Intermodal Logistics Centre at Enfield

APPENDIX D

Stormwater Quality and Soil and Water Management

Hydrology and Hydraulics

PREFACE

The technical working papers for the proposed ILC at Enfield were prepared during the first half of 2005. These were prepared in response to the requirements for the preparation of an Environmental Impact Statement (EIS) under Part 4 of the Environmental Planning & Assessment Act, 1979 (EP&A Act). Specific requirements for the EIS were issued on 1 March 2005 by the (then) Director- General of Infrastructure, Planning and Natural Resources.

The EP& A Act was amended on 1 August 2005 by the creation of Part 3A of the Act, and the Department of Infrastructure, Planning and Natural Resources was dissolved on 26 August 2005 and replaced by the Department of Planning and the Department of Natural Resources.

The proposed ILC at Enfield has since been declared a major project, pursuant to SEPP (Major Projects) 2005 and Sydney Ports has subsequently lodged an application under Part 3A of the Act.

Editorial changes to the technical working papers to reflect the changes in legislation or changes in Government departments have not been made.

The following should be considered when reading the technical papers:

- The Director-General's requirements issued under Part 4 are now deemed to have been issued under Part 3A, and any reference to the Director-General's requirements should be read as a reference to Director-General's requirements issued under Part 3A;

- Any reference to an EIS under Part 4 of the Act should be read as a reference to an Environmental Assessment under Part 3A of the Act;

- Any reference to the Department of Infrastructure, Planning and Natural Resources should be read as a reference to either the Department of Planning or the Department of Natural Resources, as appropriate.

Intermodal Logistics Centre at Enfield

ENVIRONMENTAL IMPACT STATEMENT

STORMWATER QUALITY AND SOIL AND WATER MANAGEMENT

- Final
- June 2005

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Contents

1. Summary

Sydney Ports Corporation proposes to develop the eastern section of the former Enfield Marshalling Yards site into an Intermodal Logistics Centre (ILC), where shipping containers will be transferred from rail to road and vice-versa. Container packing and unpacking and other activities will also occur on the site.

This water quality working paper considers the existing water quality at the site, and the potential water quality impacts of the proposed development. Mitigation measures and environmental safeguards are recommended for the construction and operational phases of the Enfield ILC site, in order to protect water quality on-site and downstream of the site.

The surface water of the site drains to the east via three drainage channels into the Cooks River. The water quality in the Cooks River is generally poor, reflecting a high level of urbanisation and commercial and industrial activity in the catchment.

The subcatchments within which the site is located display surface water quality characteristics typical of an urban catchment: some heavy metals, BOD_5, nutrients, and faecal indicators have been found at elevated concentrations; however, in terms of pH, conductivity and oil and grease, the water quality is generally good. The groundwater at the site is in an unconfined series of perched aquifers that have been impacted upon by some heavy metals contamination.

During construction, the major risk to surface water quality is erosion of soil and sedimentation of waterways. Mitigation measures recommended during construction therefore consist of erosion and sedimentation control measures, including a sedimentation basin, sedimentation traps and sediment fences.

During operation, the major risk to surface water quality is the range of contaminants associated with the operation of trains, trucks, forklifts and other vehicles on site. In order to mitigate these risks, collection and treatment of the runoff from the site has been recommended. This will mitigate water quality impacts of the proposed development.

Water quality monitoring is recommended to ensure that the main proposed water quality treatment measures are performing as expected.

2. Introduction

Sydney Ports Corporation proposes to develop a portion of the former Enfield Marshalling Yards Site in Enfield. The western section of the former Enfield Marshalling Yards has been developed as the new Enfield Marshalling Yards, leaving the remaining eastern section essentially vacant. The proposal is to develop the large eastern portion of the site into an Intermodal Logistics Centre, where shipping containers will be transferred from rail to road transport and vice-versa. The area of the Enfield ILC will be approximately 50 ha, which is to be levelled and paved, allowing rail and truck access, a large area for container storage and handling and several warehouses. A further four ha will also be devoted to light industrial and/or commercial development, and approximately five ha will be set aside for community and/or ecological purposes. This stage of the project is an assessment of the potential impacts of the proposed development.

The purpose of this Water Quality report is to:

- Identify and describe the environmental values of the receiving waterways downstream of the site;
- Describe existing water quality conditions;
- Describe existing land uses and identify their potential sources of pollution; and
- Assess impacts of the proposed development and resilience of waterways to assimilate potential pollutants.

The water quality working paper has been developed to comply with the requirements of the:

- Water Quality and River Flow Interim Environmental Objectives for the Cooks River Catchment 1999 (NSW EPA);
- Protection of the Environment Operations Act 1997;
- Soils and Construction 2004 (LandCom); and
- Managing Urban Stormwater 1997 (NSW EPA).

A brief description of each of the above requirements is provided below.

Water Quality and River Flow Interim Environmental Objectives for the Cooks River Catchment, NSW EPA (1999)

These guidelines describe the interim water quality and environmental objectives for coastal catchments across NSW. The EPA has identified the potential environmental values based on the responses of the local Catchment Management Committees and the wider community response. The objectives are identified based on the broad goals to be achieved in the long term for river health, maintenance of biodiversity and sustainable water resources for communities and ecosystems dependent on water of a certain quality.

Protection of the Environment Operations Act, 1997

The Protection of the Environment Operations (POEO) Act is being administered by the DEC (formerly EPA). It repeals a number of previous pollution control acts including the *Clean Waters Act 1970* and provides for integrated licences which replace the separate licences issued under the previous legislation. It introduces the concept of Protection of the Environment Policies (PEPs) and establishes a requirement for environment protection licences for a range of activities. These licences may regulate all forms of pollution including water, air, noise and waste.

Soil and Construction 2004 (LandCom)

This manual, also known as the ”Blue Book”, provides guidelines to minimise land degradation and water pollution at development sites in NSW. The guidelines focus on minimising erosion and preventing sediment moving off site during the construction phase of development.

Managing Urban Stormwater 1997 (DEC - formerly EPA)

These guidelines have been developed to provide guidance to stormwater planners and designers in the selection and functional design of a range of stormwater treatment structures.

Reference has also been made to the Healthy Rivers Commission's *Independent Inquiry into the Georges River – Botany Bay System* Final Report, September 2001. Among the objectives put forward in this inquiry, those most relevant to the current proposal are:

- Recommendation WM2: Integrated Stormwater Management at the Local Level, recommends that Councils should ensure that the costs of ongoing stormwater and urban stream management should be included as costs of development and redevelopment, and that such costs should be shared by all developers in a subcatchment.
- Recommendation RC1: Protection of Urban Streams, recommends that where development would unavoidably impact on natural channels and/or riverside vegetation, those impacts should be offset by appropriate trade-offs that would result in a net improvement to local waterways, and that all development and redevelopment proposals should identify and take advantage of opportunities to improve connectivity of natural channels and to improve ecosystem function.
- Recommendation RHO 1: Environmental Values, recommends that, in urban areas, the following values should be protected:

- Protection of visual character;
- Protection of aquatic and riparian ecosystems; and
- Protection of secondary contact recreation.

- Recommendation RHO 2: River Corridor Objectives, recommends that the following goals should be adopted throughout the catchment:
  - Retain channels and foreshores in near natural condition, and, where opportunities arise, use the development process as a catalyst for improving already degraded areas;
  - Maintain or restore aquatic, riparian and foreshore vegetation;
  - Maintain or increase public ownership of and/or access to foreshore land;
  - Control excessive erosion and sedimentation; and
  - Replace non-native with native riverbank vegetation as opportunities arise.
- Recommendation RHO 4: Water Quality Objectives, recommends that the ANZECC Guidelines (2001) should be adopted and used as indicative values for water quality and ecosystem management.

3. Environmental Values and Existing Water Quality

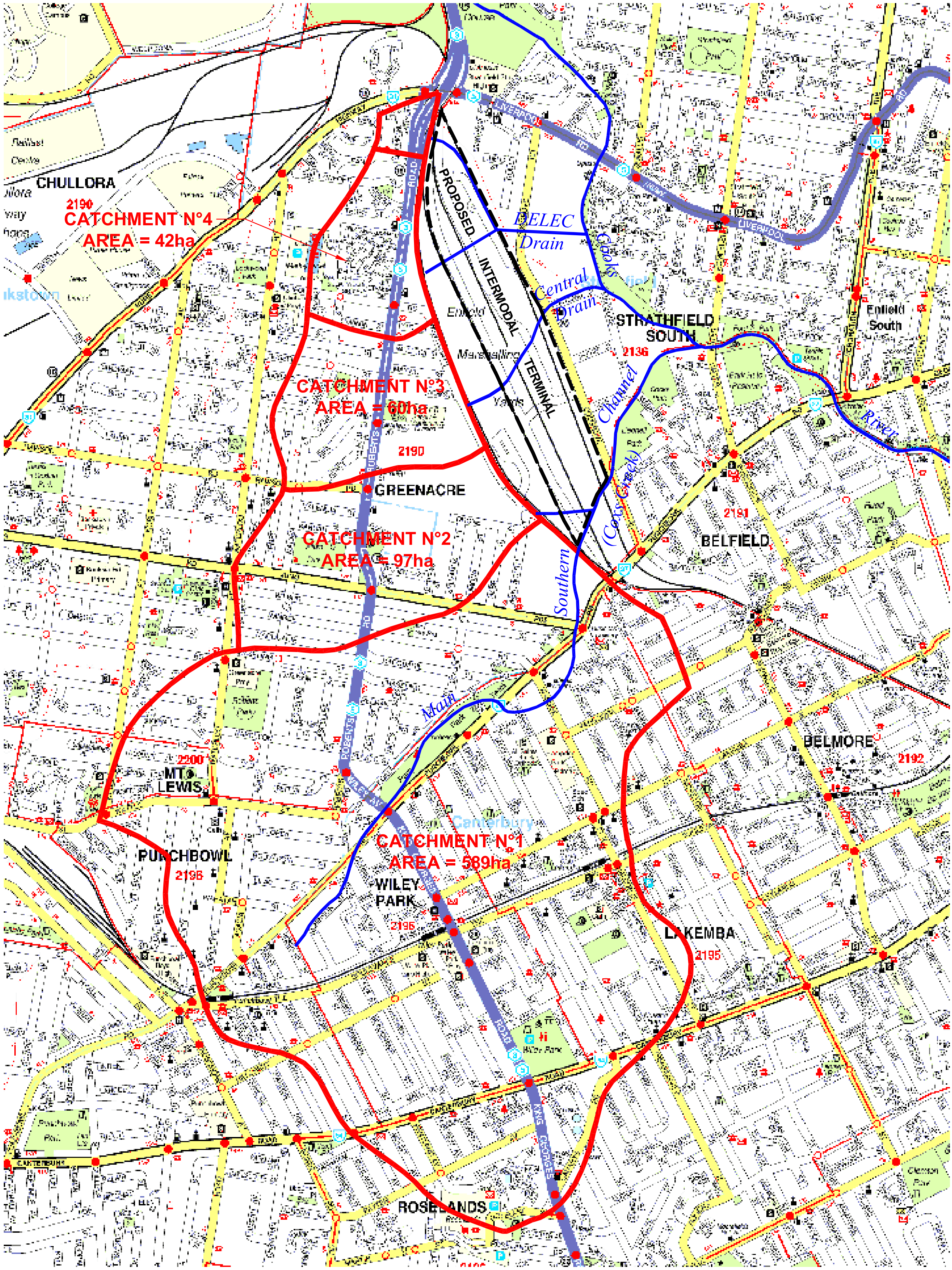
3.1 Environmental Values

The first step in undertaking an assessment of existing conditions in the waterways is through identification of the environmental values to be protected. This is followed by a water quality assessment against the identified environmental values.

The proposed development is located within the upper Cooks River Catchment. Four drainage lines cross the site, including Coxs Creek in the southern part of the site, and three unnamed drainage lines to the north of Coxs Creek. The two most northerly drainage lines meet on the site's downstream edge; therefore these are referred to throughout the rest of this report as a single drainage line, the DELEC drain. The drainage line immediately north of Coxs Creek has been called the Central drain throughout the rest of this report. Each of the three drainage lines drains to the east into the Cooks River. A map of the drainage system is shown in **Figure 1**.

SINCLAIR KNIGHT MERZ

Figure 1
DRAINAGE AREAS
Enfield Intermodal Study



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In 1999, the DEC (formerly EPA) updated their 1997 report with a series of publications for NSW waterways. *Water Quality and River Flow Interim Environmental Objectives - Cooks River Catchment* was produced for the Cooks River. In the 1999 publication, the DEC suggested that the water quality objectives for the area of the Cooks River catchment in which the proposed Enfield ILC is located should be those that apply generally to waterways affected by urban development:

- Visual amenity;
- Secondary contact recreation; and
- Protection of aquatic ecosystems.

The *Cooks River Stormwater Management Plan* (Cooks River Catchment Association of Councils, 1999) identified catchment values for the Cooks River. They used a process of consultation with the community and other key stakeholders to identify the following key values:

- Ecological values, including areas of remnant aquatic, terrestrial and riparian habitat (for example mangroves, wetlands, areas of natural creek line where the natural bed and channel have not been modified, areas of the endangered Cooks River Clay Plain Scrub);
- Heritage values, including a number of heritage sites along the foreshore;
- Recreational values, including passive recreation and some secondary contact recreation;
- Aesthetic values, including the foreshore parks and golf courses forming an almost continuous green corridor; and
- Economic values; however, the river was considered to have low economic value in its current state.

These values generally reflect the values proposed by the NSW DEC.

3.2 Existing Surface Water Quality

A search was undertaken for recorded water quality data in the vicinity of the Enfield ILC site. A number of previous reports have included information about the water quality in the area. Some monitoring of stormwater quality has also been undertaken in the vicinity of the site. All available water quality information was reviewed and summarised in this report.

The proposed Enfield ILC site currently drains generally towards the east and into the Cooks River. At the southern end of the site, Coxs Creek (also called the "Southern Drainage Channel") will convey most of the runoff from the new development into the Cooks River. Two smaller drainage channels, the Central and DELEC drains, which also drain to the east and into the Cooks River, will continue to convey runoff from some areas of the development site as shown in **Figure 1.**

3.2.1 Water Quality in the Cooks River

In terms of the broader catchment in which the proposed Enfield ILC is located, water quality in the Cooks River was considered. The *Cooks River Stormwater Management Plan* (1999) describes the current water quality conditions in the Cooks River. These are outlined in **Table 1**.

- **Table 1: Water quality in the Cooks River, as reported in the Cooks River Stormwater Management Plan, 1999.**

Indicator	Status in Cooks River
Nutrients – Phosphorus and Nitrogen	Found at high levels in the Cooks River. Sources include stormwater (containing fertilisers, detergents, animal wastes, etc) and sewage discharges.
Chlorophyll-a	Levels are high in the Cooks River and some evidence of algal blooms has been recorded.
Faecal Coliforms	High levels have been found in the Cooks River. In all subcatchments of the River, the water does not meet guidelines for either primary or secondary contact recreation. Sources are sewage discharges and animal wastes.
Dissolved Oxygen	Dissolved oxygen levels vary greatly in the Cooks River, with depleted levels occurring in the lower estuarine sections.
Toxicants	Toxicants, for example heavy metals, pesticides and herbicides, oil and grease, petrol compounds, PAHs and PCBs, have been measured at elevated levels in the water and sediment in the Cooks River.
Suspended Solids or Turbidity	Turbidity in the Cooks River is high, with results in all subcatchments well outside the ANZECC (1992) guidelines.
Water Acidity (pH)	Results for all Cooks River subcatchments are generally within guidelines for protection of aquatic ecosystems.

3.2.2 Water Quality in Coxs Creek

In terms of the water quality in the smaller subcatchments in which the proposed Enfield ILC is located, the water quality in Coxs Creek was considered. Coxs Creek passes through the site in its lower reaches (see **Figure 1**).

The *Cooks River Stormwater Management Plan* (1999) identified only one monitoring point in Coxs Creek, which was located in the lower reaches of the creek. It was monitored for the *Ecosystem Health Report to the Cooks River Catchment Management Committee* in 1996. The monitoring results indicated poor to very poor compliance with unspecified guidelines for toxic substances such as copper, cadmium, lead, mercury, zinc, pesticides and PCBs. High levels of oil and grease were also noted.

In 1992, *Water Quality in the Upper Cooks River Catchment, April-June 1992* was produced by Scientific Services for the then Water Board. They took samples from several monitoring locations on Coxs Creek. The results for two of these locations (the two that were closest to the Enfield ILC site) are summarised in **Table 2**. The locations are marked on the map in **Figure 2**.

- **Table 2: Water Quality in Coxs Creek, Scientific Services 1992**

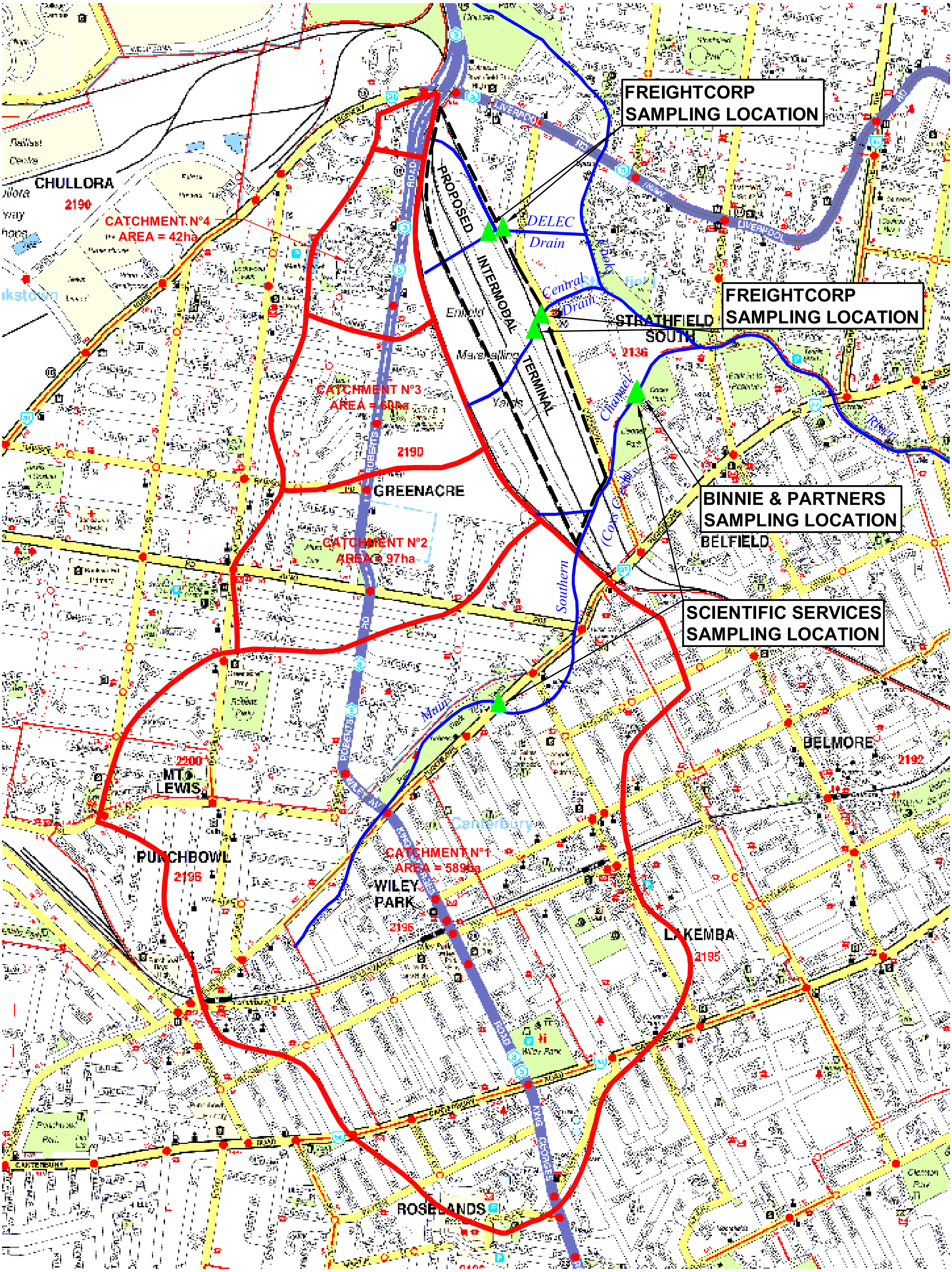
Parameters	Guideline concentration (ANZECC 2000)*	UC664 (upstream of site at Punchbowl Road)		UC661 (downstream of site at Madeline Rd gauging station)	
		Mean dry weather concentrat-ion	Wet weather concentrat-ion	Mean dry weather concentrat-ion	Wet weather concentrat-ion
Faecal coliforms (cfu/100mL)	1000	4248	57000	1222	54000
Total phosphorus (µg/L)	25	244.1	198	98.8	211
Total nitrogen (mg/L)	0.35	2.69	4.10	1.15	3.28
Suspended solids (mg/L)	-	13.1	14.0	4.5	50.0
Turbidity (NTU)	6-50	20	46	10	144
Dissolved oxygen (mg/L)	85-110% saturation	14.5	10.6	10.1	8.9
BOD_5 (mg/L)	-	8.3	4.0	2.6	5.0
pH	6.5-8.5	9.6	8.1	8.5	8.0
Grease (mg/L)	-	1.0	10.0	0.9	2.0
Copper (µg/L)	1.4	21.0	20	2.3	34
Lead (µg/L)	3.4	8.0	20	1.6	36
Zinc (µg/L)	8.0	34.9	130	35.5	240

*The ANZECC (2000)default trigger values for aquatic ecosystem protection in lowland rivers in south-eastern Australia are presented for most parameters. For faecal coliforms, the ANZECC (2000) guideline for secondary contact recreation is presented.

The results presented in **Table 2** indicate that the water quality is generally poor. Faecal coliform levels exceeded the guideline for secondary contact recreation at both locations in wet and dry weather, and nutrient and heavy metal concentrations were generally above guideline concentrations for the protection of aquatic ecosystems. However, average pH and turbidity levels were generally within the guideline limits for the protection of aquatic ecosystems.

SINCLAIR KNIGHT MERZ

Figure 2
WATER QUALITY MONITORING SITES
Enfield Intermodal Study



LEGEND

CREEKS

SAMPLING LOCATIONS

CATCHMENT BOUNDARY

PROPOSED INTERMODAL TERMINAL

0 250 500 750 1000 1250 m

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In 1991, Binnie and Partners produced a report: *Upper Cooks River Catchment Management Study*. This addressed water quality conditions in the upper Cooks River catchment, including Coxs Creek. One of the monitoring locations was just downstream of the proposed Enfield ILC site, where Coxs Creek passes under Madeline Street. The location is marked on the map in **Figure 2**. Results for this location are reproduced in **Table 3**.

- **Table 3: Water quality in Coxs Creek, Binnie and Partners 1991**

Parameters	Guideline concentration (ANZECC 2000)*	Dry flow, 18/02/91	Dry flow, 11/03/91	Wet flow, 11/03/91	Wet flow, 26/04/91
Suspended solids (mg/L)	-	8	8	44	10
Turbidity (NTU)	6-50	12	14	70	24
pH	6.5-8.5	NT**	7.8	7.3	7.4
Conductivity (μS/cm)	-	NT	834	565	353
Temperature (°C)	-	NT	30.9	23.4	16.5
Total hardness (mg/L)	-	NT	143	119	80
Oil and grease (mg/L)	-	4	<2	<2	8
BOD_5 (mg/L)	-	6	<5	6	8
Nitrate nitrogen (mg/L)	0.04	0.55	0.25	1.31	0.99
TKN (mg/L)	-	0.71	0.86	1.64	0.66
Total phosphorus (mg/L)	0.025	0.129	0.191	0.323	0.183
Arsenic (mg/L)	0.024	0.01	0.007	0.012	0.004
Cadmium (mg/L)	2×10^{-4}	0.03	<0.02	<0.02	<0.02
Copper (mg/L)	0.0014	<0.03	<0.03	0.04	<0.03
Lead (mg/L)	0.0034	<0.1	0.21	0.12	<0.1
Zinc (mg/L)	0.008	0.05	0.09	0.14	0.14
Cyanide (mg/L)	0.007	<0.005	<0.001	0.001	0.001
Faecal coliforms (cfu/100ml)	1000	190	3100	43000	13000
Faecal streptococci (cfu/100ml)	-	370	3500	23000	19000

*The ANZECC (2000)default trigger values for aquatic ecosystem protection in lowland rivers in south-eastern Australia are presented for most parameters. For faecal coliforms, the ANZECC (2000) guideline for secondary contact recreation is presented.
**NT = Not tested

In general, Binnie and Partners (1991) found that the water quality was good in terms of the pH, conductivity and oil and grease levels. Some of the heavy metals were found at concentrations exceeding the then State Pollution Control Commission (SPCC) guidelines; in particular lead and zinc were found at elevated concentrations. At some locations, suspended solids were elevated during wet weather; however, this was not the case in Coxs Creek. Nutrients and biochemical oxygen demand (BOD_5) were found at elevated concentrations throughout the upper Cooks River catchment; however, levels were still similar to other urban catchments in Sydney. Faecal coliforms and faecal streptococci were more of a concern, with high levels indicating sewage contamination.

Comparing the results to the current ANZECC guidelines, turbidity and pH were generally good; however, nutrient concentrations were high, and some heavy metal concentrations (particularly lead and zinc) were elevated. This indicates that the water quality at the time of sampling was not suitable for the protection of aquatic ecosystems. In terms of recreational water quality, faecal coliforms were reported above the recommended guideline for secondary contact recreation.

3.2.3 Surface Water Quality in the Minor Drainage Lines

The DELEC site is located in the north-eastern section of the proposed ILC site. The DELEC and Central drainage lines (see **Figure 1**) pass through the DELEC site as well as the proposed Enfield ILC site. Pacific National, who currently occupy the DELEC site, monitor the water quality conditions in these two drainage channels, at the locations marked on the map in **Figure 2**. There is also a minor drainage line north of the DELEC drain, which has a small catchment upstream of the new Enfield Marshalling Yard, and joins the DELEC drain just downstream of the proposed development area. It traverses the proposed development area underground. This drain has not been considered further in this report.

At the downstream end of the Central drain, there is a triple interceptor and at the downstream end of the DELEC drain there is an oil separation unit for water quality treatment purposes.

In 2002, FreightCorp (now Pacific National) provided monitoring results for BOD, suspended solids (SS), total grease and pH. Samples were collected and analysed weekly at the same time each week. Their results for three years (1999-2001) are summarised in **Table 4**. Data from which this summary was derived are presented in **Appendix A**.

Table 4: Summary of Freight Corp monitoring results, 1999-2001

Location and dates		Parameters	BOD (mg/L)	SS (mg/L)	Total grease (mg/L)	pH
DELEC drain 1999	Upstream	Average	11	7	3	7.6
		Min	2	1	1	6.8
		Max	65	38	9	8.7
	Downstream*	Average	10	9	3	7.5
		Min	2	1	1	6.9
		Max	90	43	8	8.3
DELEC drain 2000	Upstream	Average	7	5	2	7.9
		Min	0	0	0	6.9
		Max	21	26	14	8.7
	Downstream	Average	8	7	2	7.7
		Min	0	0	0	7.0
		Max	29	32	7	8.6
DELEC drain 2001	Upstream	Average	5	6	1	7.9
		Min	1	1	1	7.3
		Max	31	28	4	8.5
	Downstream	Average	7	9	2	7.7
		Min	2	2	1	7.1
		Max	53	21	5	8.5
Central drain 1999	Upstream	Average	10	12	5	7.4
		Min	2	7	3	7.0
		Max	39	19	10	8.5
	Downstream	Average	10	11	5	7.4
		Min	2	7	1	7.1
		Max	40	16	11	8.4
Central drain 2000	Upstream	Average	11	11	4	7.6
		Min	1	5	1	7.1
		Max	40	24	11	8.6
	Downstream	Average	12	11	5	7.6
		Min	2	2	1	7.1
		Max	31	25	11	8.6
Central drain 2001	Upstream	Average	6	11	2	7.7
		Min	1	2	1	7.0
		Max	31	25	5	8.7
	Downstream	Average	6	12	2	7.6
		Min	1	3	1	7.1
		Max	21	23	6	8.7

*The downstream sampling locations are downstream of all water quality controls

In 2005, Pacific National provided monitoring results for the DELEC drain, upstream and downstream of the DELEC site. Results included total suspended solids and oil and grease. These results, for 1999-2004, are summarised in **Table 5**. These results have been summarised by financial year.

- **Table 5: Summary of Pacific National monitoring results, 1999-2004**

Location and dates		Parameters	Suspended Solids (mg/L)	Total grease (mg/L)
DELEC drain 1999-2000	Upstream	Average	5.7	2.5
		Min	1	1
		Max	26	14
	Downstream*	Average	8.6	3
		Min	1	1
		Max	43	7
DELEC drain 2000-2001	Upstream	Average	5	1.2
		Min	1	1
		Max	26	3
	Downstream	Average	6.9	1.9
		Min	2	1
		Max	17	5
DELEC drain 2001-2002	Upstream	Average	12	3.1
		Min	1	2
		Max	190	66
	Downstream	Average	13	3.5
		Min	1	1
		Max	140	60
DELEC drain 2002-2003	Upstream	Average	8	1
		Min	4	<1
		Max	20	3
	Downstream	Average	7	2
		Min	4	<1
		Max	27	6
DELEC drain 2003-2004	Upstream	Average	0.7	5.5
		Min	<1	1
		Max	3	12
	Downstream	Average	7.2	1.2
		Min	3	<1
		Max	13	5

*The downstream sampling locations are downstream of all water quality controls

The sampled results at the upstream sites represent the total catchment upstream of the DELEC site. The sampled results at the downstream sites represent the total catchment upstream of and including the DELEC site. The downstream results do not directly represent the runoff that concentrates from the DELEC site; however, they provide an indication of any increases in concentrations as a result of the DELEC site activities.

Generally, the results in **Tables 4 and 5** indicate that there is a small increase in concentrations as a result of the DELEC site; however, the small magnitude of the increase may be primarily due to the high dilution that the DELEC runoff receives from the relatively larger upstream catchment. If the water quality controls (the triple interceptor and the oil separation unit) are not maintained, then the DELEC site could be contributing to elevated pollutant concentrations.

Sinclair Knight Merz has also undertaken water quality monitoring at the DELEC site, for a previous study. Samples were taken on 20 May 1996 and results were presented in the 1996 Report: *Enfield Locomotive Maintenance Centre Presentation Report.* The results are reproduced in **Table 6**.

- **Table 6: Monitoring results, 20 May 1996, Sinclair Knight Merz.**

Sampling location	Suspended solids (mg/L)	BOD (mg/L)	Oil and grease (mg/L)
Central drain, upstream of site	120	100	19
Central drain, downstream of triple interceptor	40	2	10
Central drain, downstream of site and triple interceptor	43	2	6
DELEC drain, upstream of site	545	11	10
DELEC drain, entry point to oil separation unit	78	31	7
DELEC drain, outlet of oil separation unit	87	4	17
DELEC drain, downstream of site and oil separation unit	73	3	15

The limited Sinclair Knight Merz monitoring results indicate that the Central Drain oil triple interceptor may be improving the water quality. At the DELEC Drain, the results are mixed, with an improvement in suspended solids between the upstream end and the downstream end (located immediately upstream of the inlet to the oil separation unit), and an increase in BOD and oil and grease. The separation unit does not appear to provide any water quality treatment, except for a reduction in BOD. Suspended solids and oil and grease concentrations increased in the oil separation unit.

3.3 Existing Groundwater Quality

3.3.1 Hydrogeology

The following interpretation of groundwater conditions beneath the Enfield ILC site has been largely based on information in the Douglas Partners (DP) 1993 report and on regional geological studies (Herbert, 1979 and 1983). The DP investigation included the drilling of 16 boreholes, some of which were extended into bedrock by coring. All but one of these boreholes was completed with a standpipe piezometer for groundwater observations. Other contaminant investigations have been essentially confined to the top 1-4 m of the site.

A postulated model for the groundwater system operating in the vicinity of the site includes the following components:

- The unweathered shale bedrock, whose surface rises beneath ridges and falls beneath watercourses. This rock unit is effectively impermeable, the few bores drilled into the unweathered shales in the Sydney area being generally dry or yielding tiny flows of saline groundwater, typically with total dissolved salts (TDS) contents of 10,000-30,000 mg/l (Old, 1942; McNally, 2004);
- The overlying weathered shale and residual soil is slightly more permeable than the fresh bedrock, though its hydraulic conductivity is still too low to qualify as a true aquifer. The weathered shale in railway cuttings at Enfield was dry at the time of our site inspection (January 2002);
- The floodplain alluvium is a potential conduit for contaminated groundwater moving off-site and towards Cooks River, by virtue of its low-lying position rather than its hydraulic conductivity. Because of its clay content, permeability is very low for an alluvial soil, probably less than 10^{-7} m/s. The alluvium is probably saturated up to the culvert outfall level, which is about RL13.4 for Coxs Creek and RL15.0 for the main northern culvert; and
- The railway embankment fill, of maximum thickness perhaps 8-10 m, is the only component within this system with hydraulic properties approximating to those of a true aquifer. No permeability test results were provided in the reports consulted, but soil descriptions suggest that this parameter is extremely variable, possibly in the range 10^{-3} to 10^{-6} m/s. This thousand-fold variation reflects large differences in bulk density, and hence in voids ratio, within the uncompacted embankment material. It is also likely that layering and inhomogeneity within the fill materials has caused vertical permeability to be very much less than horizontal permeability and has created many perched water tables.

3.3.2 Groundwater Movement

The Douglas Partners boreholes indicate that a general water table may be present at RL 12-13 m AHD in the southern portion of the site, and at RL 15-18 m AHD in the northern portion.

The southern water table, around Coxs Creek, is the more distinct. A large spring, covering about 100 square metres of swampy ground on the west side of Cosgrove Road 40 m north of the Coxs Creek culvert, is one surface expression of this water table. In both cases the direction of subsurface flow is towards the base of the culverts (ie, towards the lowest topographic locations above the impermeable shale bedrock) which lie along buried watercourses.

The overall pattern of present-day subsurface water movement appears to be as follows:

- Rain infiltrates through the surface of the railway yards fairly rapidly because of its poor compaction, or leaks subsequently from puddles and ponds. Further water is contributed from temporary groundwater mounds (perched water tables) within the spoil stockpiles;
- In the shallow-fill areas along the former ridgelines the infiltrating water moves downwards until it reaches the upper surface of the unweathered shale bedrock. It then slowly steps sideways and downwards along bedding planes and joints until it feeds into the water table at between RL 12 and RL 15 m AHD. The level of the water table falls gently downstream towards Cooks River at gradients between 1:200 and 1:400, and may fluctuate seasonally by 1-2 m;
- Water infiltrating through the deep fills also follows a step-like path, though in this case the steps represent differences in layering. In both cases these permeability contrasts can give rise to perched water tables, which are reflected by borehole standing water levels between RL 12 and RL 26 m AHD. In general the highest water levels are obtained below former ridges and the lowest along former watercourses; and
- The water table aquifer is probably a composite soil unit, made up of saturated alluvium, fractured and weathered bedrock and the lowest 1-2 m of deep fills. Alluvium makes up most of the volume and downstream from the site the width of the aquifer approximates to that of the floodplain. Once within this aquifer, groundwater migrates slowly down-gradient towards Cooks River, whose bed is at about RL 8 m AHD.

3.3.3 Groundwater Contamination

The CH2M sampling (1999) confirmed the saline nature of the shale groundwater at this site, which has a range of about 4500-15,000 mg/L TDS. This is typical of natural groundwater within the Wianamatta shales, though the lower values may reflect dilution by percolating surface water. Water within the fill embankment itself is relatively fresh, at 400-1000 mg/L, being derived from infiltrating rainwater. Heavy metal concentrations above background levels in the shale groundwater suggest that leaching from the surface soils has had some effect. Low concentrations of TPHs and phenols were also detected in some wells.

The capacity of water-borne contaminants to pollute off-site groundwater down-gradient from the Enfield site is limited by a number of factors:

- The low, virtually non-existent permeability of the Wianamatta shale bedrock, whose pore water is also naturally saline;
- The low permeability of the alluvial deposits along Coxs Creek, which is the main off-site groundwater conduit; and
- The natural attenuation of contaminants by dispersion and biodegradation (aerobic above the water table and anaerobic below this level).

Water within the fill embankment is contaminated to a depth of several metres, with elevated heavy metal contents, especially copper (Cu) and Zinc (Zn), in places. Other heavy metals and petroleum residues are present at concentrations below their respective site criteria. The movement of these contaminants will be reduced by the construction of the proposed impermeable surface capping layer.

4. Potential Water Quality Impacts of Construction and Operation

The proposed Enfield ILC could affect existing local water quality in the following ways:

- Through the erosion and transport of sediment during the construction phase; and
- By the generation of additional pollutants directly attributable to the proposed facilities on site (e.g. heavy metals, oils and greases, petroleum hydrocarbons, etc).

4.1 During Construction

During the construction phase, high sediment loads may be generated due to the exposure of soils to erosion. A series of erosion and water quality control structures and good site practices would be needed to minimise the potential for adverse impacts during construction. The recommended mitigation measures for the control of water quality during construction are outlined in **Section 5** of this report.

4.2 During Operation

Once the Enfield ILC is operational, surface runoff quantities have the potential to increase due to the impervious surfaces and concentration of runoff. The development of the Enfield ILC will involve a substantial increase in the paved area, and increased activity at the site. The main pollutants of concern will be those associated with the operation of railways, trucks, forklifts and other vehicles.

Vehicular and other activities on site will contribute a broad range of pavement surface contaminants including:

- Leakage of fuel, lubricants, hydraulic fluids and coolants;
- Fine particles worn from tyres, clutches and brake linings;
- Particulate exhaust emissions;
- Dirt, rust and decomposing coatings which drop off undercarriages;
- Vehicle components broken by vibration or impact; and
- Possible litter discarded by vehicle occupants.

Vehicle pollutants include hydrocarbons and combustion derivatives, lubricating oil, petroleum spillage, rubber, asbestos, and heavy metals such as lead, zinc, copper, cadmium, chromium, and nickel. These deposits build up on road surfaces in dry weather and usually disperse and are carried downstream during rainfall periods. Atmospheric deposition also contributes towards this build up. Unless such pollutants are retained by pollution control structures they could adversely affect downstream water quality.

During most storm events, the initial runoff dislodges and transports deposited pollutants from impervious surfaces such as road pavements. This is referred to as the first flush, and most of the stormwater pollution is expected to wash of the site in the first flush of runoff events. The first-flush effect is well documented for urban catchments, and treatment of the first flush is generally an effective way of treating urban stormwater pollution. The first flush treatment is recommeded for the operational phase of this project. The proposed mitigation measures for the control of water quality for the operational phase of the project are outlined in **Section 6** of this report.

5. Construction Phase Mitigation Measures and Environmental Safeguards

5.1 Introduction

This section of the report provides options for erosion and sediment control for the construction period only. Soil contamination issues are addressed in Chapter 9 of the EIS, entitled 'Geology, Topography, Soils and Groundwater'.

As with all construction projects, the construction phase of the proposed Enfield ILC presents a potential risk to water quality. Construction activities will include stripping of topsoil and excavation to proposed earthwork levels. The primary risk occurs when soils are exposed during earthworks. During this time, if adequate erosion and sediment control measures are not adopted suspended sediment and associated pollutants can be washed into downstream watercourses. This causes a decline in water quality, potential damage to the ecosystems, and silting up of waterways. To prevent this degradation, construction works are subject to various controls, which would be documented prior to commencement of the works in a Soil and Water Management Plan (SWMP). A SWMP documents the controls that limit movement of sediment (erosion controls), and the controls that remove sediment from runoff prior to discharge to downstream creeks and waterways (sediment controls).

A range of environmental protection measures are presented in the following sections as options for consideration for the protection of water quality values during the construction phase of the project. They represent current thinking and best practice in water quality management; however, the detailed SWMP would need to be prepared during the detailed design stages of the project. The SWMP would need to be prepared in accordance with the principles and practices in *"Soils & Construction"* (2004) by LandCom (known as the Blue Book).

The SWMP would require approval from the relevant authorities prior to the commencement of construction. The detailed SWMP would typically incorporate the erosion and sediment controls described in **Sections 5.2** to **5.3.5**. Appropriate soil erosion and sedimentation controls should be in place during the period of construction until all ground surfaces are stabilised and re-vegetated. This working paper has examined the preferred locations where sedimentation basins are likely to be required during the construction stage to ensure these structures can be accommodated within the available space on site.

5.2 Erosion Control

Sediment would be generated during the construction of the proposed Enfield ILC site, as existing ground surfaces would be disturbed. It is therefore important that sound erosion control measures be implemented to prevent sediments from entering Coxs Creek, the Central Drain and the DELEC Drain, which would result in pollutants being discharged into the Cooks River.

It is environmentally sound, easier, and more cost-effective to prevent erosion, rather than concentrating on trapping sediment transported from eroding areas. This applies particularly to areas where the soils have a high proportion of fine silts and clays, or are dispersible. Erosion control measures are therefore an effective means of sediment control.

Erosion control measures generally function by reducing the duration of soil exposure to erosive forces, either by holding the soil in place, or by shielding it. Carrying out earthworks in stages, and progressively revegetating each stage when complete, would minimise the extent of land exposed to erosive forces. Proper management of surface runoff may be accomplished by interception, diversion and safe disposal of runoff in conjunction with staged construction activities.

Erosion control techniques are based upon effective use of construction practices, structural controls and vegetative measures. Erosion control measures would be temporary for the construction phase of the project.

The following preventative measures and practices, that are integral components of effective erosion control, are suggested:

- Site management;
- Land shaping;
- Batter stabilisation;
- Revegetation;
- Temporary seeding; and
- Permanent revegetation.

In addition, erosion management measures may be required, as described in the following sections (**Sections 5.2.1 to 5.2.7**).

5.2.1 Banks and Channels

Either individually or in combination, these structures are used to intercept and direct runoff water to a desired location. By doing so, they convert sheet flow to concentrated flow, and decrease the time of concentration of runoff.

There are two major types of banks and/or channels:

- **Perimeter Bank:** This is a temporary earth bank located around the perimeter of construction sites or around disturbed areas within the site. It prevents sediment-laden runoff from leaving a construction site or disturbed area, and prevents off-site runoff from entering. Stormwater runoff prevented from entering a disturbed site by a perimeter bank should be directed to a stable disposal area. Refer to standard Figure SD5-5 in LandCom's *Soils and Construction* (2004) manual, which is included in Appendix B (hereafter these standard Figures are referred to as Figure SD#-# and all of the standard figures referred to are included in Appendix B);

- **Diversion Bank/Channel**: A diversion channel is an earth channel with a minor ridge on its lower side constructed across the slope. It is designed to protect slopes or development works below it by intercepting surface runoff and diverting it to a stable outlet at a non-erosive velocity (refer to Figure SD5-6).

5.2.2 Level Spreader

A level spreader (also called a level sill) is an excavated outlet constructed at zero grade. It converts an erosive, concentrated flow of runoff into sheet flow, and discharges it at a non-erosive velocity onto an undisturbed area stabilised by vegetation (refer to Figure SD5-6).

Level spreaders may be used as outlets for diversion or perimeter banks or channels, where storm runoff has been intercepted and diverted to stable areas. They should be used only where the spreader can be constructed on undisturbed soil. The area directly below the spreader sill should be uniform in slope and well vegetated, allowing water to spread out as sheet flow.

The cross-sectional area and length of the level spreader shall be at least sufficient to discharge the design flow from the selected frequency rainfall event.

5.2.3 Check Dams

A check dam is a small, temporary dam built across a swale, diversion channel or waterway. Its primary function is to reduce the velocity of flow in the channel and thus reduce erosion of the channel bed (refer to Figure SD5-4). The entrapment of sediment behind these structures is a secondary function.

Check dams can be used:

- To protect a grass lined channel during initial establishment of vegetation; and
- As a substitute for channel lining in a temporary channel.

Check dams can be constructed by using any materials on the site that can withstand the flow of water. Rock, log and sandbag check dams can be the sturdiest, if these materials are correctly placed in position. Wire netting, woven brush and straw bales can also be used, but the random placement of trees and logs across a channel does not necessarily constitute an effective check dam.

Although check dams are not intended as sediment trapping devices, larger-sized particles will inevitably accumulate behind them. This sediment should be removed before it accumulates to one-half of the original height of the dam, and placed where it will not be washed back into the drainage system.

5.2.4 Bank and Channel Linings

Bank and channel linings are materials used to stabilise the channel bed and banks against excessive velocities. They are used where the capacity of a channel is exceeded as a result of changes in flow regime, where steep grades occur in a channel, or where runoff must be lowered directly from one elevation to another. They are used instead of or in addition to, vegetative cover where such cover is subject to scour by erosive velocities, or where vegetation cannot be maintained because of pollutants in the streamflow.

The choice of specific lining material will be based on consideration of the velocity of flow, economics, permanence, aesthetics, maintenance and other factors. Examples of the various lining materials commonly available include:

- **Permeable:** grass, gravel and rock (including mattresses), geotextiles (usually combined with rock), jute mesh, natural/synthetic erosion matting, sandbags (refer to Figure SD5-7); and
- **Impermeable:** concrete, pressure-grouted mattress, asphalt/bitumen, grouted rip-rap, plastic sheeting, half pipes, concrete filled bags.

5.2.5 Grade Stabilising Structures

Grade stabilising structures are employed to provide erosion resistant controls in the bed of bare or vegetated earth channels. Their principal function is to pass the design flow from a higher to a lower elevation and to dissipate the excess energy in a controlled manner. A lower grade and a non-erosive velocity can then be adopted for the channel section below the structure.

These structures have special application on construction sites and urban developments, especially where increases in flow rate would produce active erosion in the bed of a previously stable channel or stream. They are also used to stabilise the bed of actively eroding gullies (usually in conjunction with a flume or gully control structure) to halt the headward erosion of the gully.

Grade stabilising structures usually take either of two forms:

- **Flumes:** These structures convey flows down an even gradient (usually between 1:20 and 1:5 slope). Flumes can have the same range of surface treatments or lining as waterways. However, special provisions may be necessary in the vicinity of the crest and the stilling basin, particularly in the case of grassed flumes; and

- **Drop Structures:** These comprise a vertical drop constructed of suitable material and a stilling basin for energy dissipation.

In addition to the materials used to line waterways or banks and channels, the following materials may also be used successfully in the construction of flumes and drop structures:

- Timber (e.g. form ply and railway sleepers);
- Galvanised roofing iron or sheet;
- Gabions;
- Conveyor belting;
- Sandbags (sand/cement mix);
- Half pipes (batterdrain) or full pipes (pipe drop); and
- Sheet piling.

5.2.6 Energy Dissipaters

Energy dissipaters function largely by impact and/or turbulence. Impact blocks, T junctions and vertical discharge sumps are examples of this type of structure. When these controls are used care should be taken with the downstream disposal of water. They should not discharge onto a steep or erodible slope, as further gullying and headward erosion will result (refer to Figure SD5-8).

5.2.7 Outfall Aprons

Stabilised channel sections for energy dissipation should generally be designed and installed with the same care as channel linings. The channel section can take the form of rip-rap or Reno mattress protection downstream of a culvert or concrete lined channel.

5.3 Sediment Control

The installation of appropriate erosion control measures will greatly reduce the quantity of soil eroded from a construction site. However, some erosion will inevitably occur, and measures are therefore required to ensure that eroded material is trapped and retained.

Sediment control measures are designed to:

- Trap eroded sediment before it leaves the site and pollutes adjacent properties or water bodies;
- Function as temporary solutions until permanent measures, such as revegetation and paving, are in place or until the catchment is otherwise permanently stabilised. Ideally, they should be used as techniques to support or back-up a range of erosion control structures, not as the sole strategy to control sedimentation;

- Reduce the velocity of runoff and allow suspended soil particles to settle by gravity or filtration. They include such structures as sedimentation basins, sedimentation traps and sediment filters; and
- Require regular maintenance and cleaning. If too much sediment is allowed to accumulate in them, they will cease to function. In this circumstance, little or no settling will occur, and trapped sediment may be re-suspended and washed away.

The sediment control structures described in this section are intended as options for temporary measures for use during the construction stage of the project.

5.3.1 Sedimentation Basins

A key component of the SWMP should be the collection of runoff from disturbed areas and filled ground into suitably sized sedimentation basins.

A sedimentation basin is a barrier or dam designed to intercept sediment-laden runoff and retain the sediment (refer to Figures SD6-1 to SD6-4). It is usually located on a drainage line below a construction site, or at some other stormwater collection point. It may be fitted with a dewatering system, which allows the basin to remain empty between rainfall events.

These basins have the function of trapping sediments from disturbed areas where the drainage area is usually larger than 0.5 ha and runoff is heavily sediment-laden. In doing so, they prevent sediment from clogging stormwater pipes and floodways, and reduce the environmental damage to vegetation and wildlife caused by sediment. They can also lessen the flooding which is associated with a reduction in a stream's capacity caused by deposited sediment.

Sedimentation basins must be installed prior to development or construction activity on a site, and should remain in place until such activity has been completed and the land stabilised. They should be located away from busy construction areas at a point where they can trap a high proportion of polluted runoff which is not diluted by clean runoff from undisturbed watersheds. They should be sited where the terrain provides maximum storage capacity and where desilting is feasible.

A sedimentation basin does not replace on-site control measures such as perimeter banks, temporary revegetation or sedimentation traps at stormwater inlets. These measures retain a portion of the sediment carried in runoff, and the sedimentation basin is a final check to trap a significant part of the remaining sediment, before runoff discharges into stormwater mains or enters streams. In accordance with the POEO Act 1997, the contractor is responsible for obtaining the necessary temporary discharge licenses.

A typical sedimentation basin should have:

- Compacted earth, rock, or gabion embankments;
- Upstream storage provided by excavation;
- One or more inflow points carrying sediment laden runoff;
- A primary outlet;
- An emergency outlet or spillway;
- A basin dewatering device;
- Outlet protection to reduce erosion downstream; and
- All-weather access for sediment removal.

Unlike the sedimentation trap, which is generally a minor facility achieved by modifying road works or drainage facilities during the construction phase, the sedimentation basin is a specifically sited and purpose designed structure. Formal hydrologic and hydraulic design procedures must be applied.

A sedimentation basin may be either temporary or permanent in terms of design life. However, there is an over-riding need in both cases for adequate design procedures which should take account of peak flows (rates and volumes) and a reasonable estimate of sediment yield from the contributing catchment.

Storage surface area is a critical design feature, and should be maximised within the site constraints. The distance between the basin inlet and outlet should also be the maximum practical, to ensure optimum retention time and hence optimum sediment trapping efficiency.

5.3.2 Soil Landscape Characteristics

A preliminary design of sedimentation basins has been undertaken, for the purpose of this working paper, to identify preferred locations for sedimentation basins (refer to **Section 5.3.3**). The exact sizes of the sedimentation basins will be determined during the detailed design phase of the development of the proposed Enfield ILC site. Selected locations have been based on topographical features, downstream location, approximated drainage areas and current land uses. In construction projects in general, disturbed areas larger than 0.5 ha would require a sedimentation basin, and disturbed areas of less than 0.5 ha would need to employ a combination of various measures to be described in a SWMP.

The majority of the site consists of imported fill material. However, for the sections of the site where the fill is not deep or where no previous fill has been placed, the (former) Soil Conservation Service 1:100,000 sheet soil landscape maps indicate that the main original soil profile is Blacktown soil (bt). Blacktown soils are characterised by moderate erodibility, poor drainage and expansive subsoils. These soils are finely grained and are defined by LandCom's *Soils and*

Construction (2004) manual as dispersible type D. This means that on average more than 33% of the soils have relatively small particle sizes finer than 20 µm.

The type D soils present on the site mean that sedimentation basins required during the construction phase of the Enfield ILC would need to be relatively large. This is primarily due to the finely grained soils that take longer to settle and require lower settling velocities. Type D soils will also require flocculation due to their dispersive nature.

Additional information on the soil constraints and other parameters relating to the relative size of sedimentation basins is given in **Table 7.**

- **Table 7: Constraints and Characteristics of Parameters Used in Determining the Relative Sizes of Sedimentation Basins**

Site Constraints/Characteristics	Value/Rating
Rainfall Erosivity (R)* Rainfall Zone *	Moderate (R = 3250, for Enfield) Zone 10
Soil Erodibility (K) (Subsoil) *	High** (K=0.038 for Bt and, and K=0.050 assumed for any imported Soils).
Typical slope gradient	Low to steep (1% for the majority of the site, with local 25% slope areas)
Original Soil Landscape types	Blacktown (Bt)
Estimated Soil Loss	Up to 680 tonnes/ha per year
Soil Loss class*	Class 1 to 5***
Soil Texture Group	Type D (Fine grained and dispersible soils) for Bt soils based on the Blue Book. In addition (>30% finer than 0.02mm) for Bt based on the Soil Conservation Service data (DLWC) for the Sydney Area 1:100,000 sheet.
Dispersion percentage	Percent dispersion for Bt soil type = 2.4% to 10.3% (both based on the Soil Conservation Service data (DLWC) for the Sydney Area 1:100,000 sheet). Note: *The DOH "Blue Book" specifies that Bt is Type D presumably because the upper limit of Bt4 it is just above 10%, as a precautionary and conservative measure, it will be assumed (in this report) that Bt soils are type D soils and therefore any proposed sedimentation basins located downstream of disturbed Bt soils may require flocculation.*
Volumetric Runoff Coefficient	0.39 as derived from the Blue Book (based on soil hydrologic type D)
75th percentile 5 day rainfall event	Bankstown = 19.5 mm

*Based on LandCom Soils and Construction, 2004.
**Soil Conditions Report, Egis January 2002
***Soil Loss Class 1 represents very low erosion hazard (up to 250 t/ha per year) and Soil Loss Class 5 represents high erosion hazard (500 to 750 t/ha per year), Ref: LandCom (2004) *Managing Urban Stormwater: Soils and Construction*

5.3.3 Sedimentation Basin

The development area has been divided into construction phase subcatchments as shown in **Figure 3.** The largest subcatchment during the construction phase will be Dc (the subscript ‘c’ refers to construction phase), which would discharge to sedimentation basin D. Catchments Ac, Bc and C2c would not require a sedimentation basin due to their relatively small size. Instead appropriate local erosion and sediment controls should be used to provide the required water quality controls.

The sedimentation basin for catchment Dc is likely to be relatively large. It is therefore important to provide estimates of the required land take for this sedimentation basin, and ensure that the appropriate area is allocated for this structure during the construction stages. The required size of sedimentation basin D is 6.3 ML, and it would require a minimum surface area of 3600 m^2 (eg: 90m x 40m). This is based on a maximum water depth of 2.1 m with side slopes of V:H = 1:2.

The preferred location of sedimentation basin D is shown in **Figure 3**. This sedimentation basin should be enlarged and converted to a detention basin at the end of the construction phase.

5.3.4 Sedimentation Traps

Sedimentation traps are temporary sediment control structures formed by excavation and/or an embankment to intercept sediment-laden runoff and retain the sediment. They function by trapping sediment in runoff before it enters stormwater pipes or channels, and are usually located at inlets that receive runoff from only a small catchment.

Sedimentation traps have similar functions to sedimentation basins, but differ in that, generally, they are smaller, simpler to construct, relatively inexpensive, and more easily moved as the development proceeds. However, sedimentation traps might be less effective at retaining pollutants where significant quantities are finer than 0.02 mm, especially if soils are dispersible, where flocculation may be required.

Sedimentation traps are recommended for use during the construction phase on this site. The traps should be located outside the area being graded and installed prior to the start of grading activities or the removal of existing vegetation. Traps should be located to obtain maximum storage benefit from the terrain, for ease of periodic clean out and disposal of the trapped sediment, and in a manner that will not divert flows should they fail, or interfere with construction activities.

Figures SD6-11 and SD6-12 show two examples of such sedimentation traps.

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Legend

River
Stormwater infrastructure
Sedimentation Basin (Not to Scale)
Construction Subcatchments

Enfield
Figure 3
Construction Phase Subcatchments

SKM

5.3.5 Sediment Filters

Sedimentation basins and traps function by impounding relatively large volumes of runoff from disturbed areas, particularly where the runoff is concentrated or channelled, and allowing sediment to settle out. Sediment filters, on the other hand, function by intercepting and filtering small volumes of runoff, which mainly occur as sheet flow.

These structures may be required:

- Below small areas of disturbance;
- Along the boundaries of a development; or
- At the beginning of vegetative filter or buffer strips.

Sediment filters have a useful life of only 3 to 12 months depending on the materials used. Straw bales last up to 3 months; sediment fences can function for 6 months or longer if sediment accumulations are removed. Sediment fences also trap a higher percentage of sediment than straw bale banks.

Sediment filters are relatively inexpensive and easy to install. However, they can only function to their design limits if particular care is taken with their location, installation and maintenance. Should a sediment filter fail, sheet flow is changed into concentrated flow and serious damage can result; damage which may exceed that if no sediment filter had been installed.

There are four major types of sediment filters (refer to Figures SD6-7, SD6-8 and SD6-13):

- Straw bale sediment filters;
- Sediment fences;
- Straw bale-geotextile fabric sediment filters; and
- Vegetative filter strips.

5.4 Temporary Construction Exit

A temporary construction exit is recommended. It should be comprised of a pad of coarse gravel, occasionally with a concrete, steel or timber shaker ramp, located at exits from construction sites. It is designed to minimise the transport of sediment from construction sites onto public roads via the wheels and sides of vehicles (refer to Figure SD6-14).

When a site is dry, much of the soil is shaken from vehicles as they traverse this ramp. In wet weather, mud is to be hosed off on the ramp as vehicles leave the site.

The exit pad should be constructed by placing a layer of geotextile filter fabric over the pad site and covering it with a layer of 50 to 75 mm sized gravel to a minimum depth of 0.2m. Its width should be no less than the full width of the exit point, and its length a minimum of 15m.

All drainage from the exit pad should be directed into a sediment trap. A mountable berm (1:5 batters) may be required adjacent to the road footpath area, to prevent drainage directly onto the road.

Additional gravel may have to be added periodically, to maintain the correct functioning of the pad.

6. Operational Mitigation Measures and Environmental Safeguards

6.1 Potential Water Quality Impacts

During the operational phase, the proposed Enfield ILC has the potential to impact on the water quality of Coxs Creek, the Central and DELEC drains, and Cooks River by the introduction of contaminants including:

- Stormwater related contaminants:
  - Suspended sediment from the paved surface;
  - Heavy metals attached to particles washed off the paved surface;
  - Oil and grease and other hydrocarbon products; and
  - Anthropogenic Litter; and
- Accidental spillages:
  - Pollutants released into the drainage system as a result of an accidental spillage, although low probability events for the new Enfield ILC site.

These pollutants potentially impact on the environment in the following ways:

- Suspended sediments reduce clarity of water and silt up downstream waterways;
- Heavy metals are toxic to aquatic biota;
- Oils and grease are unsightly and cause water quality problems in streams;
- Litter is unsightly and pollutes streams; and
- Accidental spills of chemicals can cause severe damage to the ecology of waterways.

6.2 Water Quality Management Devices

The following post-construction water quality management methods may be required:

- Stormwater treatment by medium filtration;
- Accidental spill interception and containment structures; and
- Stormwater treatment by separation of sediments and oil and grease.

The key operational water quality measure and environmental safeguard should be the capture and treatment of the first flush represented by the first 10 mm of rainfall runoff. Treatment should target the expected pollutants that have been outlined in **Section 4**:

- Petroleum hydrocarbons;
- Oil and grease;
- Heavy metals and other toxicants; and
- Suspended solids.

The ideal pollution control device for the site is one that can treat all of the pollutants identified above, and that can store the captured material in a relatively dry or moist environment. This prevents the environment within the treatment device from becoming anaerobic, which could have negative effect on water quality.

6.3 Stormwater Treatment

6.3.1 Pollution Control and First Flush

Pollutants deposited on to exposed areas can be dislodged and entrained by the rainfall-runoff process. Usually the stormwater that initially runs off an area will be more polluted than the stormwater that runs off later, after the rainfall has 'cleansed' the catchment. The stormwater containing this high initial pollutant load is called the 'first flush'. The existence of this first flush of pollutants provides an opportunity for controlling stormwater pollution from a broad range of land uses. First flush collection systems are employed to capture and isolate this most polluted runoff, with subsequent runoff being diverted directly to the stormwater system (refer to *www.environment.nsw.gov.au).*

The water quality treatment controls to mitigate against a likely increase in stormwater pollutant loads from the redeveloped site should aim to treat the pollutants identified above. The treatment should also target the containment and treatment of the first flush, typically the first 10mm of rainfall runoff (refer to Stormwater First Flush Pollution, NSW EPA Environment Protection Manual).

Whilst it will not be possible to contain larger storm events, it is important to aim to capture and treat a relatively high percentage of the average annual runoff volume generated from the site. Generally, capturing and treating up to 10mm of rainfall from all storm events would result in the treatment of more than 90% of the average annual runoff volume from the site.

6.3.2 Selection of Water Quality Treatment Device

6.3.2.1 Enfield ILC Site

Runoff from an industrial site such as the proposed Enfield ILC site, with the potential to contain harmful pollutants, requires a high level of treatment. Many proprietary treatment devices can provide a good level of treatment for sediments, oil and grease. However, the device that best fits the needs of this site should be capable of providing a high level of treatment for all the pollutants that have been identified. This should be a device that is filled with an appropriately selected medium to suit the site-specific needs and the anticipated types of pollutants. An example of a system which would be acceptable to this site is one which would pass stormwater through filtration cartridges, which trap particulates and absorb pollutants such as heavy metals (including solubles), oil and grease and hydrocarbons.

The reduction in pollutant loads required for the subcatchments is discussed in **Section 6.3.4.**

6.3.3 Sizing of Water Quality Devices

The selected water quality treatment will be sized to treat the first flush stormwater from the upstream catchment for at least the first 10 mm of runoff.

The storage volume and the outflow discharge rate from the treatment devices will be designed to ensure that the captured runoff receives treatment in less than 24 hours thereby allowing the storage capacity to be available within that period. For storm events with less than 10 mm of rainfall, the storage capacity would be fully available again after few hours, for instance a 4 mm rainfall runoff volume would be fully treated within approximately 6 to 9 hours.

The storage component for the first flush would serve a dual purpose of storage (for later treatment) and also to a limited extent as part of the detention system for mitigation purposes of the peak flows from the redeveloped site. It is proposed to provide a bypass system that would divert runoff into a second and separate compartment once the capacity of the storage (for treatment) is reached.

There are four separate sub-catchments within the Enfield ILC site that would require separate treatment devices: catchments A, B C2 and D (refer to **Figure 4.** The subscript ‘p’ refers to the proposed development subcatchments).

6.3.3.1 Catchment D

The area for Catchment D representing the main terminal area is approximately 42.5 hectares. To satisfy the water quality treatment criteria identified above, three water quality treatment devices are recommended with a first flush containment (storage) basin of 4,250 m^3. The suggested location of these treatment facilities is shown in **Figure 4**. The combined maximum treatment rate from the three units should be 48 L/s. The selected units should be able to treat up to 4,150 m^3/day of runoff from this catchment. The storage basin with the units that have some spare capacity should treat more than 10 mm of rainfall runoff, which would be in accordance with the criteria.

The outlet discharge pipe should be a minimum 375 mm diameter concrete pipe that should convey approximately 48 L/s. This pipe should discharge into a downstream trunk drain and should not be allowed to mix with untreated runoff from other areas of the site.

6.3.3.2 Catchments A, B and C2

In catchment C2 (see **Figure 4**), the runoff from the site should be captured and conveyed to a stormwater treatment device. The recommended water quality treatment device should be capable of providing treatment for pollutants generated from road runoff. The device should discharge treated runoff into the DELEC Drain. The device should been sized to provide treatment for all storm events smaller than and equal to the 1 in 3 month event, which would satisfy the first flush requirements of 10 mm of rainfall.

The future light commercial and industrial represented by catchments A and B in **Figure 4** would need to provide individual water quality controls on site prior to discharging into Council's drainage system on Cosgrove Road.

The remaining areas C1 and C3 remain unchanged and would not require any water quality controls.

6.3.4 Estimation of Pollutant Loads on Site for Existing and Proposed Conditions

The primary pollutants of concern (see **Section 6.1**) are heavy metals, oil and grease and hydrocarbons. The majority of the pollutants are likely to be sediment-bound; therefore suspended solids are also considered to be a pollutant of concern for the operational stages of the development.

To estimate the potential net pollutant load impact on existing creeks and waterways as a result of the proposed Enfield ILC site, it is important to firstly assess the pollutant load export rates for existing conditions over the entire proposed development area, and then compare it with the expected pollutant load export rates for the developed site. There are two scenarios that need to be assessed for the developed site: firstly any increase in pollutant loads for an uncontrolled situation (ie. no water quality controls); and secondly the net increase or decrease in pollutant loads for a controlled site (ie. with proposed water quality treatment devices). The assessment of pollutant loads will be based on predictions of annual average loads based on typical Event Mean Concentrations, average annual rainfall, and estimated runoff yields.

The annual average rainfall for the Enfield site is 1050 mm. The volumetric runoff coefficient for the undeveloped and developed sections of the site are 0.15 and 0.35 respectively. A search was undertaken to gather relevant information on typical runoff concentrations of heavy metals, suspended solids, hydrocarbons and oil and grease for the existing and proposed land uses on site. None of the existing water quality data (in section 3.2) was directly relevant to the search. Typical concentrations for each of the pollutant parameters are presented in **Table 8**. Zinc, Copper and Lead were selected as the most relevant parameters to represent heavy metals.

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- Stormwater infrastructure
- Proposed Subcatchment
- Proposed First Flush Basin with water quality devices (not to scale)
- River

Enfield
Figure 4
Proposed Case Subcatchments

SKM

- **Table 8: Derived typical stormwater runoff concentrations for existing and proposed conditions in mg/L**

	SS	Zn	Cu	Pb	PAHs	Oil and grease
Undeveloped site	95	0.20	0.040	0.05	0.0025	5.5
Developed site (Enfield ILC)	150	0.45	0.090	0.10	0.0075	8.5

SS = suspended solids; Zn = Zinc; Cu = Copper; Pb = Lead; PAHs = Polycyclic Aromatic Hydrocarbons.

The following references have been used to derive the above typical concentrations:

- Best Practice Environmental Management Guidelines for Urban Stormwater CRC for Catchment Hydrology, 1997;
- Metals and Hydrocarbons in Stormwater Runoff from Urban Roads CSIRO, 1997;
- Water Sensitive Road Design. Design Options for Improving Stormwater Quality of Road Runoff CRC for Catchment Hydrology, 2000;
- Urban Stormwater Quality. A Statistical Overview CRC for Catchment Hydrology 1999; and
- Road Runoff and Drainage: Environmental Impacts and Management Options Austroads 2001.

6.3.4.1 Existing conditions

Figure 5 shows the subcatchments used in the estimation of the pollutant loads for existing conditions (the subscript 'e' refers to the existing conditions subcatchments). The pollutant load estimates for existing conditions have been summarised in **Table 9**. The developed parts of subcatchments such as for C and B have been separated in the assessment as shown in **Table 9**.

- **Table 9: Estimated annual average pollutant loads for existing conditions (in kg per year)**

Catchment ID and area (ha)	Pollutant parameters					
Undeveloped unless indicated otherwise	SS	Zn	Cu	Pb	PAHs	Oil and grease
D_e – 23.83 ha	3566	8	1.5	1.9	0.09	206
B_e – 10.39 ha - developed	5727	17	3.4	3.8	0.29	325
C_e – 14.24 ha	7850	24	4.7	5.2	0.39	445
C_e – 2.93 ha - developed	1023	2	0.4	0.5	0.03	59
A_e – 4.16 ha	1452	3	0.6	0.8	0.04	84
Totals – 55.55 ha	**19618**	**53**	**10.7**	**12.2**	**0.84**	**1119**

* The subscript 'e' refers to the existing conditions subcatchments.

6.3.4.2 Proposed conditions

The pollutant load estimates for the developed conditions if no controls were to be provided have been summarised in **Table 10**, and the pollutant load estimates for the developed conditions with the proposed controls have been summarised in **Table 11**.

- **Table 10: Estimated annual average pollutant loads for developed conditions with no water quality controls (in kg per year)**

Catchment ID and area (ha)	Pollutant parameters					
Developed unless indicated otherwise	SS	Zn	Cu	Pb	PAHs	Oil and grease
Dp – 42.43 ha	23390	70	14.0	15.6	1.17	1325
Ap and Bp – 4.95 ha	2729	8	1.6	1.8	0.14	155
C2p – 5.24 ha	2889	9	1.7	1.9	0.14	164
C1p and C3p – 2.93 ha undeveloped	1023	2	0.4	0.5	0.03	59
Totals – 55.55 ha	**30030**	**89**	**18**	**20**	**1.5**	**1703**

* The subscript 'p' refers to the developed conditions subcatchments

- **Table 11: Estimated reduced annual average pollutant loads for developed conditions with proposed water quality controls (in kg per year), and percentage improvements**

Catchment ID and area (ha)	Pollutant parameters					
	SS	Zn	Cu	Pb	PAHs	Oil and grease
Dp – 42.43 ha	6081	36	5.8	8.57	0.57	451
Required average removal by water quality device	*75%*	*50%*	*60%*	*45%*	*50%*	*65%*
Ap and Bp – 4.95 ha	1,364	6	1.23	1.36	0.10	116
Required average removal by water quality device	*75%*	*25%*	*25%*	*25%*	*25%*	*50%*
C2p – 5.24 ha	722	6	1.30	1.44	0.11	82
Required average removal by water quality device	*75%*	*25%*	*25%*	*25%*	*25%*	*50%*
C1p and C3p – 2.93 ha (remains undeveloped)	1023	2	0.4	0.5	0.03	59
Totals – 55.55 ha	**9191**	**51**	**8.7**	**11.9**	**0.81**	**708**
Estimated increase (+), or decrease (-), in annual pollutant loads	***-58%***	***-7%***	***-20%***	***-2.5%***	***-2%***	***-39%***

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0 100 200
Metres

Legend

River

Stormwater infrastructure

Existing Subcatchments

Enfield

Figure 5

Existing Case Subcatchments

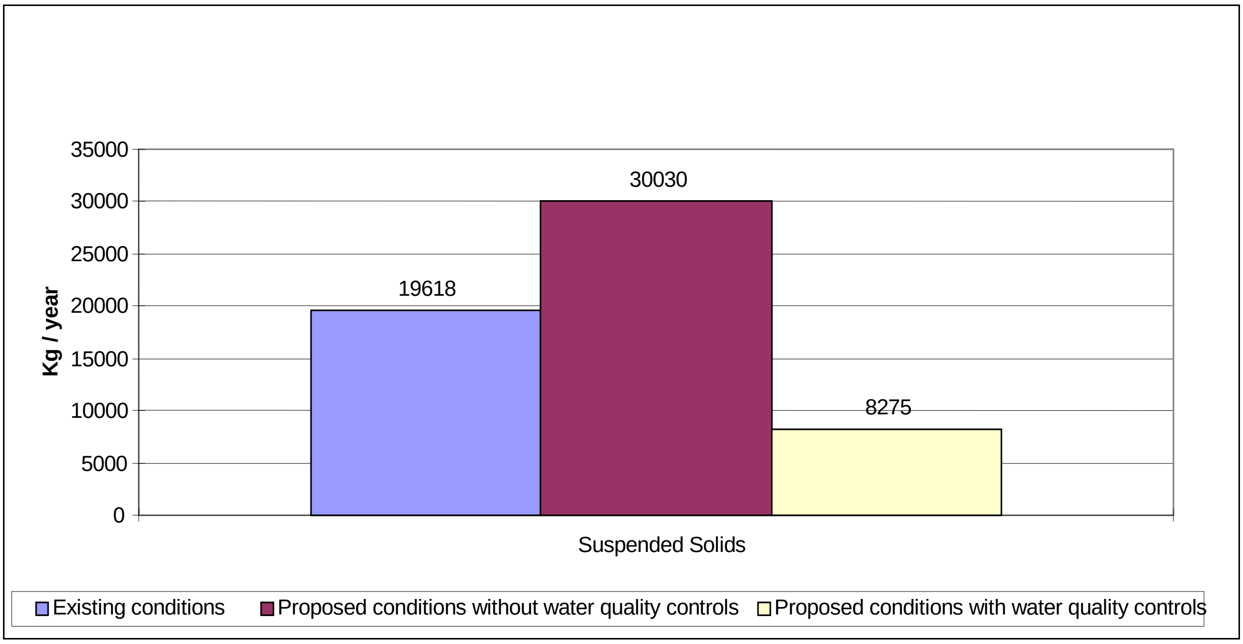
SKM

Figure 6 to **Figure 9** summarise the estimated annual average pollutant loads for the site for:

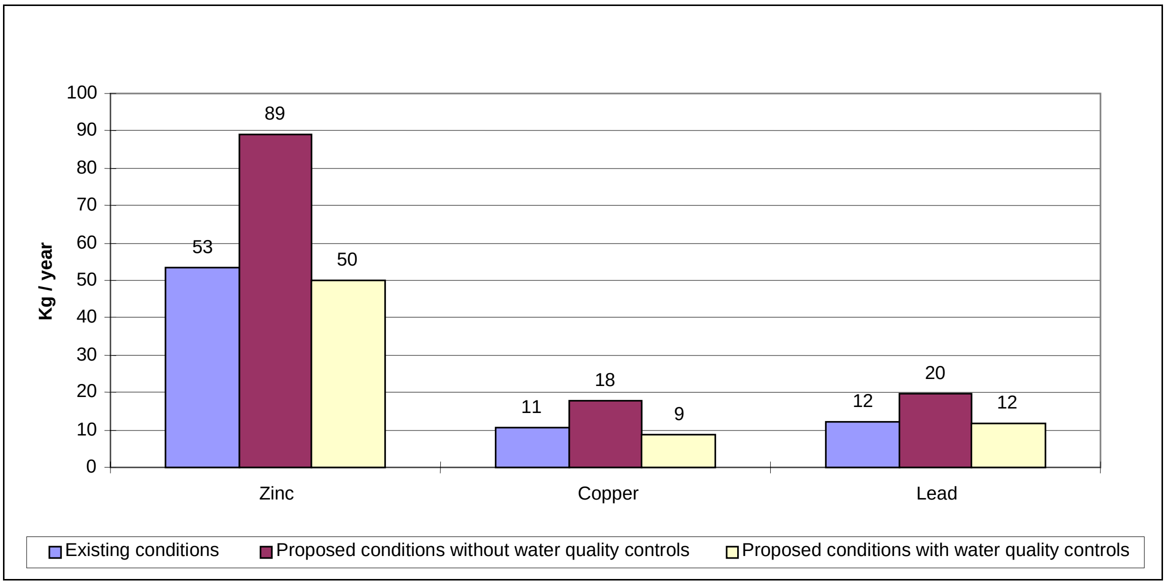
- Existing conditions;
- Proposed conditions for the Enfield ILC site , without any water quality controls; and
- Proposed conditions for the Enfield ILC site, with water quality controls.

For each of the pollutants suspended solids, heavy metals, PAHs and oil and grease, the estimated net change between existing conditions and proposed development (with water quality controls) is a decrease ranging from 2 % for lead and PAH to 58 % for suspended solids, as shown in **Table 11**. Therefore there would be a significant improvement in suspended solids loads, a marginal improvement in heavy metal and PAH loads, and average pollutant loads in stormwater runoff from the site are not expected to increase as a result of this project.

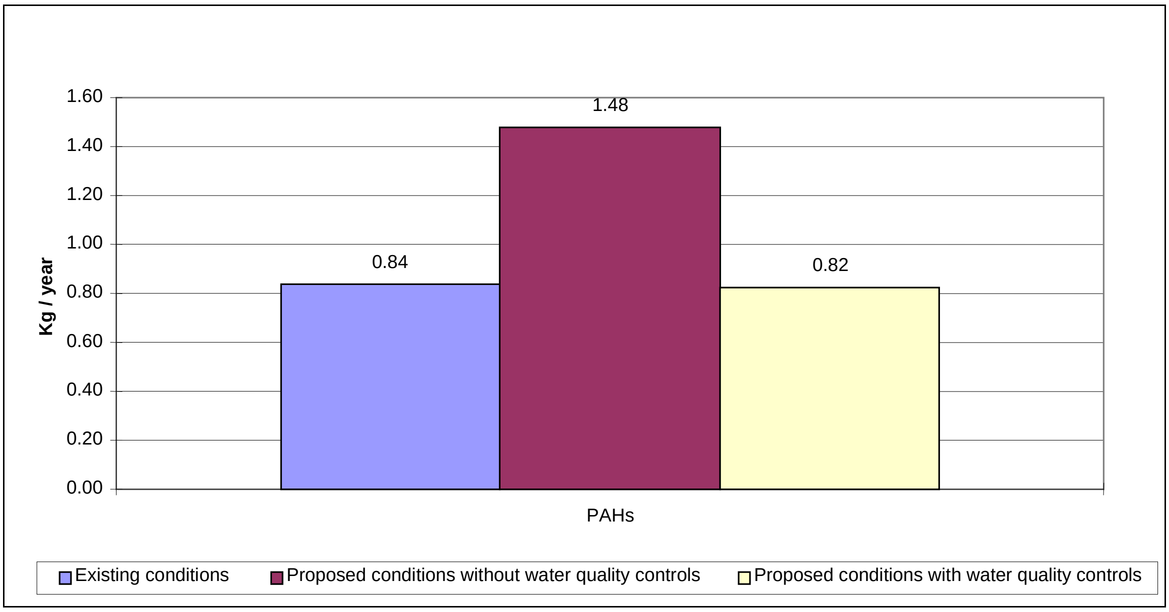
- **Figure 6: Annual pollutant loads for existing and proposed conditions for suspended solids – catchment D**



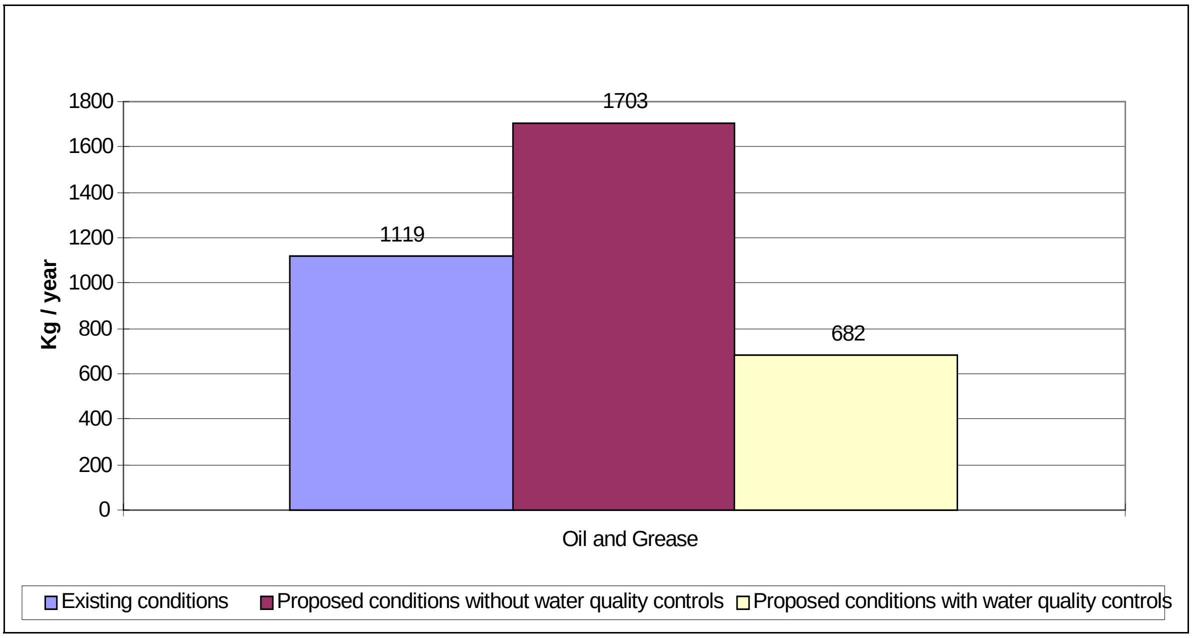
- **Figure 7: Annual pollutant loads for existing and proposed conditions for zinc, copper and lead – catchment D**



- **Figure 8: Annual pollutant loads for existing and proposed conditions for hydrocarbons – catchment D**



- **Figure 9: Annual pollutant loads for existing and proposed conditions for oil and grease – catchment D**



6.4 Accidental Spill Management

Although the Enfield ILC site is very unlikely to contribute to chemical spills, some risk of accidental spillage of hazardous materials would always be present. In the absence of satisfactory means of containment and treatment, the spillage of contaminants could pass rapidly into the drainage system and into downstream ecosystems. Measures must be incorporated into the drainage system to prevent the spillage from reaching the downstream ecosystems and waterways if space is available to incorporate protective opportunities. These pollutants can potentially impact on the environment in the following ways:

- Heavy metals are toxic to aquatic biota; and
- Accidental spills of chemicals or petrol in accidents can cause severe damage to the ecology of waterways.

It is recommended to contain any potential accidental spill within the first flush containment basin by providing remote and manually operated isolation valves that ensure that the spill is totally contained. A major accidental spill could be in the order of 20,000 L, which is the estimated volume of a diesel tanker. The 20,000L spill should be contained in the first flush containment system or the proposed water quality control device. Following containment, the first flush system should be cleaned and maintained, and the spill should be disposed of in an appropriate manner.

6.5 Monitoring

While the expectation is that the recommended stormwater treatment methods would be effective in achieving the desired outcome of water quality improvement of the site runoff, water quality monitoring is recommended to ensure that the water quality management devices on site are functioning as expected. Water flowing into and out of the water quality devices should be monitored for key pollutants including suspended solids, heavy metals, hydrocarbons and oil and grease. Maintenance of the water quality control devices should be undertaken at regular intervals. The frequency of maintenance will greatly depend on the continuous performance of the device, and should be determined from the water quality monitoring. Water quality monitoring should be for a period of 12 months from the full development of the Enfield ILC site. If during this time the pollutant levels are higher than expected, the frequency of maintenance should be increased and appropriate works should be undertaken to ensure adequate treatment is achieved. Monitoring could be discontinued after the 12-month period if the water quality devices are functioning as expected.

7. Watercycle Management

Appropriate water cycle management at the Enfield ILC site will assist to meet water sensitive urban design and ecologically sustainable development requirements. The available options of implementing water cycle management principles on the Enfield ILC site has been considered at a conceptual level.

Several water cycle management opportunities have been considered and their suitability to the Enfield ILC site assessed. The reduction in demand for potable water and the re-use of greywater or stormwater have been identified as the main suitable opportunities for the site that would assist in meeting the requirements of water sensitive urban design and ecologically sustainable development

7.1 Water Demand

There are three areas of water demand that have been identified for the site; these are the container wash down facilities, toilet flushing in the buildings and provision of water to the frog habitat area.

The estimated annual water demand for these facilities are:

- Container wash down facilities: 7,000 to 10,000 m^3/year per wash bay (two wash bays to be provided);
- Toilet flushing: 2,400 m^3/year, assuming dual flush toilets are installed; and
- Frog habitat area top-up: based on average monthly evaporation, demand would range from 1.04 m^3/day in June to 2.96 m^3/day in December (annual total = 720 m^3/year).

Irrigation of landscaped areas on site will not be required after the first 6 months of plant establishment, therefore landscape irrigation was not considered amongst the demands.

7.2 Minimisation of Demand for Water

The demand for potable water can be reduced through the use of water efficient appliances and fixtures. These appliances should be installed at the site. Water efficient fixtures may include water efficient taps and dual flush toilets. A traditional toilet uses over 6L of water for each flush, whilst a dual flush toilet can use as little as 3L for a half flush.

7.3 Re-use of Greywater and Stormwater

Two sources of water have been considered for providing re-use of water on site, greywater and stormwater re-use.

7.3.1 Greywater

Greywater from the site (non-sewage waste water) can be treated and re-used. *(NSW Health Interim Guidance for Greywater and Sewage Recycling in Multi-Unit Dwellings and Commercial Premises, Oct. 2004).*

This process involves capture and storage and treatment of greywater for re-use in toilet flushing and landscape irrigation. Re-use of sewage and greywater is not recommended for implementation at this site due to the costs and possible health and safety issues. The relatively small volume of water that could be reclaimed from greywater, compared to the total demands on site, does not justify the expense of installing and maintaining the greywater treatment facilities.

7.3.2 Stormwater

There are several large warehouses proposed for the site, each of which will generate significant runoff from its roof. This runoff could be captured in above or below-ground rainwater storage tanks and stored for reuse purposes. This water would be relatively clean, and beyond basic filtration to exclude gross pollutants, treatment would not be required. However, there are several issues that need to be considered when determining the suitability and feasibility of re-using rainwater, which would include health and safety, feasibility, and reliability of the source to supply water when it is needed.

Health and safety

Rainwater that would be used for toilet flushing purposes on site facilities would require disinfection. Chlorine application is the standard method of microbiological treatment.

There are other criteria that the rainwater must satisfy. The most relevant parameters are: pH 6.5-8.5, 1mg/L chlorine and Thermotolerant coliforms less than 10cfu/100mL.*(ANZECC 2000 guidelines , Use of Reclaimed Water)*

An appropriate disinfection system would need to be further investigated during the detailed design stages of the project.

Feasibility

Under current potable water rates (Approx $1/kL), the re-use scheme is unlikely to provide financial benefits in the short term; however, the environmental benefits should also be considered in the decision making process.

Reliability

A water balance desktop assessment, undertaken on a daily basis over 50 years, indicates that there would be sufficient rainwater available to meet the demands of:

- The two wash bays;

- Toilet flushing; and
- Top-up of the frog habitat area.

The following assumptions were made in the water balance:

- The total area of roofs from which rainwater could be captured is 5.77 ha;
- It would be possible to capture 80% of all roof runoff, until the rainwater tanks are full;
- Where a range of estimates was given for water demand, the upper estimate was used; and
- For a reuse scheme to be reliable, it would have to be capable of meeting the required demand for approximately 80% of the time.

The results of an annual water balance desktop assessment that has considered the water demands and available supply of re-use water indicate that if 1,500 m^3 of rainwater storage is provided, this would meet the demands of the wash bays, toilet flushing and frog habitat area 80% of the time. This storage volume would be distributed across the site at each building. The sizes of individual tanks will vary according to roof areas at each building.

It is not expected that the captured rainwater will be able to meet all demands, all the time, and hence allowance must be made for periods of drought. Therefore, it will be necessary to provide access to the mains water supply, as a back-up system. This preliminary assessment indicates that a re-use scheme for this site would provide a fairly acceptable and reliable outcome; however, a more detailed water balance study would determine the exact size of required storages and provide additional information of the long term average percentage of volume of water that the re-use scheme would provide.

Conclusion on water re-use concept

The preliminary assessment indicates that environmental and long term cost benefits could be obtained from a re-use scheme on the Enfield ILC site. The treatment and re-use of roof runoff has a range of possible benefits, including:

- Reducing discharge into the downstream waterways, providing some detention and reduction in pollutant loads
- Reducing demands placed on Sydney's potable water supply, and
- Long term cost savings by reducing the volume of water that needs to be purchased from Sydney Water.

8. Conclusions and Recommendations

This report outlined the existing environmental values and existing water quality at the development site; provided options and recommendations for water quality treatment control for both the construction and operational phases of the development; and discussed watercycle management for the site.

A range of environmental protection measures for the protection of water quality during the construction phase of the project representing current best practice have been presented in this report. During the detailed design stage of the project a SWMP would be prepared which should consider these options for erosion and sediment control in order to prevent any potential damage to ecosystems and decline in water quality as a result of construction.

For the operational phase of the project, water quality treatment methods have been recommended that will treat the first flush runoff from the proposed Enfield ILC site. It is recommended to capture and treat up to 10mm of rainfall from all storm events which would result in the treatment of more than 90% of the average annual runoff volume from the site. This should be done to ensure that water quality in runoff from the site to Coxs Creek, the Central and DELEC drains and Cooks River is maintained or improved. Each block within the ancillary development, however, would be subject to individual water quality controls, depending on the landuse. A first flush contaminant basin has also been recommended for accidental spill management for the site. Water quality monitoring is recommended for 12 months to ensure that the proposed water quality management devices on site are functioning as expected.

Watercycle management opportunities for the site have been considered and their suitability assessed. The reduction in demand for potable water and the re-use of stormwater, through the provision of raintanks, have been identified as the main recommendations for implementation that would meet the requirements of water sensitive urban design and ecologically sustainable development. The preliminary assessment indicates that environmental and long term cost benefits could be obtained from such a re-use scheme. This could also have a range of possible benefits including providing detention and reduction in pollutant loads and reducing demands on Sydney's potable water supply.

In conclusion, the proposed development would not impact on stormwater quality provided adequate controls are implemented during the construction and operational phases.

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Appendix A Water Quality Data (DELEC Site)

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North Weir 1999

Date	B.O.D. Entry Point (mg/L)	B.O.D. Exit Point (mg/L)	Suspended Solids Entry Point (mg/L)	Suspended Solids Exit Point (mg/L)	Total Grease Entry Point (mg/L)	Total Grease Exit Point (mg/L)	pH Entry Point	pH Exit Point
6/01/1999	15	7	7	5	1	1	8.10	7.50
13/01/1999	5	5	6	4	2	2	7.40	7.30
20/01/1999	37	30	16	13	3	1	7.60	7.40
27/01/1999	12	13	3	5	2	8	7.40	7.30
3/02/1999	7	9	3	2	3	4	7.50	7.40
10/02/1999	9	14	13	18	1	2	7.40	7.30
17/02/1999	29	15	4	11	1	1	6.80	6.90
24/02/1999	65	17	8	5	4	5	7.20	7.20
3/03/1999	10	4	13	8	1	1	7.00	7.00
10/03/1999	10	7	6	14	3	1	7.30	7.40
17/03/1999	11	5	4	5	2	2	7.40	7.40
24/03/1999	6	5	13	6	3	5	7.20	7.20
31/03/1999	4	11	3	6	5	1	7.30	7.30
7/04/1999	10	5	3	2	3	1	7.30	7.20
14/04/1999	59	90	4	7	5	2	7.30	7.30
21/04/1999	5	2	5	4	3	3	7.20	7.30
28/04/1999	2	3	6	29	3	2	7.40	7.30
5/05/1999	2	2	2	1	2	1	7.30	7.20
12/05/1999	3	7	2	2	2	1	7.30	7.20
19/05/1999	10	4	3	5	1	1	7.80	7.30
26/05/1999	6	11	10	7	2	1	7.40	7.50
2/06/1999	5	13	10	7	1	1	7.60	7.40
9/06/1999	13	6	38	12	3	4	7.80	7.40
16/06/1999	4	4	3	17	3	1	7.40	7.30
23/06/1999	18	5	27	21	9	8	8.70	8.20
30/06/1999	11	4	3	7	1	1	7.50	7.20
7/07/1999	4	24	1	2	1	1	8.50	8.30
14/07/1999	21	18	26	43	7	5	6.90	7.20
21/07/1999	5	5	2	4	1	2	7.40	7.30
28/07/1999	2	2	5	5	3	1	7.40	7.40
4/08/1999	3	3	3	6	3	5	7.60	7.70
11/08/1999	3	2	3	18	2	2	7.70	7.40
18/08/1999	4	3	4	6	4	4	7.60	7.40
25/08/1999	8	22	3	6	1	3	7.50	7.40
1/09/1999	5	3	7	11	1	2	8.10	7.40
8/09/1999	9	20	3	7	1	4	7.60	7.30
15/09/1999	10	12	5	12	3	5	8.60	7.80
22/09/1999	6	5	3	7	1	3	8.10	7.70
29/09/1999	9	5	7	8	7	3	8.30	8.10
6/10/1999	4	6	7	22	3	1	8.40	8.30
13/10/1999	32	30	11	10	6	4	8.20	8.00
20/10/1999	4	6	5	7	3	5	7.60	7.40
27/10/1999	5	5	3	6	2	1	7.60	7.60
3/11/1999	3	3	3	6	1	1	7.90	7.70
10/11/1999	7	7	3	10	3	7	7.70	7.50
17/11/1999	5	15	3	10	1	3	7.80	7.60
24/11/1999	14	9	3	6	3	5	8.30	8.20
1/12/1999	10	8	23	6	7	3	7.40	7.40
8/12/1999	13	9	11	7	3	3	7.30	7.30
15/12/1999	4	4	5	7	2	3	7.20	7.30
22/12/1999	5	5	11	9	3	4	7.60	7.50
29/12/1999	11	10	7	9	3	3	7.60	7.50
Average	11	10	7	9	3	3	7.61	7.46
Standard deviation	13	13	7	7	2	2	0.42	0.31
Minimum	2	2	1	1	1	1	6.80	6.90
Maximum	65	90	38	43	9	8	8.70	8.30

North Weir 2000

Date	B.O.D. Entry Point (mg/L)	B.O.D. Exit Point (mg/L)	Suspended Solids Entry Point (mg/L)	Suspended Solids Exit Point (mg/L)	Total Grease Entry Point (mg/L)	Total Grease Exit Point (mg/L)	pH Entry Point	pH Exit Point
5/01/2000	15	7	7	5	1	1	8.10	7.50
12/01/2000	7	7	7	4	3	5	7.60	7.40
19/01/2000	8	7	2	7	2	3	7.00	7.00
26/01/2000	6	6	7	11	2	3	8.00	7.60
2/02/2000	10	5	5	6	2	3	7.70	7.50
9/02/2000	9	7	10	13	3	6	7.00	7.00
16/02/2000	21	8	4	13	1	1	8.40	7.80
23/02/2000	17	29	7	9	1	2	7.70	7.40
1/03/2000	10	12	2	3	1	1	8.00	7.80
8/03/2000	0	0	0	0	0	0		
15/03/2000	10	8	5	4	6	4	6.90	8.00
22/03/2000	7	5	20	32	14	4	7.20	7.10
29/03/2000	12	5	2	5	1	3	7.40	7.30
5/04/2000	16	10	12	15	7	7	7.20	7.30
12/04/2000	12	3	1	5	1	2	8.00	7.60
19/04/2000	6	10	3	1	1	3	7.70	7.60
26/04/2000	2	4	3	6	2	4	7.90	7.70
3/05/2000	1	2	3	5	1	4	7.60	7.80
10/05/2000	5	7	5	7	1	3	8.10	8.20
17/05/2000	8	23	3	6	1	2	7.80	7.50
24/05/2000	10	9	3	8	1	1	8.10	7.90
31/05/2000	3	3	1	5	1	1	8.70	8.60
7/06/2000	2	4	2	4	1	2	7.80	7.60
14/06/2000	6	8	3	5	1	2	7.50	7.40
21/06/2000	5	13	3	6	1	2	8.20	7.60
28/06/2000	8	9	3	4	1	1	7.60	7.50
5/07/2000	8	8	3	6	1	3	8.00	7.70
12/07/2000	8	8	6	3	1	2	8.30	7.70
19/07/2000	7	6	3	3	1	2	8.30	7.70
26/07/2000	7	10	8	12	1	1	7.90	7.70
2/08/2000	2	12	5	7	1	1	7.50	7.60
9/08/2000	8	8	4	9	3	4	7.80	7.70
16/08/2000	9	12	4	5	1	3	8.20	7.50
23/08/2000	3	8	5	8	1	3	8.30	8.10
30/08/2000	2	1	4	6	1	1	8.40	8.40
6/09/2000	5	8	2	9	1	1	8.30	7.90
13/09/2000	8	9	6	5	1	2	7.90	7.60
20/09/2000	5	15	5	15	1	2	8.30	7.30
27/09/2000	5	8	3	9	1	3	8.10	7.70
4/10/2000	8	10	3	14	1	3	8.30	8.10
11/10/2000	5	9	3	7	1	1	8.10	8.00
18/10/2000	6	6	3	7	1	1	8.10	7.60
25/10/2000	5	6	7	5	1	1	7.40	7.70
1/11/2000	13	24	4	4	1	2	7.70	7.30
8/11/2000	3	4	3	8	1	4	8.10	8.00
15/11/2000	9	6	26	12	2	3	7.90	8.50
22/11/2000	14	10	4	4	2	3	7.30	7.40
29/11/2000	3	3	3	5	1	2	7.50	7.50
6/12/2000	2	2	3	4	1	1	7.80	7.70
13/12/2000	11	22	4	6	2	5	7.70	7.40
20/12/2000	4	8	3	5	1	1	8.10	7.80
27/12/2000	3	4	7	5	3	4	7.70	7.60
Average	7	8	5	7	2	2	7.85	7.66
Standard deviation	4	6	4	5	2	1	0.40	0.33
Minimum	0	0	0	0	0	0	6.90	7.00
Maximum	21	29	26	32	14	7	8.70	8.60

North Weir 2001

Date	B.O.D. Entry Point (mg/L)	B.O.D. Exit Point (mg/L)	Suspended Solids Entry Point (mg/L)	Suspended Solids Exit Point (mg/L)	Total Grease Entry Point (mg/L)	Total Grease Exit Point (mg/L)	pH Entry Point	pH Exit Point
3/01/2001	5	17	6	8	1	2	7.80	7.90
10/01/2001	13	5	3	7	1	2	8.20	7.30
17/01/2001	2	7	5	9	1	4	8.10	7.70
24/01/2001	5	6	3	8	1	2	7.90	7.60
31/01/2001	3	4	18	15	1	1	7.30	7.10
7/02/2001	5	6	5	6	1	2	8.10	7.90
14/02/2001	5	7	5	5	1	1	7.30	7.10
21/02/2001	6	12	3	7	1	1	7.50	7.60
28/02/2001	2	4	2	5	1	1	7.80	8.10
7/03/2001	2	3	3	8	1	2	8.00	8.30
14/03/2001	4	3	15	17	3	4	8.10	7.70
21/03/2001	1	3	4	6	1	1	7.30	7.30
28/03/2001	2	4	3	10	1	1	7.90	7.80
4/04/2001	2	3	3	3	1	1	8.50	8.50
11/04/2001	4	3	3	7	2	2	7.80	7.60
18/04/2001	1	3	4	2	1	2	7.80	7.60
25/04/2001	3	6	5	8	1	2	7.80	7.70
2/05/2001	3	5	5	5	1	1	8.50	7.80
9/05/2001	2	3	7	7	1	1	7.80	7.50
16/05/2001	3	2	3	3	1	1	7.90	8.00
23/05/2001	6	8	3	6	1	1	8.10	7.70
30/05/2001	2	3	4	6	2	2	8.10	7.90
6/06/2001	2	3	1	4	1	1	7.80	8.10
13/06/2001	31	53	4	5	1	2	7.70	7.50
20/06/2001	2	2	8	5	1	1	8.10	8.00
27/06/2001	5	3	5	4	1	1	8.00	7.40
4/07/2001	3	3	2	7	1	1	7.80	7.40
11/07/2001	4	9	10	21	1	3	8.10	7.80
18/07/2001	2	2	4	12	1	1	7.90	7.50
25/07/2001	6	4	28	16	2	2	7.80	7.90
1/08/2001	2	4	2	8	1	1	7.30	7.30
8/08/2001	2	2	2	5	1	1	7.50	7.40
15/08/2001	13	19	3	7	1	1	7.80	7.40
22/08/2001	4	5	6	7	1	1	7.90	7.40
29/08/2001	5	4	21	19	1	1	8.10	8.20
5/09/2001	3	6	7	7	1	3	7.90	7.50
12/09/2001	9	8	11	15	2	3	7.70	7.60
19/09/2001	3	5	5	6	1	1	8.50	7.80
26/09/2001	3	10	7	21	1	3	8.30	8.00
3/10/2001	8	9	5	16	1	2	7.80	8.30
10/10/2001	4	13	3	10	1	2	8.10	7.90
17/10/2001	6	7	5	9	3	3	8.00	7.70
24/10/2001	10	10	7	7	4	5	8.00	7.70
31/10/2001	3	5	5	7	1	2	8.10	7.70
7/11/2001	11	5	13	10	2	3	7.80	7.40
14/11/2001	3	4	21	16	2	3	7.90	7.60
21/11/2001	3	3	7	12	1	2	7.90	7.50
28/11/2001	7	10	2	6	1	2	7.70	7.20
5/12/2001	4	10	4	6	1	2	8.00	8.30
12/12/2001	7	7	4	8	1	1	7.90	7.30
19/12/2001	5	11	8	15	1	2	8.00	7.50
27/12/2001	5	10	5	7	1	1	8.00	7.50
Average	5	7	6	9	1	2	7.90	7.68
Standard deviation	5	8	5	5	1	1	0.27	0.32
Minimum	1	2	1	2	1	1	7.30	7.10
Maximum	31	53	28	21	4	5	8.50	8.50

South Weir 1999

Date	B.O.D. Entry Point (mg/L)	B.O.D. Exit Point (mg/L)	Suspended Solids Entry Point (mg/L)	Suspended Solids Exit Point (mg/L)	Total Grease Entry Point (mg/L)	Total Grease Exit Point (mg/L)	pH Entry Point	pH Exit Point
27/01/1999	14	12	7	7	6	1	7.3	7.3
24/02/1999	39	40	12	15	9	11	7.0	7.1
24/03/1999	2	4	9	8	5	7	7.1	7.2
31/03/1999	3	2	9	7	3	2	7.2	7.2
28/04/1999	2	2	14	15	5	3	7.2	7.1
26/05/1999	19	18	11	12	4	1	7.4	7.4
23/06/1999	8	6	19	16	10	6	8.5	8.4
30/06/1999	19	10	13	15	3	2	7.3	7.2
28/07/1999	5	2	16	10	4	5	7.2	7.2
25/08/1999	6	18	15	12	5	6	7.2	7.4
22/09/1999	8	6	11	14	5	4	7.5	7.6
29/09/1999	13	9	13	10	6	5	7.9	7.8
27/10/1999	4	4	8	9	3	5	7.6	7.6
24/11/1999	7	14	11	12	6	6	7.3	7.6
22/12/1999	6	6	10	8	3	5	7.4	7.5
29/12/1999	10	11	14	13	4	4	7.4	7.4
Average	10	10	12	11	5	5	7.4	7.4
Standard deviation	9	10	3	3	2	3	0.4	0.3
Minimum	2	2	7	7	3	1	7.0	7.1
Maximum	39	40	19	16	10	11	8.5	8.4

SKM

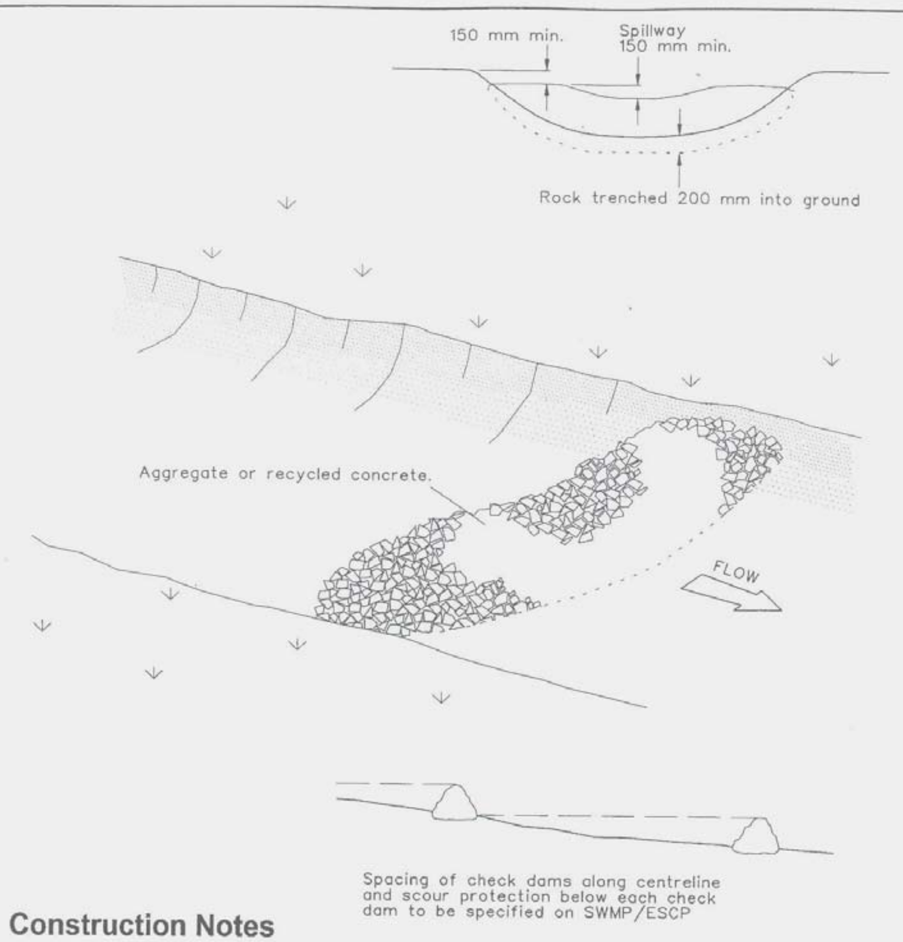
South Weir 2000

Date	B.O.D. Entry Point (mg/L)	B.O.D. Exit Point (mg/L)	Suspended Solids Entry Point (mg/L)	Suspended Solids Exit Point (mg/L)	Total Grease Entry Point (mg/L)	Total Grease Exit Point (mg/L)	pH Entry Point	pH Exit Point
5/01/2000	10	7	16	7	2	2	7.5	7.6
12/01/2000	2	2	11	9	5	4	7.5	7.3
19/01/2000	5	6	10	12	4	7	7.5	7.6
26/01/2000	6	8	19	21	5	6	7.5	7.5
2/02/2000	4	8	11	12	5	3	7.4	7.4
10/02/2000	10	5	15	14	5	4	7.1	7.1
16/02/2000	25	13	12	15	2	5	7.7	7.7
23/02/2000	14	22	15	12	11	7	7.4	7.5
1/03/2000	6	8	7	9	7	9	7.9	7.7
15/03/2000	9	9	17	10	3	4	7.5	7.6
22/03/2000	10	9	8	6	4	4	7.3	7.3
29/03/2000	5	4	9	10	5	5	7.1	7.1
5/04/2000	19	17	15	17	7	8	7.4	7.3
12/04/2000	12	15	17	15	5	4	7.4	7.4
19/04/2000	8	11	12	10	7	5	7.6	7.5
26/04/2000	1	5	17	13	9	7	7.5	7.5
3/05/2000	17	22	11	13	7	7	7.8	8
10/05/2000	40	6	14	10	2	2	8.2	8.2
17/05/2000	26	15	11	10	4	5	7.4	7.4
24/05/2000	8	10	12	10	3	3	7.8	7.9
31/05/2000	3	9	12	10	2	6	8.6	8.6
7/06/2000	13	14	7	8	3	5	7.5	7.5
14/06/2000	6	15	9	19	4	11	7.3	7.2
21/06/2000	8	15	11	9	3	5	7.5	7.5
28/06/2000	5	10	7	8	2	5	7.4	8
5/07/2000	16	15	10	6	4	6	7.8	7.6
12/07/2000	15	31	8	17	3	9	7.6	7.2
19/07/2000	15	21	8	13	1	5	8.0	8.0
26/07/2000	3	5	16	25	5	3	7.4	7.4
2/08/2000	15	5	10	2	1	3	7.8	7.7
9/08/2000	4	5	24	23	6	5	7.7	7.6
16/08/2000	13	23	9	9	2	7	7.6	7.4
23/08/2000	9	18	9	13	5	7	7.9	7.7
30/08/2000	23	6	11	9	9	7	8.3	8.3
6/09/2000	26	31	7	5	2	3	8	7.5
13/09/2000	5	8	11	13	3	5	7.7	7.6
20/09/2000	5	6	11	10	1	1	7.4	7.7
27/09/2000	24	30	7	8	2	2	7.5	7.6
4/10/2000	5	9	9	9	1	3	7.8	7.9
11/10/2000	5	7	5	11	1	2	7.8	7.6
18/10/2000	5	7	10	12	1	2	7.5	7.5
25/10/2000	5	7	8	6	2	3	7.4	7.4
1/11/2000	19	20	6	9	7	3	7.3	7.3
8/11/2000	3	5	10	10	2	4	7.8	7.6
15/11/2000	6	4	6	13	1	4	8.5	8.4
22/11/2000	9	15	13	11	2	3	7.3	7.4
29/11/2000	2	2	9	10	5	5	7.3	7.3
6/12/2000	9	12	11	9	7	5	7.5	7.6
13/12/2000	17	30	5	4	4	7	7.4	7.4
20/12/2000	3	5	8	9	1	3	8.4	8.2
27/12/2000	6	4	6	3	5	3	7.4	7.3
Average	11	12	11	11	4	5	7.6	7.6
Standard deviation	8	8	4	5	2	2	0.3	0.3
Minimum	1	2	5	2	1	1	7.1	7.1
Maximum	40	31	24	25	11	11	8.6	8.6

South Weir 2001

Date	B.O.D. Entry Point (mg/L)	B.O.D. Exit Point (mg/L)	Suspended Solids Entry Point (mg/L)	Suspended Solids Exit Point (mg/L)	Total Grease Entry Point (mg/L)	Total Grease Exit Point (mg/L)	pH Entry Point	pH Exit Point
3/01/2001	31	3	6	5	2	3	7.4	7.3
10/01/2001	6	5	10	6	2	3	7.6	7.6
17/01/2001	13	6	7	11	3	5	7.9	8
24/01/2001	4	3	12	9	1	1	8	8.1
31/01/2001	2	2	10	16	1	1	7.4	7.2
7/02/2001	7	5	7	8	3	1	7.7	7.9
14/02/2001	10	8	14	16	3	4	7.0	7.1
21/02/2001	8	2	8	7	3	1	7.7	7.6
28/02/2001	2	2	17	15	1	1	8.1	8
7/03/2001	2	3	15	17	1	2	8.2	8.1
14/03/2001	5	12	15	18	2	3	7.8	7.7
21/03/2001	7	9	15	13	1	2	7.2	7.3
28/03/2001	5	2	4	7	2	1	8.1	8
4/04/2001	2	4	6	3	1	3	8.3	7.7
11/04/2001	1	2	10	12	1	1	7.4	7.5
18/04/2001	3	8	2	3	2	2	7.7	7.5
2/05/2001	3	3	9	10	1	2	7.9	7.9
9/05/2001	5	17	11	9	3	2	7.3	7.3
16/05/2001	3	3	15	17	2	3	7.9	7.7
23/05/2001	8	8	7	8	1	2	7.8	7.8
30/05/2001	2	3	8	7	1	2	7.7	7.8
6/06/2001	5	5	15	13	2	2	8	7.7
13/06/2001	8	21	5	4	2	2	7.5	7.5
20/06/2001	2	2	11	13	1	1	7.8	7.7
27/06/2001	5	5	21	13	2	3	7.4	7.4
4/07/2001	8	5	11	10	2	3	7.3	7.4
11/07/2001	12	11	11	15	1	2	7.9	7.7
18/07/2001	2	2	11	7	1	1	7.4	7.5
25/07/2001	13	3	15	6	4	1	8.1	8
1/08/2001	2	2	9	8	1	2	7.3	7.2
8/08/2001	4	4	8	10	1	2	7.3	7.3
15/08/2001	8	7	9	11	1	3	7.3	7.3
22/08/2001	6	18	17	22	3	5	7.3	7.5
29/08/2001	3	1	25	23	1	1	8.7	8.7
5/09/2001	8	10	11	13	5	5	7.4	7.4
12/09/2001	8	15	10	11	4	6	7.8	7.9
19/09/2001	4	7	12	13	2	3	7.5	7.5
26/09/2001	7	8	13	11	3	2	7.6	7.5
3/10/2001	6	8	8	14	1	2	8.2	8
10/10/2001	8	7	13	21	2	5	8	8
17/10/2001	6	4	13	12	3	2	8.3	8.4
24/10/2001	9	6	15	11	3	5	7.8	7.6
31/10/2001	5	3	10	12	2	2	7.8	7.6
7/11/2001	21	10	15	11	3	3	7.6	7.4
14/11/2001	3	5	17	19	1	2	8	8.1
21/11/2001	3	3	11	13	3	4	7.5	7.4
28/11/2001	4	5	8	4	3	2	7.2	7.3
5/12/2001	4	6	9	13	4	3	7.6	7.4
12/12/2001	5	7	18	19	2	1	7.4	7.5
19/12/2001	7	10	11	11	3	3	7.6	7.4
27/12/2001	5	7	9	11	1	3	7.9	7.7
Average	6	6	11	12	2	2	7.7	7.6
Standard deviation	5	4	4	5	1	1	0.3	0.3
Minimum	1	1	2	3	1	1	7	7.1
Maximum	31	21	25	23	5	6	8.7	8.7

Appendix B: Standard Figures from LandCom's (2004) *Managing Urban Stormwater: Soils and Construction*



Construction Notes

1. Check dams can be built with various materials, including rocks, logs, sandbags and straw bales. The maintenance program should ensure their integrity is retained, especially where constructed with straw bales. In the case of bales, this might require their replacement each two to four months.

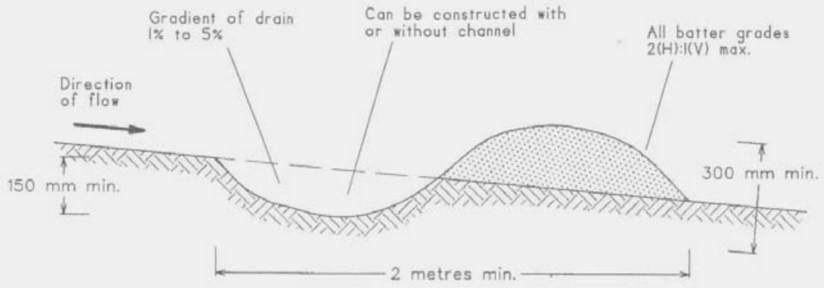
2. Trench the check dam 200 mm into the ground across its whole width. Where rock is used, fill the trenches to at least 100 mm above the ground surface to reduce the risk of undercutting.

3. Normally, their maximum height should not exceed 600 mm above the gully floor. The centre should act as a spillway, being at least 150 mm lower than the outer edges.

4. Space the dams so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM

SD 5-4

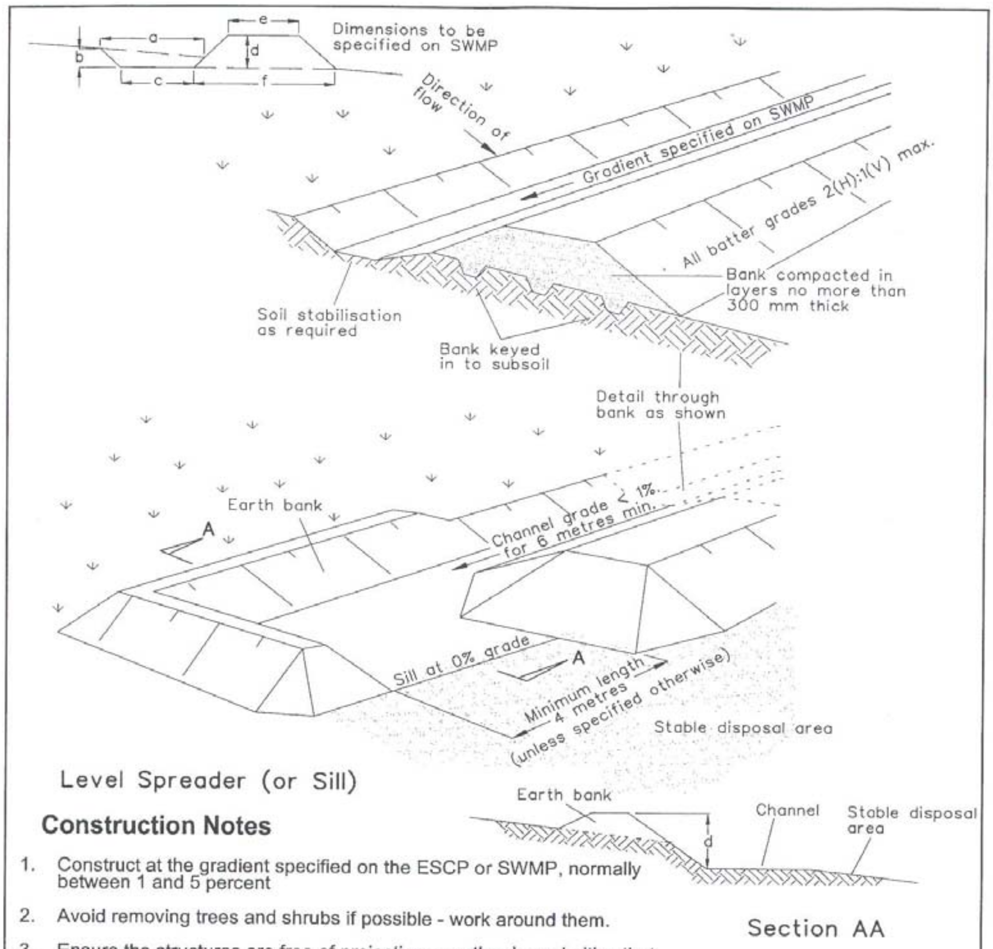


Construction Notes

1. Build with gradients between 1 percent and 5 percent.
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V shaped.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction.

EARTH BANK (LOW FLOW) **SD 5-5**

5-25

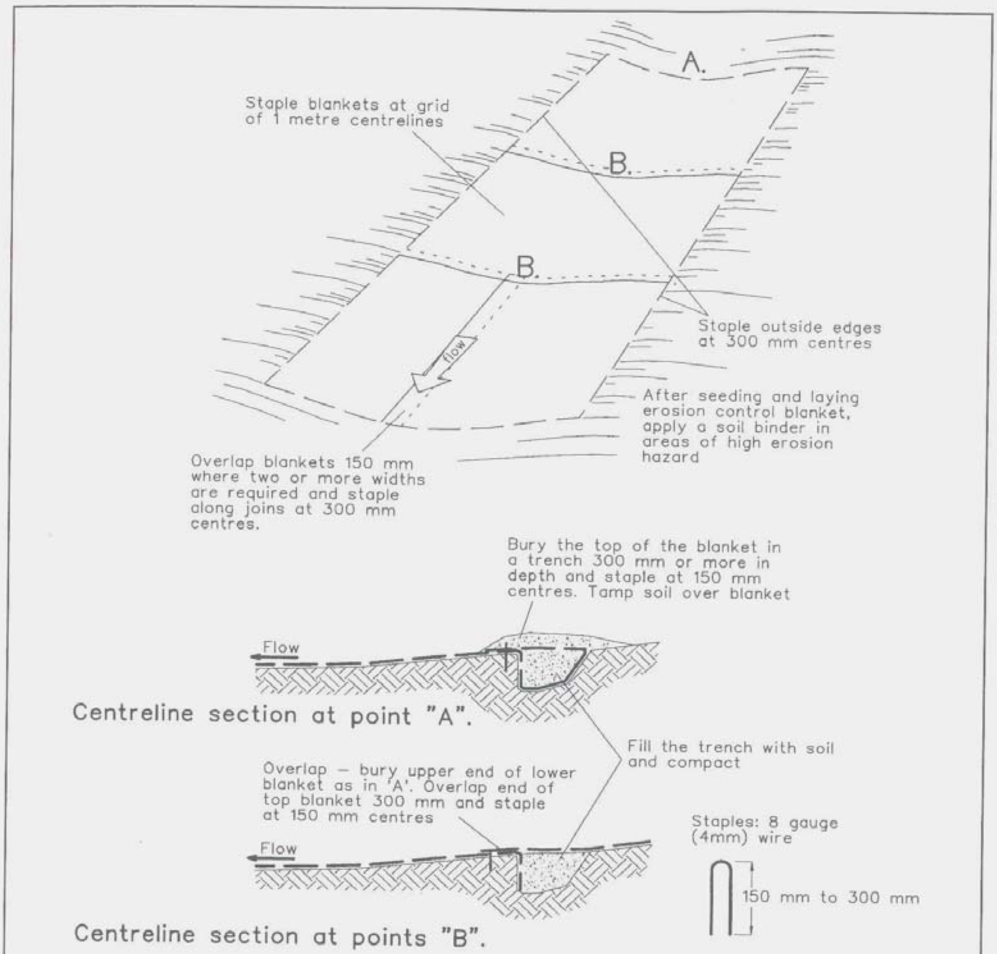


Construction Notes

1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V-shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

EARTH BANK (HIGH FLOWS) **SD 5-6**

5-26



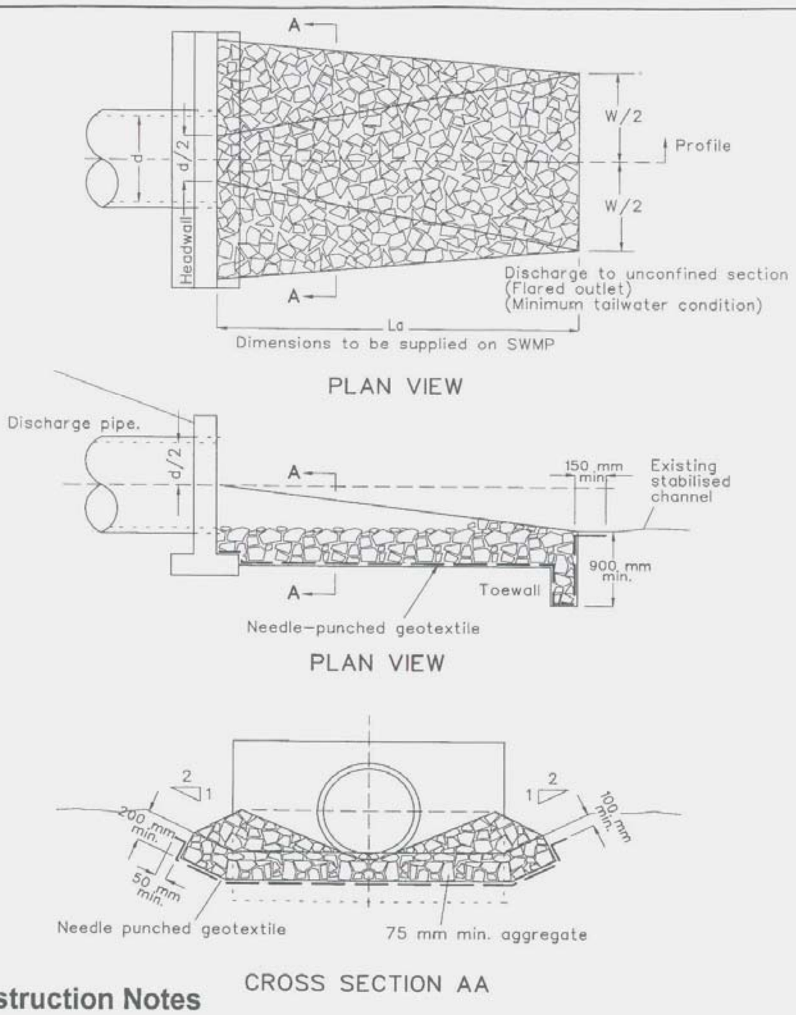
Construction Notes

1. Remove any rocks, clods, sticks or grass from the surface before laying matting
2. Ensure that topsoil is at least 75 mm deep.
3. Complete fertilising and seeding before laying the matting.
4. Ensure fabric will be continuously in contact with the soil by grading the surface carefully first.
5. Lay the fabric in "shingle-fashion", with the end of each upstream roll overlapping those downstream. Ensure each roll is anchored properly at its upslope end (Standard Drawing 5-7b).
6. Ensure that the full width of flow in the channel is covered by the matting up to the design storm event, usually in the 10-year ARI time of concentration storm event.
7. Divert water from the structure until vegetation is stabilised properly.

RECP : CONCENTRATED FLOW **SD 5-7**

5-28

SKM

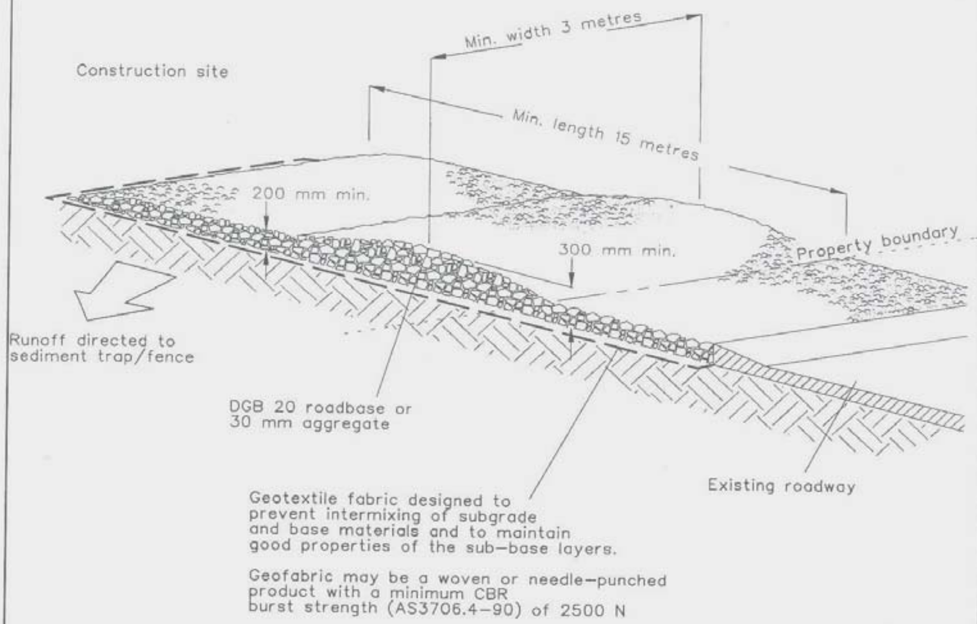


Construction Notes

1. Compact the subgrade fill to the density of the surrounding undisturbed material.
2. Prepare a smooth, even foundation for the structure that will ensure that the needle-punched geotextile does not sustain serious damage when covered with rock.
3. Should any minor damage to the geotextile occur, repair it before spreading any aggregate. For repairs, patch one piece of fabric over the damage, making sure that all joints and patches overlap more than 300 mm.
4. Lay rock following the drawing, according to Table 5.2 of Landcom (2004) and with a minimum diameter of 75 mm.
5. Ensure that any concrete or riprap used for the energy dissipater or the outlet protection conforms to the grading limits specified on the SWMP.

ENERGY DISSIPATER **SD 5-8**

5-34

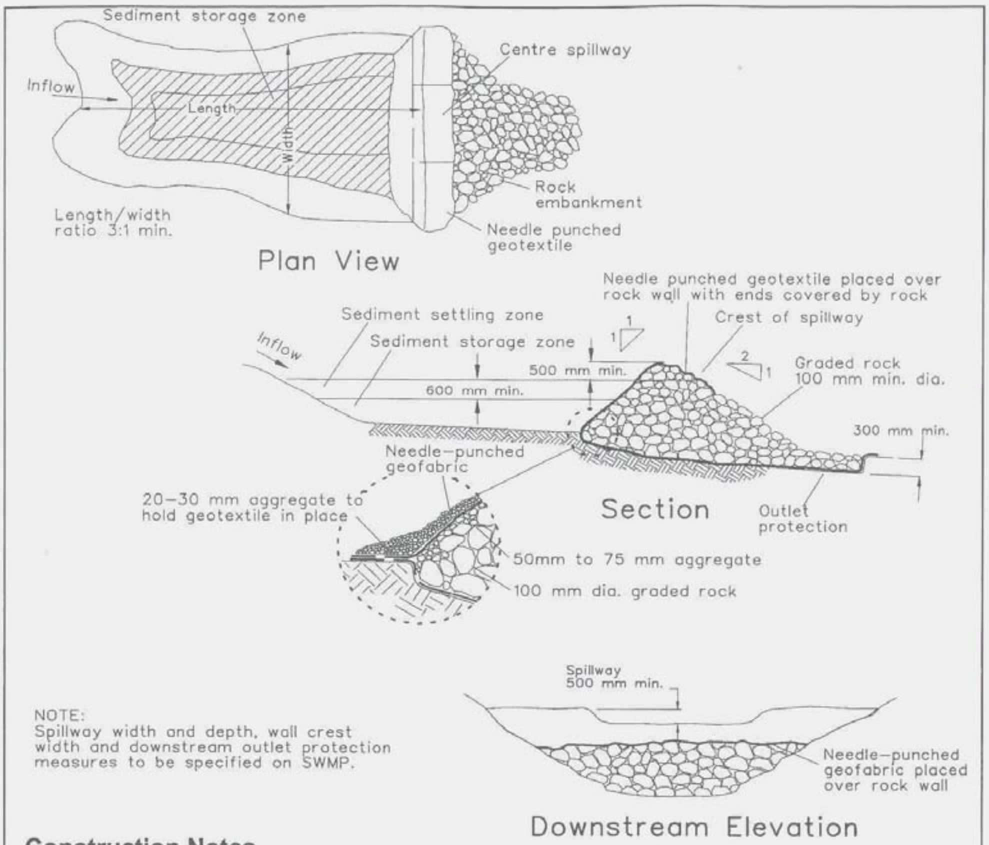


Construction Notes

1. Strip the topsoil, level the site and compact the subgrade.
2. Cover the area with needle-punched geotextile.
3. Construct a 200-mm thick pad over the geotextile using road base or 30-mm aggregate.
4. Ensure the structure is at least 15 metres long or to building alignment and at least 3 metres wide.
5. Where a sediment fence joins onto the stabilised access, construct a hump in the stabilised access to divert water to the sediment fence

STABILISED SITE ACCESS **SD 6-14**

6-48



Construction Notes

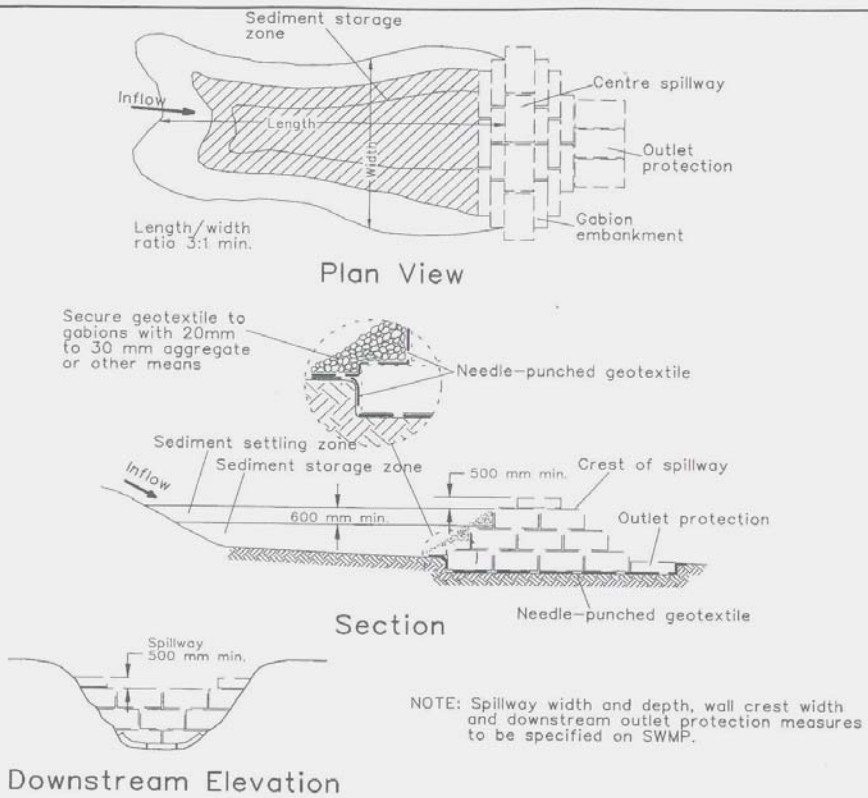
1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Excavate to 300 mm depth for base of the dam wall.
3. Line the excavation with a needle-punched geotextile allowing sufficient to line below the wall, and over the upstream rock and the spillway to 500 mm below the spillway exit on the downstream face.
4. Make up the wall profile and outlet protection with100 mm (min.) diameter graded rock. Spread a layer of 50 mm to 75 mm diameter aggregate over the upstream batter for a more even surface, and add 100 mm to 150 mm of 20 mm to 30 mm gravel over the 50 mm to 75 mm diameter aggregate.
5. Lay geotextile over the upstream batter and through the spillway, fixing in place with 100 mm rock.
6. Place a "Full of Sediment" marker to show when less than design capacity occurs and sediment removal is required.
7. Replace the upstream geotextile layer each time sediment is removed

ROCK SEDIMENT BASIN

(APPLIES TO 'TYPE C' SOILS ONLY)

SD 6-1

6-16



Construction Notes

(Applies to Type C soils only)

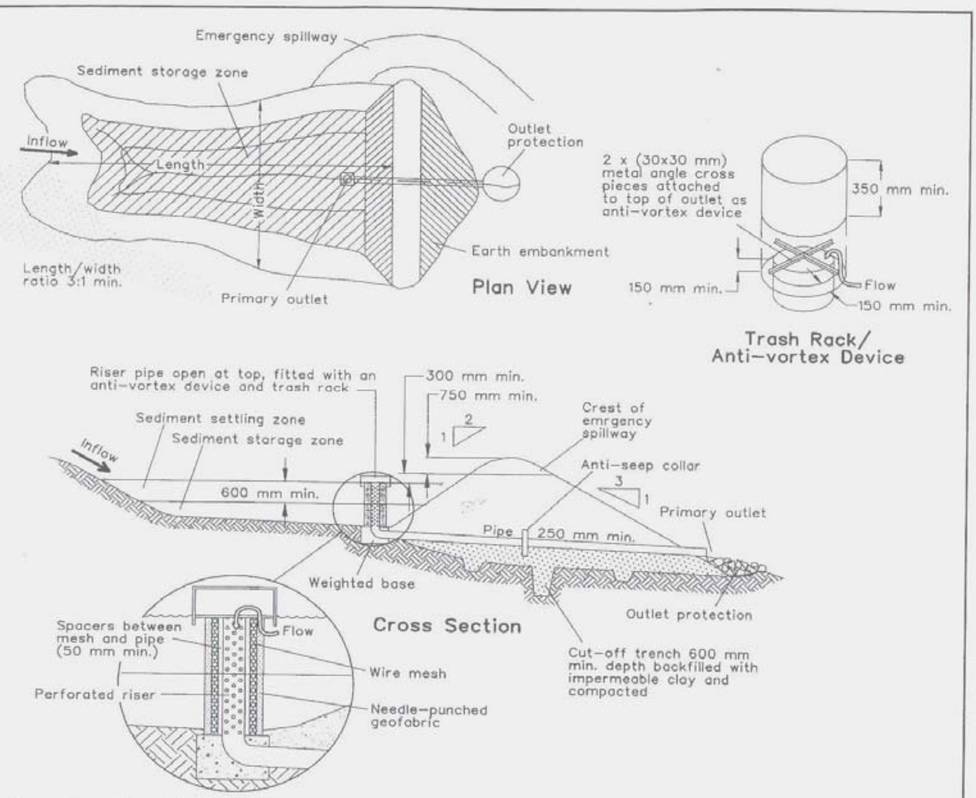
1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Excavate to 300 mm depth for the base of the dam wall and form a level platform for the gabions.
3. Line the excavation with a needle-punched geotextile allowing sufficient to line below the wall, and over the upstream gabions and spillway to 500 mm below the spillway exit on the downstream face.
4. Make up the wall profile and outlet protection with gabion units filled with graded rock as specified on the SWMP.
5. Construct a spillway 500 mm below the crest of the dam and for the width specified on the SWMP.
6. Lap the geotextile over the upstream face and through the spillway and fix it in place with the top row of gabions.
7. Cover the upstream face of the wall with 20 mm to 30 mm gravel and geotextile (Standard Drawing 6-2b)
8. Place a "Full of Sediment' marker to show when less than design capacity occurs and sediment removal is required.
9. Replace the upstream geotextile layer when sediment is removed if a dry basin is required.

GABION SEDIMENT BASIN

(APPLIES TO 'TYPE C' SOILS ONLY)

SD 6-2

6-17



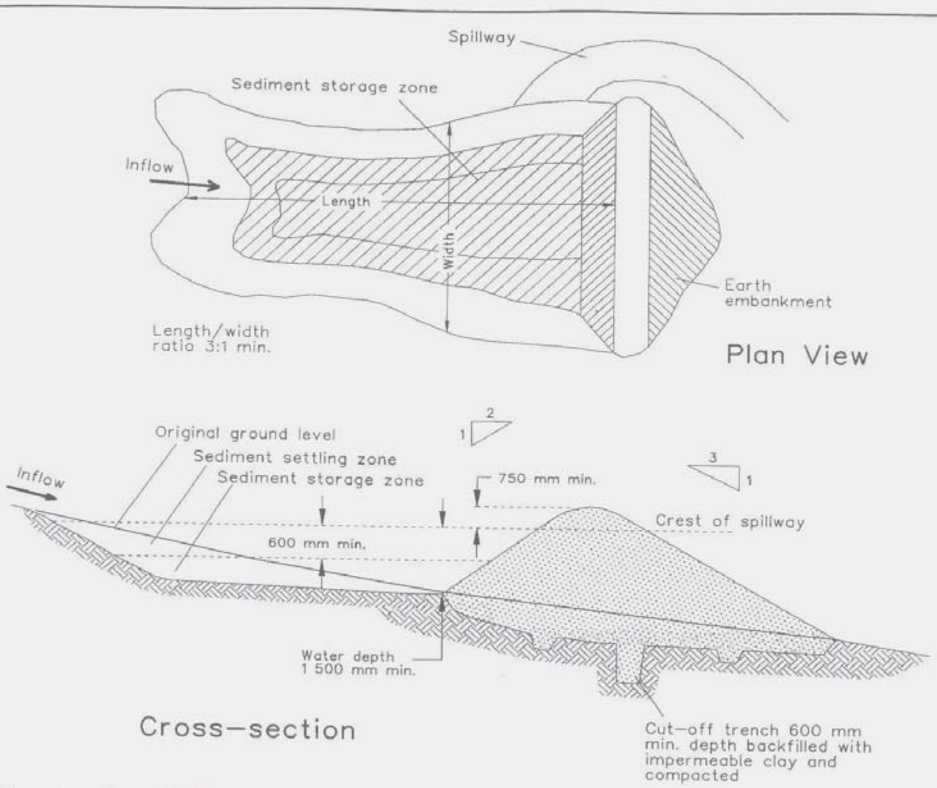
Construction Notes

1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Form a cut off trench under the centreline of the embankment 600 mm deep and 1,200 mm wide, extending to a point on the watercourse wall above the riser sill level.
3. Maintain the trench free of water and recompact the materials with equipment as specified in the SWMP to 95 per cent Standard Proctor Density.
4. Select fill according to the SWMP that is free from roots, wood, rock, large stone or foreign material.
5. Prepare the site under the embankment by ripping to at least 100 mm to help bond the compacted fill to the existing substrate.
6. Spread the fill in 100 mm to 150 mm layers and compact it at optimum moisture content following the SWMP.
7. Install the pipe outlet with seepage collars as specified in the SWMP and Standard Drawing 6-3b.
8. Form batter grades at 2(H):1(V) upstream and 3(H):1(V) downstream or as specified in the SWMP

EARTH BASIN - DRY
(APPLIES TO 'TYPE C' SOILS ONLY)

SD 6-3

6-18



Construction Notes

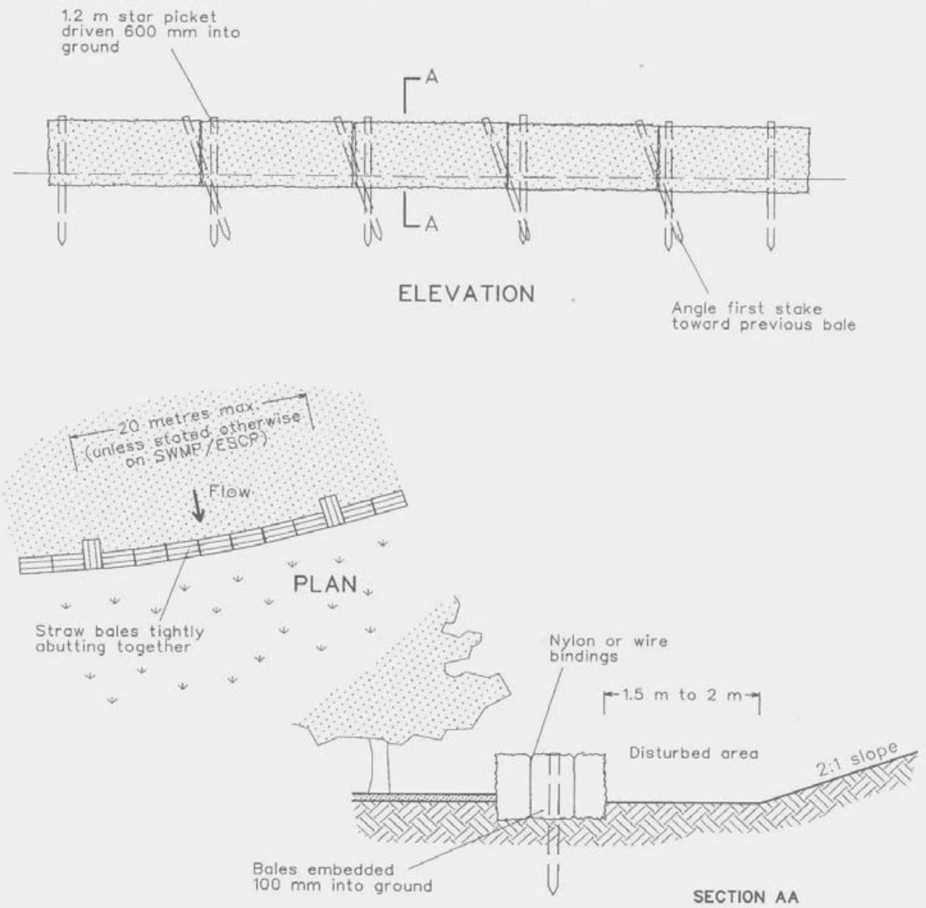
1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Construct a cut-off trench 500 mm deep and 1,200 mm wide along the centreline of the embankment extending to a point on the gully wall level with the riser crest.
3. Maintain the trench free of water and recompact the materials with equipment as specified in the SWMP to 95 per cent Standard Proctor Density.
4. Select fill following the SWMP that is free of roots, wood, rock, large stone or foreign material.
5. Prepare the site under the embankment by ripping to at least 100 mm to help bond compacted fill to the existing substrate.
6. Spread the fill in 100 mm to 150 mm layers and compact it at optimum moisture content following the SWMP.
7. Construct the emergency spillway.
8. Rehabilitate the structure following the SWMP.

EARTH BASIN - WET

(APPLIES TO 'TYPE D' AND 'TYPE F' SOILS ONLY)

SD 6-4

6-19

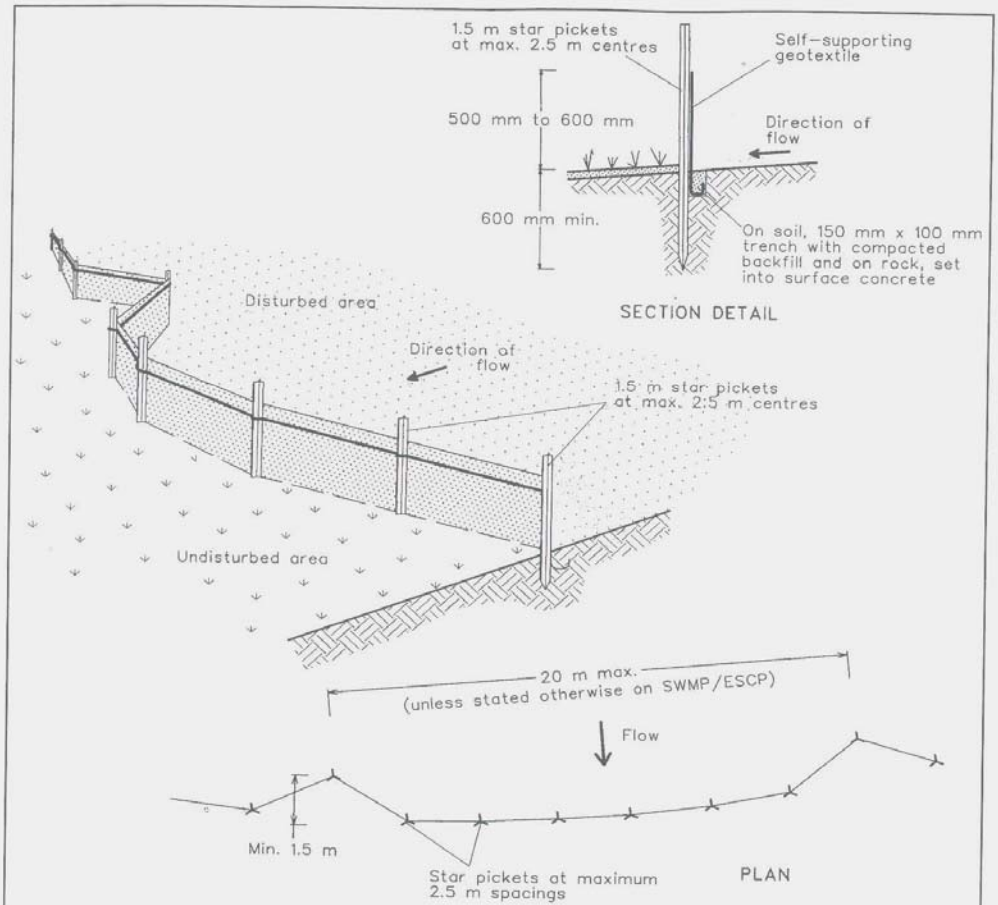


Construction Notes

1. Construct the straw bale filter as close as possible to being parallel to the contours of the site.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws are to be placed parallel to ground.
3. Ensure that the maximum height of the filter is one bale.
4. Embed each bale in the ground 75 mm to 100 mm and anchor with two 1.2 metre star pickets or stakes. Angle the first star picket or stake in each bale towards the previously laid bale. Drive them 600 mm into the ground and, if possible, flush with the top of the bales. Where star pickets are used and they protrude above the bales, ensure they are fitted with safety caps.
5. Where a straw bale filter is constructed downslope from a disturbed batter, ensure the bales are placed 1 to 2 metres downslope from the toe.
6. Establish a maintenance program that ensures the integrity of the bales is retained - they could require replacement each two to four months.

STRAW BALE FILTER **SD 6-7**

6-35



Construction Notes

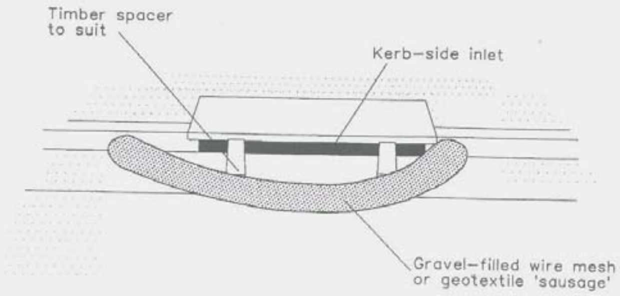
1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

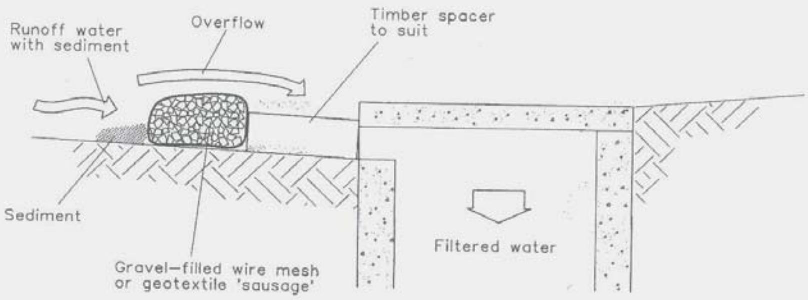
SEDIMENT FENCE

SD 6-8

6-36

SKM





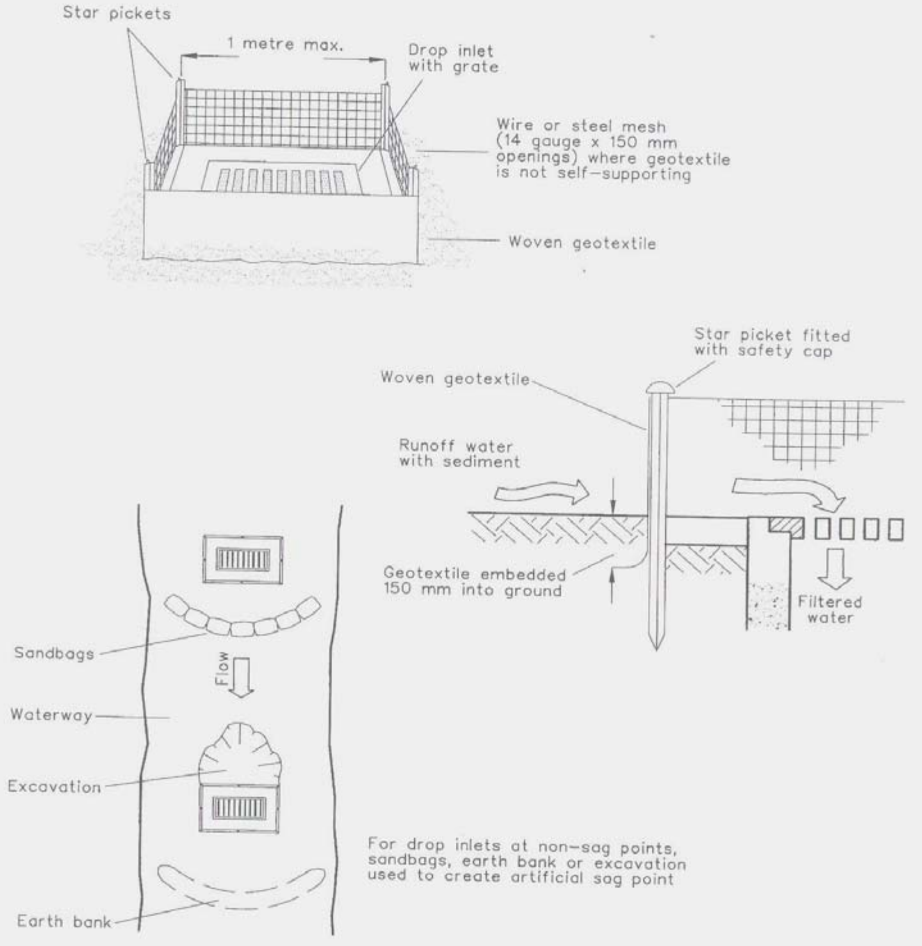
NOTE: This practice only to be used where specified in an approved SWMP/ESCP.

Construction Notes

1. Install filters to kerb inlets only at sag points.
2. Fabricate a sleeve made from geotextile or wire mesh longer than the length of the inlet pit and fill it with 25 mm to 50 mm gravel.
3. Form an elliptical cross-section about 150 mm high x 400 mm wide.
4. Place the filter at the opening leaving at least a 100-mm space between it and the kerb inlet. Maintain the opening with spacer blocks.
5. Form a seal with the kerb to prevent sediment bypassing the filter.
6. Sandbags filled with gravel can substitute for the mesh or geotextile providing they are placed so that they firmly abut each other and sediment-laden waters cannot pass between.

MESH AND GRAVEL INLET FILTER **SD 6-11**

6-40

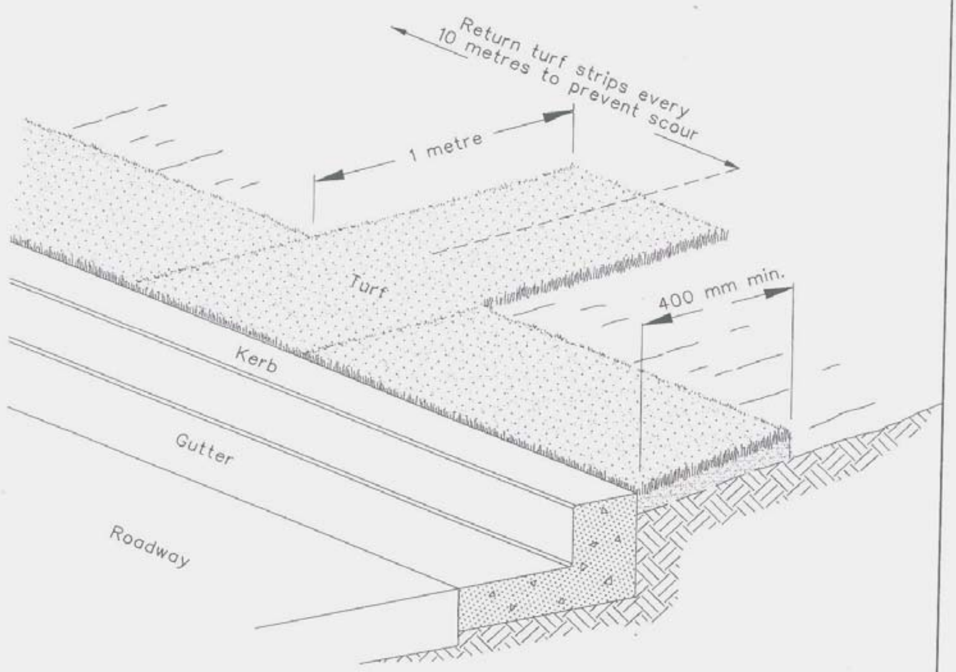


Construction Notes

1. Fabricate a sediment barrier made from geotextile or straw bales.
2. Follow Standard Drawing 6-7 and Standard Drawing 6-8 for installation procedures for the straw bales or geofabric. Reduce the picket spacing to 1 metre centres.
3. In waterways, artificial sag points can be created with sandbags or earth banks as shown in the drawing.
4. Do not cover the inlet with geotextile unless the design is adequate to allow for all waters to bypass it.

GEOTEXTILE INLET FILTER **SD 6-12**

6-41



Construction Notes

1. Install a 400-mm minimum wide roll of turf on the footpath next to the kerb and at the same level as the top of the kerb.
2. Lay 1.4 metre long turf strips normal to the kerb every 10 metres.
3. Rehabilitate disturbed soil behind the

KERBSIDE TURF STRIP **SD 6-13**

6-44