.01
Chlorpyrifos	0.01
Demeton	0.04
Demeton-S-methyl	4
Diazinon	0.01
Dimethoate	0.15
Fenitrothion	0.2
Malathion	0.05
Parathion	0.004
Profenofos	0.02
Temephos	0.05
CARBAMATE & OTHER PESTICIDES	
Carbofuran	0.06
Methomyl	3.5
S-methoprene	0.2
PYRETHROIDS	
Deltamethrin	0.0001
Esfenvalerate	0.001
HERBICIDES & FUNGICIDES	
Bypyridilium herbicides	
Diquat	1.4
Paraquat	0.5

Chemical	Trigger values for freshwater (µg/L)
Phenoxyacetic acid herbicides	
MCPA	1.4
2,4-D	280
2,4,5-T	36
Sulfonylurea herbicides	
Bensulfuron	800
Metsulfuron	8
Thiocarbamate herbicides	
Molinate	3.4
Thiobencarb	2.8
Thiram	0.01
Triazine herbicides	
Amitrole	22
Atrazine	13
Hexazinone	75
Simazine	3.2
Urea herbicides	
Diuron	0.2
Tebuthiuron	2.2
Miscellaneous herbicides	
Acrolein	0.01
Bromacil	180
Glyphosate	370
Imazethapyr	240
Ioxynil	0.4
Metolachlor	0.02
Sethoxydim	2
Trifluralin	2.6
GENERIC GROUPS OF CHEMICALS	
Surfactants	
Linear alkylbenzene sulfonates (LAS)	280
Alcohol ethoxyolated sulfate (AES)	650
Alcohol ethoxylated surfactants (AE)	140
Oils & Petroleum Hydrocarbons	ID
Oil Spill Dispersants	
BP 1100X	25

Chemical	Trigger values for freshwater (µg/L)
Corexit 7664	16
Corexit 8667	1200
Corexit 9527	1100
Corexit 9550	140

Trigger values are for the 95% level of protection for slight to moderately disturbed systems where available, exceptions are highlighted as below:

▩	99% level of protection (recommended where chemical may bioaccumulate or 95% provides inadequate protection for test species).
🟨	low reliability trigger value (due to insufficient data), to be used only as an indicative interim working level
🟧	Environmental Concern Level (ECL), to be used only as an indicative interim working level, see ANZECC (2000) 8.3.4.5
🟩	other source (see note)
ID	insufficient data

Appendix A

DEWHA Correspondence

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From: Kelly, Pat [Pat.Kelly@environment.gov.au]
Sent: Thursday, 5 November 2009 10:55 AM
To: Duchatel, Kathryn
Cc: Teasdale, Jonathan
Subject: EPBC 2007/3646 Armidale Dumaresq proposed landfill EA [SEC=UNCLASSIFIED]
Attachments: DEWHA comments on EA Report 070809.doc.pdf

Hi Kathryn

Thank you for your e-mail of 23 September 2009 (copy attached below) with a proposal to address the specific matters raised by DEWHA in our letter to the NSW Dept of Planning, August 2009 (copy attached), in relation to the adequacy of the draft Environmental Assessment (EA) report for EPBC 2007/3646.

In response to your specific queries (in italics):

(i) Based on a preliminary search I haven't found a great deal of supporting literature or data that would assist in specifying in detail the ecological areas of the GRAWHA. Do you know of any sources (outside those available that generically discuss all GRAWHA sites) that would assist in more accurately defining the GRAWHA downstream of the proposed landfill site?

The department considers that the sources you have identified accurately reflect those currently available in relation to specific information on the Oxley Wild Rivers National Park. The department considers that this information would then be interpreted against the World Heritage listing information found at http://www.environment.gov.au/heritage/places/world/gondwana/values.html.

The department does consider that the values most at risk are those which will be most affected by water quality, and also where weeds are likely to reduce values. Weeds are most likely to cause degradation of values in riverine environments, however, they could also be an issue in other environments.

(ii) Following discussion with other AECOM discipline leaders in relation to preparing detailed contingency plans, the advice I have been given is that this is something more accurately addressed during the construction phase (i.e. so that all dimensions and physical characteristics are understood and contingencies adopted for).

The department considers that, while many aspects of contingency plans may be more accurately addressed during the construction phase, some actions will not be dependent on the layout of the site, and can therefore be addressed in detail prior to final plans. For those specific aspects, it would be recommended to have a commitment to at least "in principle" plans at this stage.

In summary to your e-mail, the department concurs with your proposed approach to Council with one proviso, that in relation to (c) below, the department also requests that the Proponent conduct field inspections **within** the GRAWHA, to identify existing baseline conditions, prior to any action being taken.

Please contact me if you require any further clarification on the above advice.

Kind regards

Pat

[(c) Limited field inspection to assess the condition of the Gara River downstream of the proposed landfill site and upstream of the GRAWHA, to identify existing condition and potential threats in waterways and the catchment].

Ms Pat Kelly
Assessment Officer (SE QLD & NSW)
Environment Assessment Branch
Department of the Environment, Water, Heritage and the Arts
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Please consider our environment before printing this e-mail.

From: Duchatel, Kathryn [mailto:Kathryn.Duchatel@aecom.com]
Sent: Wednesday, 23 September 2009 4:27 PM
To: Kelly, Pat
Subject: EPBC 2007/3646 Armidale Dumaresq proposed landfill EA

Dear Pat,
On behalf of the former Maunsell AECOM (now AECOM) I have been asked to provide a fee proposal to Armidale Dumaresq Council to fulfil the following specific matters raised by DEWHA in your letter to Megan Webb of the Dept of Planning, NSW, these being the preparation of:

1. a detailed monitoring program for ground and surface water quality on the site and key areas adjacent to the perimeter of the site and at appropriate locations downstream of the Gara River; and
2. a management plan that identifies the potential impacts on the heritage values of the downstream GRAWHA.

While most of the specific objectives for these two matters are prescriptive in their description, I was hoping to get a better understanding of two of the management plan requirements, these being:

(i) Identify and describe the values of the GRAWHA with a particular focus on ecological areas that would be most vulnerable to impacts from the proposed construction and operation of the landfill site; and

(ii) The provision of detailed contingency plans should environmental events (such as flooding) threaten containment of the landfill barriers.

With regards to

(i) Based on a preliminary search I haven't found a great deal of supporting literature or data that would assist in specifying in detail the ecological areas of the GRAWHA. Do you know of any sources (outside those available that generically discuss all GRAWHA sites) that would assist in more accurately defining the GRAWHA downstream of the proposed landfill site, and

(ii) Following discussion with other AECOM discipline leaders in relation to preparing detailed contingency plans, the advice I have been given is that this is something more accurately addressed during the construction phase (i.e. so that all dimensions and physical characteristics are understood and contingencies adopted for).

In the interim, my proposal to Council will incorporate the following:

(a) Consultation with relevant agencies that are knowledgeable of the locality (i.e. DEWHA, NSW DPI – Agriculture, Council, Oxley Wild River NP DECC NPWS rangers),

(b) Background review of available literature, data or relevant studies of the Oxley Wild River NP and GRAWHA,

(c) Limited field inspection to assess the condition of the Gara River downstream of the proposed landfill site and upstream of the GRAWHA, to identify existing condition and potential threats in waterways and the catchment, and

(d) Provide sufficient guidance on the basis of the above requirements 1 and 2, that will provide the criteria for a contingency plan to be developed during the construction preparation and installation phase.

I would be grateful to hear back from you in relation to whether what I am proposing (in terms of investigation for these sub-components) is what you are expecting.

Regards

Kathryn Duchatel
Senior Environmental Scientist
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Please note: My email has changed to kathryn.duchatel@aecom.com. Please update your address books accordingly.

From May 4 Maunsell AECOM, Bassett, EDAW AECOM and ENSR come together as one company - one AECOM. AECOM is a Fortune 500 company with over 43,000 people located in over 100 countries delivering advanced environmental, planning, design, engineering, management and advisory services to a broad range of markets.

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