EIS 1344 Vol 1

AB020020

Statement of environmental effects : Penrith Lakes Scheme : development application 4 (DA4)

Environmental Management Pty Ltd
P.O. Box 276
KATOOMBA NSW 2780
Phone: 02 9804 6021
Fax: 02 9413 4957

November 1997

Penrith Lakes Development Corporation Ltd.

STATEMENT OF ENVIRONMENTAL EFFECTS
PENRITH LAKES SCHEME

DEVELOPMENT APPLICATION 4
(DA4)

Prepared for:

Penrith Lakes Development Corporation Ltd
Locked Bag 2000
SOUTH PENRITH NSW 2750
Phone: 02 4729 0044
Fax: 02 4730 1462

Prepared by:

Enviro-Managers Pty Ltd
P.O. Box 270
ARTARMON NSW 2064
Phone: 02 9904 6031
Fax: 02 9413 4997

November 1997

Penrith Lakes Development Corporation Ltd.

STATEMENT OF ENVIRONMENTAL EFFECTS
PENRITH LAKES SCHEME

DEVELOPMENT APPLICATION 4
(DA4)

Prepared for:

Penrith Lakes Development Corporation Ltd
Locked Bag 2000
SOUTH PENRITH NSW 2750
Phone: 02 4729 0044
Fax: 02 4730 1462

Prepared by:

Enviro-Managers Pty Ltd
P.O. Box 270
ARTARMON NSW 2064
Phone: 02 9904 6031
Fax: 02 9413 4997

November 1997

Penrith Lakes Development Corporation Ltd.

STATEMENT OF ENVIRONMENTAL EFFECTS
PENRITH LAKES SCHEME

DEVELOPMENT APPLICATION 4
(DA4)

Prepared for:

Penrith Lakes Development Corporation Ltd
Locked Bag 2000
SOUTH PENRITH NSW 2750
Phone: 02 4729 0044
Fax: 02 4730 1462

Prepared by:

Enviro-Managers Pty Ltd
P.O. Box 270
ARTARMON NSW 2064
Phone: 02 9904 6031
Fax: 02 9413 4997

November 1997

EXECUTIVE SUMMARY

OBJECTIVES AND OUTLINE OF THE DEVELOPMENT

The Penrith Lakes Development Corporation seeks Development Consent for the continuation of sand and gravel extraction in an area called DA4, encompassing a total area of about 737 hectares primarily between the Nepean River and Castlereagh Road on the western side of the Scheme area.

In recognition of the importance of the sand and gravel resources occurring in the floodplain of the Nepean River north of Penrith, the NSW Government in 1981 undertook to prepare an environmental plan of the area known as the "Penrith Lakes Scheme". A comprehensive environmental study (RES) of the area was undertaken which addressed the environmental considerations associated with the planned extraction of the sand and gravel resources and the establishment of a lake scheme as the rehabilitated landform. The Sydney Regional Environmental Plan N° 11 - Penrith Lakes Scheme (SREP 11) was prepared following the environmental study and review of submissions and was gazetted in November 1986. The DA4 application is the fourth sequential Development Application submitted by the Corporation in the Scheme area.

In accordance with previously established techniques, extraction will involve the removal of overburden and the extraction of the sand and gravel resource. Overburden removed will be utilised to rehabilitate former extraction areas to create the complex of public lakes, public open space and urban areas in accordance with established plans. The sand and gravel resource will be hauled by truck to shareholder plants, where it will be processed to form the quarry products required by the Sydney construction industry. The Penrith Lakes Scheme is the largest quarrying operation in Australia moving approximately 25,000 tonnes of raw feed and 18,000 m^3 of overburden daily.

The quarrying operations are expected to yield in the order of 57 million tonnes of sand and gravel and 6 million tonnes of fine sand. At an extraction rate of approximately 5.2 million tonnes per annum average reserves will be exhausted by the year 2011. The objective of the proposal is to ensure the continued supply of sand and gravel to Sydney's building and construction industry and to meet the commitments for the completion of the Penrith Lakes Scheme.

JUSTIFICATION AND ALTERNATIVES

The Sydney Region uses about 7.5 million tonnes of hard rock aggregate and 6 million tonnes of sand per annum. The Penrith Lakes Scheme provides approximately 75% of the sand and 40% of the hard rock aggregate to the Sydney construction industry. Alternative sources of these materials are located at increasing distances from the metropolitan area. Should the scheme not proceed, there would be an immediate crisis in the supply of sand and gravel to the building industry, and more distant sources would need to be developed or upgraded with increasing impacts and costs to the community.

ENVIRONMENTAL INTERACTIONS AND IMPACTS

Topography and Landform: The quarrying and rehabilitation of the DA4 area, will alter the existing landform from a relatively level alluvial plain into a recreational and wildlife Lake Scheme bordered by gently rolling and/or terraced landforms. The retention or restoration of a section of the original floodplain and its enhancement during the rehabilitation process will maintain the character and form of historical landscape elements.

Soils and Soil Erosion: Application of established environmental procedures for erosion control, revegetation and maintenance of rehabilitated lands in the DA4 area will ensure the creation of stable, erosion free and useable landforms. The bank to the Nepean River will, for most of its length, be retained intact.

Water Management: Detailed investigations have been undertaken to establish the infrastructure required to provide adequate quantities of quality water within the lakes and to minimise impact on the Hawkesbury-Nepean River system. These include water supply, reticulation, flood and stormwater control. Water quality is managed through the early establishment of a complete, diverse and well-balanced aquatic ecosystem. Water quality performance of the lake systems will improve as the lakes become biologically mature.

A pumping station will be constructed on the Nepean River to divert flows to the Scheme. Of the 26000 ML/annum average diversion, 85% will be returned to the Nepean River. The RES identified this as the best solution for the Scheme and Hawkesbury-Nepean River system.

Air Quality: To minimise dust emissions, the Corporation dampens unsealed roads, establishes rapid grass cover, minimises advance clearing, and ceases overburden stripping operations when necessary. Impacts from dust have been assessed at nearest residences for various years of the schemes operation. These investigations have shown that the deposition and concentration of total suspended particles is nominal for

residences to the north, south and centre of the area and predicted to be well within acceptable criteria. No residence will be affected by airborne respiratory dust and silica.

Noise: To minimise noise at nearest residences, management procedures will include dispersing equipment over larger areas, operating equipment below the active quarry face, which acts as a shield, and locating haul roads away from residential areas. Noise predictions at nearest residences, show that it is unlikely that 60 dBA short-term and 55 dBA long term will be exceeded for residents, for any extended time period, in each of the years modelled (except the Nepean Park homestead). Proposed noise controls will limit the period that these exceedances occur to ensure compliance with the design criteria. Additional control measures are required in the vicinity of the Nepean Park homestead to minimise noise impacts.

Flora and Fauna: The Penrith Lakes Scheme and adjacent Nepean River provide a substantial area of wetland habitat and greatly enrich the biodiversity of the district. Based on the findings of the biological investigations it is concluded that quarrying in the DA4 area will not have a significant impact on flora and fauna, including threatened species, and the preparation of a Species Impact Statement is not required. Generally, it is considered that the development will be advantageous to native fauna. The featureless and, for native species, sterile farm paddocks, which are so inhospitable to most native fauna, will eventually be replaced by wetland habitat and some terrestrial native habitat will be restored to the landscape. The process will provide an opportunity to greatly enhance the regional biodiversity.

Visual Environment: Extraction and rehabilitation operations in the northern part of the DA4 area will be visible to residents located on the elevated portions of the Castlereagh Escarpment and Smith Street. As operations proceed away from these areas, visual impacts will be ameliorated by the distance between observers and the operations. At all times, the operations will be visible to the few residents on the Blue Mountains escarpment who have direct, but long distant views of the extractive operations. In particular, operations in the northern part of the Scheme will be visible from Hawkesbury Lookout. As extractive operations proceed in the southern parts of the DA4 area, operations will become visible to Emu Heights. Visual impacts, however, overall are short-term, as quarrying operations proceed quickly through the Scheme area.

Archaeological Sites: A number of conservation zones have been proposed which will ensure that most of the significant archaeological sites in the DA4 area will be preserved. Some isolated artifact sites will be lost during the quarrying operations. A Consent to Destroy Application will be made to the National Parks and Wildlife Service before quarrying of these areas.

European Heritage: A number of items of heritage significance occur in the DA4 area. All of the items originally recommended for retention in the Regional Environmental Study will be retained. Additional identified items, including a mass concrete house, will also be retained and restored. Management plans will be prepared for this item and all other Corporation items to be retained. Items not to be retained include, Landers Inn, the northern part of Castlereagh Road, and Minnaville. The need to optimise use of the resource, minimise rehabilitation costs through adjustment of flood weirs, to retain proposed recreational opportunities and reduce visual amenity, prevent the retention of these items.

Agriculture: The proposed development would result in the loss of an area presently used for relatively intense agricultural activities. Cessation of these agricultural activities is not expected to have a significant impact either on total production from the area or on supplies to the metropolitan area.

Traffic and Urban Development: The development application provides for the removal and relocation of Castlereagh Road. The relocation of Castlereagh Road traffic onto the Cranebrook Road alignment would increase the average annual traffic volumes on Cranebrook Road to around the 17,000 to 19,000 vehicles. The level of service provided by the existing roadworks would be approaching capacity. The Corporation has prepared preliminary designs for a four lane divided carriage north of Cranebrook Village. Two alternative routes exist to the east and west of Cranebrook village. Detailed planning of urban development and the road network will be completed by the end of 1998.

Employment and Economic Impacts: The scheme provides direct employment for 456 people in Penrith City and Greater Western Sydney area and has a direct expenditure of $25.8 million in the Penrith Local Government Area and $114.3 million in the Greater Western Sydney Region. The Penrith Lakes Scheme is a significant contributor to the local economy and a major employer.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 STRUCTURE OF THE DOCUMENT

The structure of this report and scope of each section is as follows:

Section 1	Provides the objectives of the application and history of development of the Scheme.
Section 2	Describes the planning context for the Scheme including planning consents, conditions, and the Structure Plan.
Section 3	Discusses the need for DA4 in the context of the Sydney Region's reserves of gravel and sand and the management strategy adopted for their exploitation. The reserves of the Scheme area are presented in the context of the short-term demand for sand and hard rock aggregate. Consequences of no approval or delay in approval of DA4 are discussed.
Section 4	Describes the proposed development in terms of its extent and its relationship to the overall Scheme. The staging sequence within the DA4 area is presented together with details of topsoil, overburden and resource removal operations, hours of operation, and employment.
Section 5	Describes the environmental management procedures for water, tailings management, rehabilitation, and monitoring procedures undertaken.
Chapter 6	Describes the environmental interactions of the DA4 area in relation to landform, soils and erosion, noise, air quality, water resources, and flora and fauna. The likely impacts of the DA4 development on each of these aspects of the physical environment are presented together with proposed ameliorative measures to minimise potential impacts.
Chapter 7	Describes the environmental interactions of the DA4 area in relation to visual amenity, heritage sites (Aboriginal and European), agriculture, traffic and urban development. The likely impacts of the DA4 development on each of these aspects of the cultural environment, together with the employment and energy requirements, are presented together with proposed ameliorative measures to minimise potential impacts.

1.2 OBJECTIVES AND OUTLINE OF THE DEVELOPMENT

The Penrith Lakes Development Corporation Ltd (the Corporation) seeks Development Consent for the continuation of sand and gravel extraction from the northern and western parts of the Penrith Lakes Scheme in an area called DA4. The DA4 area is shown on **Figure 1.1** and encompasses a total area of about 737 hectares primarily between the Nepean River and Castlereagh Road on the western side of the Scheme area. In addition, a small area to the north of Church Lane on the eastern side of Castlereagh Road forms part of the application.

In recognition of the importance of the sand and gravel resources occurring in the floodplain of the Nepean River north of Penrith, the NSW Government in 1981 undertook to prepare an environmental plan of the area known as the "Penrith Lakes Scheme". A comprehensive environmental study of the area was undertaken which addressed the environmental considerations associated with the planned extraction of the sand and gravel resources and the establishment of a lake scheme as the rehabilitated landform. The Sydney Regional Environmental Plan N° 11 - Penrith Lakes Scheme (SREP 11) was prepared following the environmental study and review of submissions and was gazetted in November 1986.

The DA4 application is the fourth sequential Development Application submitted by the Corporation in the Scheme area. The process of sequential submission of Development Applications for the Scheme area was established by the implementation of SREP 11.

In accordance with previously established techniques, extraction will involve the removal of overburden and the extraction of the sand and gravel resource using dozers, scrapers, shovel, excavators and trucks. Overburden removed will be utilised to rehabilitate former extraction areas to create the complex of lakes, open space and urban areas in accordance with established plans. The sand and gravel resource will be hauled by truck to shareholder plants, where it will be processed to form the quarry products required by the Sydney construction industry. A geological review of resources in the Scheme area has identified a resource of fine sand in the overburden of DA4, which will be selectively quarried and processed for the Sydney market.

The quarrying operations are expected to yield in the order of 57 million tonnes of sand and gravel and 6 million tonnes of fine sand. At an extraction rate of approximately 5.2 million tonnes per annum average reserves will be exhausted by the year 2011.

The objective of the proposal is to ensure the continued supply of sand and gravel to the building and construction industry and to meet the commitments for the completion of the Penrith Lakes Scheme. The Corporation will continue to apply well-established environmental management procedures in its extraction and rehabilitation operations and carry out its activities in accordance with the requirements of Government authorities.

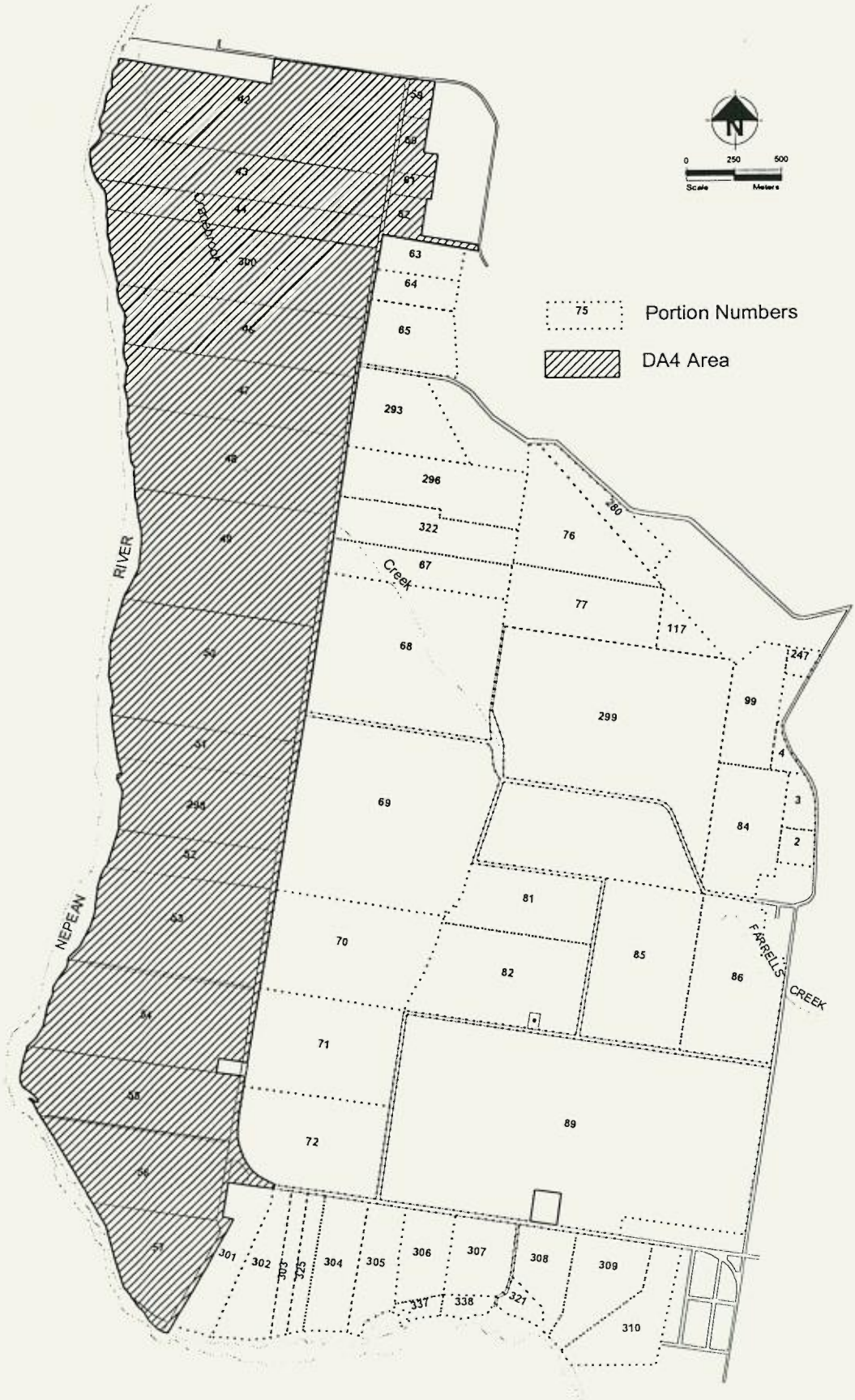


Figure 1.1 DA4 Area

1.2 BACKGROUND TO DEVELOPMENT OF THE PENRITH LAKES SCHEME

The Penrith area has been a major source of supply of medium to coarse grained sand and crushed river gravel for the Sydney construction industry since the 1880s and today provides most of Sydney's requirements for these materials.

Initially, excavation of the sand and gravel was from deposits in the Nepean River; however, as these reserves were depleted during the late 1950s attention was turned to the reserves under the Penrith-Castlereagh floodplain. Development consents to quarry parts of the floodplain to the northwest of Penrith were subsequently obtained by four quarrying companies:

- BMI Limited (now a subsidiary of Boral Limited);
- Farley and Lewers Limited (now a unit of CSR Limited);
- Ready Mixed Concrete Limited (now a unit of CSR Limited);
- Pioneer Concrete Services Limited (now a subsidiary of Pioneer International Limited).

In the late 1960s, the piecemeal manner in which the quarrying operations were being undertaken and the restriction this placed on the rehabilitation of the quarried areas were causing concern.

At the request of the Penrith City Council, the State Planning Authority (now the Department of Urban Affairs and Planning) examined concepts for coordinating the extraction of the sand and gravel resources and rehabilitation of the quarried areas. As a result, the Penrith Lakes Scheme Working Party was established, comprising representatives of five State Government Departments, the Penrith City Council and the quarrying companies. Its aim was to examine the feasibility of a program of orderly and economical extraction and comprehensive rehabilitation with a view to creating a regional water-orientated recreation resource in the former quarry areas.

This concept became know as the 'Penrith Lakes Scheme'.

In 1976 the working party prepared an interim report for the comprehensive rehabilitation of the area. Further studies were undertaken to assess the technical, environmental and financial feasibility of the proposal, including determining a suitable water supply, and agreed mechanism for coordinating the extraction and rehabilitation activities of the independent companies.

Consequently, in 1980 the Penrith Lakes Development Corporation Ltd, comprising representatives of the participating companies, commenced operation.

1.3 THE CORPORATION AND ITS SHAREHOLDERS

The Corporation is an unlisted public company formed to undertake the coordinated extraction and rehabilitation operations of its three shareholder companies in accordance with the expressed wish of the NSW Government and the Penrith City Council.

The shareholders, Boral Limited, Pioneer International Limited and CSR Limited, exercise joint control by means of their ownership in the Corporation.

The Corporation was established to:

- undertake detailed studies to test the technical, environmental and financial feasibility of the Scheme;
- obtain approvals for quarrying and rehabilitation;
- coordinate the sequential long-term quarrying and rehabilitation operations of the shareholder companies in the Penrith-Castlereagh floodplain;
- ensure that the quarrying and rehabilitation operations were undertaken in an economical and environmentally acceptable manner.

To achieve these objectives, the Corporation has been empowered by the shareholder companies to acquire the lands owned by the shareholders as well as to make additional land purchases as necessary in the Scheme area. The Corporation undertakes the extraction of the raw feed and subsequent rehabilitation work that would otherwise have been carried out separately by the shareholder companies.

By selling the raw feed to its shareholders, the Corporation is able to raise sufficient revenue to progressively meet the costs of administration, planning, design, extraction, rehabilitation and associated works for the Scheme. The shareholder companies continue to process the raw feed in their existing plants, and the individual shareholder companies, in competition with each other, market the product.

1.4 PENRITH LAKES SCHEME

The Penrith Lakes Scheme, which involves rehabilitating sections of Castlereagh floodplain concurrently with quarrying operations, is a complex engineering undertaking, requiring the excavation of overburden, sand and gravel to a typical depth of about 14m below ground level over a total area of about 2000 hectares.

Approximately 50% of the material to be excavated will be processed and sold, while the remaining overburden will be redistributed to create a variety of landforms.

A total of four large lakes and other water-related areas with a combined water area of 720 hectares are proposed for the 2000 hectares of land embraced by the Scheme. The largest lake would be about 340 hectares in area, and is capable of accommodating a large club standard sailing course.

The total land area excluding lakes would be 1280 hectares. About 300 hectares of this land has been designated for possible future urban uses, which are discussed in more detail in **Sections 2.8** and **7.6** of this Document.

1.5 SYDNEY OLYMPICS AND INTERNATIONAL REGATTA CENTRE

The Corporation worked closely with Sydney Olympic 2000 Bid Ltd in preparing technical information, assisting in special functions and site tours associated with the successful bid for the 2000 Olympic Games.

The successful rehabilitation of the Scheme is reflected in the now completed Sydney International Regatta Centre (SIRC). Officially handed over in July 1995, the Olympic Coordinating Committee is currently responsible for the care, control and management of the area. The Corporation maintains responsibility for lake water management through until Scheme completion.

Significant events have been held at the Centre since its opening including the 1996 Australian Rowing Championship, the "Head of the River" GPS Rowing carnival, long distance swimming and triathlons. Significant celebrations are being organised for the 1998 Australia Day.

1.6 EDUCATION AND COMMUNITY INVOLVEMENT

The Scheme has generated significant interest locally, regionally, nationally and internationally. The Corporation encourages public interest in its activities and has undertaken a number of initiatives to encourage public participation.

1.6.1 Walking Trail

The closure of Farrells Lane for the advancement of quarry operations in to the DA3 area removed a walking area for the residents of Cranebrook Village. The Corporation constructed a walking trail from the village to the Regatta Centre. The walking trail, which parallels Cranebrook Road was opened for use by residents in September 1996.

1.6.2 Mission Employment

The Corporation, in conjunction with the Sydney City Mission, assists in vocational training for the unemployed. The mission established a program for 50 to 60 students per year that included horticultural, first aid, occupational health and safety, computer operations and personal effectiveness and job seeking skills. Courses are on-going. The Corporation facilitates this activity by allowing the Mission to use part of the Site Office for training and by allocating a variety of landscaping works around the site.

1.6.3 Penrith Lakes Environmental Education Centre

An Environmental Education Centre has been established on Scheme lands. Opened in 1997, it was formed through a partnership arrangement between the NSW Department of Education, Catholic Education Office, TAFE of Western Sydney, University of Western Sydney, the NSW Minerals Council and the Corporation. The centre caters for students from kindergarten through to tertiary education and uses the Scheme as a contextual learning area, integrated with other features of the area.

1.6.4 Open Days

Open days are held twice a year for residents of Penrith City, Hawkesbury Shire, and Blue Mountains City. The day consists of three sessions of two hours each during which Corporation staff members explain the Scheme, demonstrate the flood model and provide an overview of the Scheme from selected vantage points.

1.6.5 Other Facilities

The Corporation provides facilities for lecture presentations, literature, brochures and other material, and a video on the Scheme and International Regatta Centre.

Approximately 30 secondary schools and tertiary institutions visit the Scheme per year along with numerous professional, business, community and environmental groups.

2.0 PLANNING CONTEXT

2.1 BACKGROUND

The Environmental Planning and Assessment Act 1979 (as amended) and Regulations (1994) provide for the making of environmental planning instruments for the proper management, development and conservation of the State's natural and man-made resources.

The extensive deposits of sand and gravel occurring in the floodplain of the Nepean River, north of Penrith have been recognised by the State Government as a resource of regional significance to supply the future demands for construction materials in the Sydney Region. As a result, the resource has been identified in a number of planning instruments with the objective of providing a development control process establishing environmental and technical matters which must be taken into account in implementing the Penrith Lakes Scheme in order to protect the environment. Key documents produced in relation to the Scheme since 1981 are listed in **Table 2.1** and discussed below.

TABLE 2.1
KEY DOCUMENTS AND OUTCOMES

Date	Document/Report	Result
April '81	Development Application (DA1)	Consent granted in July '82 for interim extraction while preferred Scheme in preparation.
Feb. '84	Penrith Lakes Scheme-Regional Environmental Study	Selection of preferred Scheme and description of its effects.
Oct. '86	Sydney Regional Environmental Plan N°. 9 – Extractive industry	Identified Penrith Lakes as priority for extraction.
Nov. '86	Sydney Regional Environmental Plan N°. 11–Penrith Lakes Scheme	Legal framework for implementation of Scheme.
Nov. '86	Development Application (DA2)	Consent granted in February '87 for extraction of DA2 area in accord with SREP N°. 11.
May '89	Amendment N°. 2 to Sydney Regional Environmental Plan N°. 11-Penrith Lakes Scheme	Amendment extended REP boundary and made provision to incorporate international standard rowing course into Scheme.
Aug. '89	Development Application (Rowing Lake)	Consent granted in November '89 to modify DA2 and extract additional lands to construct rowing course.
Jan. '94	Application to amend SREP N°. 11 (Amendment N°. 3) Structure Plan	Amendment to incorporate results of flood and drainage studies. Approved November 1994.
April '94	Development Application (DA3)	Consent granted in June 1995 for extraction of DA3 area in accordance with SREP N°. 11.
Sept 97	Application to amend SREP 11 (Amendment N° 4) Structure Plan	Proposed amendment to incorporate implications arising from geological review. Under consideration

2.2 SYDNEY REGIONAL ENVIRONMENTAL PLAN N^{O}. 9 - EXTRACTIVE INDUSTRY

In 1984, the then Department of Environment and Planning and the Department of Mineral Resources cooperated in a regional environmental study and plan to develop a framework for the planning and management of extractive resources within the Sydney Region. Following public exhibition and comment, Regional Environmental Plan(SREP) N^{O}. 9(1) was made in 1986. The aims of the plan were to facilitate the development of extractive resources close to the metropolitan area to ensure that the cost of supply of construction materials to the public could be kept to a reasonable level. The plan identified and protected existing and potential extractive resources of regional significance. It also aimed to ensure that extractive operations were carried out in an environmentally acceptable manner.

The plan considered sand, coarse aggregate (including river gravel and hard rock aggregate), clay/shale, loam, dimension stone, peat, flagging stone and bush rock.

In 1995, the plan was amended to reflect changes needed as regional resources became depleted and additional resources identified or redefined. The results of these changes were contained within Sydney Regional Environmental Plan (SREP) N^{O}. 9(2).

The sand and gravel resources of the Penrith Lakes Scheme were considered resources of regional significance under SREP 9(1) and, at the time of gazettal of REP 9(2) in 1995, were of such significance as to be considered under a separate Regional Environmental Plan (SREP 11 -Penrith Lakes).

2.3 SYDNEY REGIONAL ENVIRONMENTAL PLAN N^{O}. 11 - PENRITH LAKES SCHEME AND SUBSEQUENT AMENDMENTS

In February 1981, the then Director of Environment and Planning decided that, in accordance with the requirements of the NSW Environmental Planning and Assessment Act, a draft regional environmental plan and study should be prepared for the Penrith Lakes Scheme area. The Department of Planning sought and obtained the Penrith City Council's support for this decision.

A detailed and comprehensive Regional Environmental Study of the entire Scheme area was prepared under the guidance of a steering committee chaired by the Department of Environment and Planning (DEP) and consisting of representatives of the DEP, Penrith City Council, the then Water Resources Commission, the Department of Mineral Resources, and the Corporation.

The plan, prepared by specialist consultants, examined the environmental issues associated with the planned extraction of the resource and assessed the feasibility of creating a lake scheme as the rehabilitated landform. The study examined the need for the resources, alternative Schemes, recreation needs, infrastructure, and water, air, noise, biological, and cultural environments. These detailed studies form the basis for the assessment of the environmental impact of the Scheme and the background studies for subsequent Development Applications.

The Regional Environmental Study (RES) was publicly exhibited in 1984. Based on the RES and associated submissions, a draft Regional Environmental Plan was prepared by the Department and exhibited in early 1986. Arising from the draft REP and submission received, the Department prepared Sydney Regional Environmental Plan 11-Penrith Lakes Scheme (SREP 11), which was gazetted on November 18, 1986.

The Scheme design evolved from an exhaustive process, which included community consultation. The RES presented three basic designs that were technically, environmentally and financially feasible. These designs were:

- The **Large Main Lake Scheme** which was the most expensive, but maximised recreational opportunities,
- The **Small Main Lake Scheme**, which retained principal access roads such as Castlereagh Road and Farrells Lane, and
- The **Wetlands Scheme**, which was the least expensive, retained principal access roads, and had significant regional water quality benefits.

The community wishes, expressed through Government, Council, special interest groups and the public at that time, supported the Large Main Lake Scheme as the preferred option.

Following the exhibition of the RES, the Minister established a Management Working Party (Government Negotiating Committee) to investigate the most appropriate mechanisms for the effective implementation and future management of the Penrith Lakes Scheme. A formal proposal was presented by the Corporation to the NSW Government in November 1985 for construction of the preferred 'large main lake alternative'.

In August 1986 the Government and the Corporation entered into a Deed of Agreement which defined the rights and responsibilities of each party, in relation to the implementation of the Penrith Lakes Scheme.

This process provided the foundation upon which the Scheme was built. Both the Government and the Corporation have made commitments and significant investments to implement the Large Main Lake alternative. DA4 is a continuation of the established commitments to implement the initial concept decided upon by the community in 1986.

2.3.1 Amendments to SREP 11

Subsequent amendments have been made to SREP 11 and the structure plan forming part of SREP 11.

The first amendment occurred in June 1988. This amendment removed a sunset clause from the original REP after related conditional activities had been completed prior to the date specified in the REP.

Arising from submissions received on the RES exhibition, the Director of Planning requested the Corporation to investigate the possibility of incorporating an international standard rowing course into the Penrith Lakes Scheme. In August 1989, the Minister for Planning, the Minister for Sport and Recreation, and the Corporation entered into an agreement for the construction of such a course within the Scheme.

SREP 11 was amended in May 1989 (Amendment N°. 2) to extend the boundary of the Scheme, which would permit construction of the course to international standards. In November 1989 the Minister for Planning granted consent to:

- an application to modify the consent area to incorporate the rowing course, and
- an application to extract and rehabilitate on additional lands adjoining the consent area to accommodate course requirements.

The additional lands associated with these applications provided another 8 million tonnes to available resource volumes in the consent area.

In 1994, the Corporation lodged an application to amend the Structure Plan associated with SREP 11 (Amendment N°. 3). The proposed amendments were necessary to accommodate the results of detailed flood and stormwater management studies into the Structure Plan. These amendments were approved in November 1994.

As operations have moved further north, the exposed resource has become more and more inconsistent. Areas devoid of resources have been found and prior channels are common throughout the development area. A review of resource knowledge highlighted gaps in information. In 1995 the Corporation commissioned a major geomorphological investigation to determine resource distribution and quality. The outcomes of this investigation suggested a significant downgrade of resource reserves and an upgrade of overburden availability. These outcomes were thought to have major implications for Scheme design.

The Corporation initiated a major design review in mid-1996, with the review focussed on addressing the new resource information and also including associated issues which were being considered at that time.

This review process led to the lodgement of an application to amend the SREP 11 Structure Plan (Amendment N°. 4) to reflect better outcomes with the resources available. The application was lodged in September 1997.

2.4 DEVELOPMENT APPLICATIONS AND ENVIRONMENTAL ASSESSMENT

2.4.1 Development Application 1 (DA1)

Prior to the adoption of the preferred Scheme and completion of the Regional Environmental Study, there was a need to ensure a continuing supply of sand and gravel to shareholder companies. As a result a Development Application (DA1) and accompanying Environmental Impact Statement were lodged in 1981. The DA was approved in July 1982 for the extraction of some 100 hectares of resource-bearing land in the Scheme area. This approval made available an estimated 12.5 million tonnes of sand and gravel resources, sufficient to allow time for detailed planning studies of the Scheme to be completed.

Under SREP 11, provision was made for the submission of sequential Development Applications accompanied by Statement of Environmental Effects for the progressive release of extraction areas of the Scheme's resources. These sequential development application areas are shown on **Figure 2.1.**

2.4.2 Development Application 2 (DA2)

The Minister for Planning approved a development application and Statement of Environmental Effects for the second stage of Penrith Lakes Scheme in February 1987. The DA2 area contained 327 hectares of resource-bearing land, providing an estimated 39 million tonnes of sand and gravel, sufficient to meet requirements for an estimated 8 years.

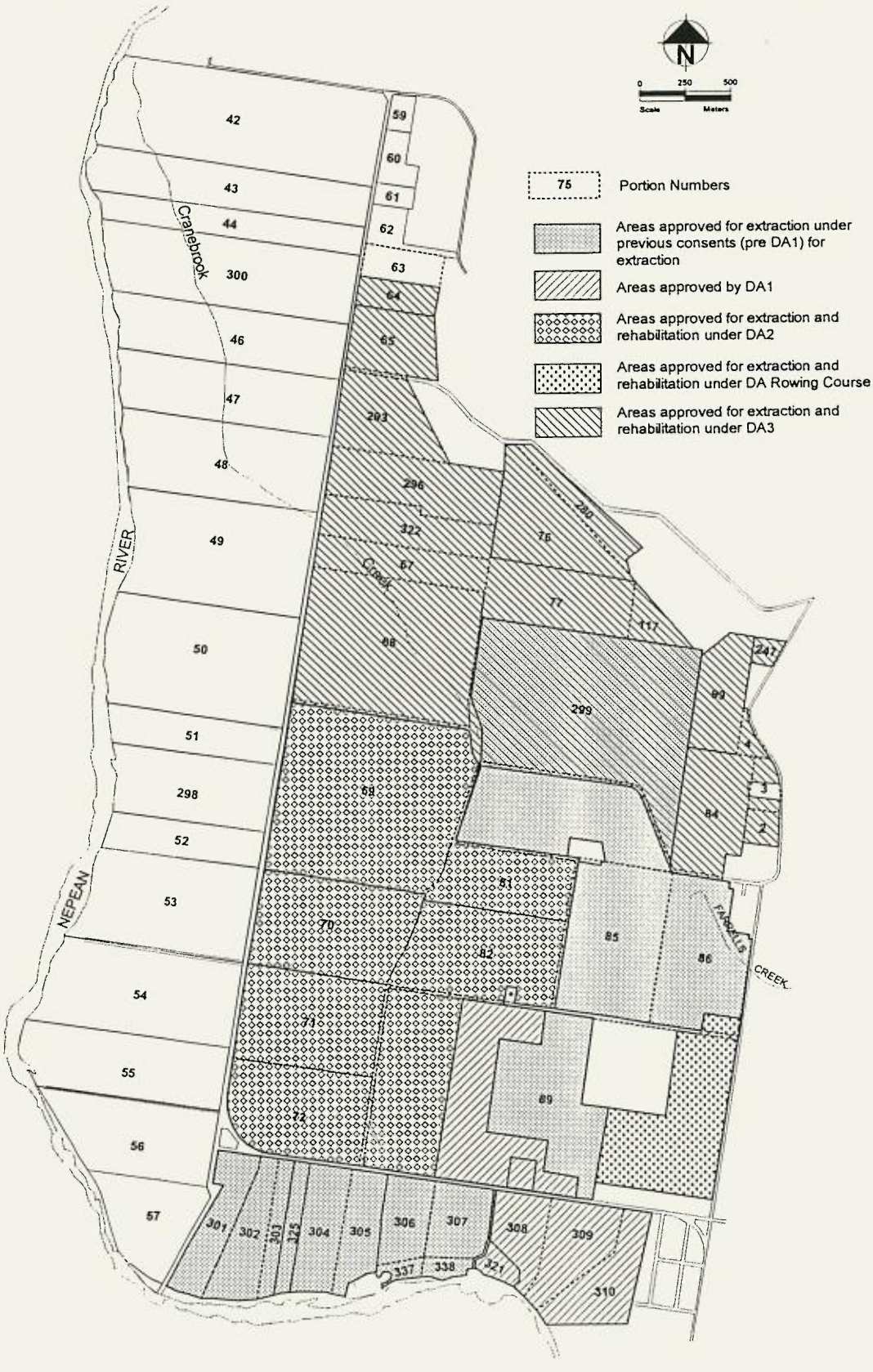


Figure 2.1 Approved Extraction Areas

2.4.3 Development Application 3 (DA3)

DA3 development application and Statement of Environmental Effects were lodged in April 1994 to continue extraction operations north of the DA2 area. The development application area involved approximately 406 hectares and contained approximately 35 million tonnes of resources. The application was approved in June 1995.

2.4.4 Development Application 4 (DA4)

The Corporation seeks consent to quarry the remaining reserves of sand and gravel contained within the Scheme area. This Statement of Environmental Effects accompanies the DA4 application for this development.

The Minister for Urban Affairs and Planning is the Consent Authority for the application.

2.5 CURRENT CONSENT CONDITIONS

The Corporation currently operates within the DA3 area under a conditional consent granted by the Minister for Urban Affairs and Planning in June 1995. A total of 63 conditions form the consent under which the Corporation's activities are carried out.

A summary of these conditions is provided in **Table 2.2.**

2.6 ADMINISTRATION

In 1987, the Penrith Lakes Scheme Monitoring Committee was formed under Section 22 of the Environmental Planning and Assessment Act 1979. This committee, comprising of representatives from eight Government departments and Penrith City Council, has the responsibility of monitoring progress of the Scheme and ensuring compliance with consent conditions. It meets at regular intervals to review Corporation works in the preceding period and to ensure that those works are undertaken in accord with previous approvals and to the agreed standards and specifications.

In respect of rehabilitation works, the Corporation is required to lodge, at two yearly intervals, detailed rehabilitation construction plans. These plans are to cover works for the following two-year period and must be in accord with the Structure Plan. The plans are prepared in consultation with nominated authorities. The Committee reviews these plans prior to them being referred to the Minister for Planning for approval. The required level of guarantee is also reviewed and adjusted if necessary during the process of preparing the two-year plans.

The Monitoring Committee also reviews progress of the Scheme to ensure that rehabilitation works are undertaken in accord with agreed plans, standards and specifications. The Corporation is required to submit a report every two years, providing details of works undertaken during the period and the results of all construction/environmental monitoring.

TABLE 2.2

CONSENT CONDITIONS

Condition N°.	Subject	Condition Requirement
1	Statutory Responsibility	Corporation to meet requirements of all public authorities having statutory responsibility in respect of the development.
2	EPA Approvals	Corporation to obtain approval of EPA under Air, Water and Noise Control Acts.
3-7	Guarantee	Corporation to provide a bank guarantee to the State Government.
8	Existing Consents	Existing consents to be surrendered and replaced with DA3 consent conditions.
9-10	Staged Sequence	Corporation to carry out operations in accordance with submitted plans unless instructed by the Consent Authority.
11-14	Detailed Consent	Corporation to provide at 2 yearly intervals detailed plans of works in consultation with Government authorities.
15-26	Rehabilitation	All land rehabilitation to be in accordance with Land Rehabilitation Manual. Conditions relating to slopes, drainage and erosion control, revegetation, repairs and maintenance, landscaping species selection, plant density, water plants and geotechnical assessment.
27-28	Water	Corporation to maintain water management in accordance with SEE.
29	Noise	Limitations on noise levels set at Cranebrook Village, Castlereagh Escarpment and other dwellings outside the Scheme area.
30-33	Hours of Operation	Hours of operation set for non-noise sensitive areas, operations near Cranebrook Village. Describes procedure for variation to hours, and equipment maintenance.
34-37	Air Quality	Conditions relating to management/monitoring of dust.
38	Heritage	Heritage reports to be prepared in vicinity of heritage sites.
39-41	Transport	Conditions relating to off-road haulage, non-use of public roads, and access.
42	Excavation in Vicinity of Castlereagh Road	Construction of 1.2 m high bund wall no closer than 20 m to Castlereagh Road.
43-49	Other Landowners	Conditions relating to drainage, damage to other property, adverse water supply, limits of working.
50-52	Termination or Temporary Cessation of Extraction	Details requirements for temporary cessation or total cessation of work.
53-63	Monitoring	Details conditions for monitoring of land rehabilitation (compaction, settlement, records and reporting), noise, air quality, monitoring records, certificates of practical completion, inspections and audits.

All plans and reports have been submitted to the Committee within the approved time and to a satisfactory standard. An exception to this were plans for the 1989-90 period where delays were caused by amendments to plans required as a result of incorporating the rowing lake into the Scheme. Plans for the 1995 and 1996 period were delayed because of implications arising from resource evaluation studies.

2.7 APPLICATIONS AND APPROVALS

Activities within the Scheme, other than those associated with agricultural land uses, require the Minister for Planning's approval under SREP N°. 11 - Penrith Lakes Scheme. The Corporation has submitted and obtained approval for the following:

- Construction of SIRC.
- Incorporation of certain lands into DA2 area.
- Construction of administration office.
- Construction of storage and machinery sheds.
- Construction of underpass on Castlereagh Road.
- Incorporation of certain lands into DA3 area.

2.8 THE STRUCTURE PLAN

2.8.1 Amendments to the Structure Plan

The Structure Plan forming SREP 11-Penrith Lakes Scheme is currently subject to an amendment application.

Recent geomorphological studies undertaken by the Corporation have given a more detailed understanding of the remaining resources contained within the Scheme area. Results of these studies have significant influences upon Scheme development and design.

The influences on Scheme development relate to the disposition of resources and inconsistencies within the resources. The principal influence on Scheme development will be how and when resources are extracted, and in association, the timing of rehabilitation works. These matters are the subject of this development application (DA4).

The influences upon Scheme design need to be addressed through a review of the existing Structure Plan under SREP 11. An application to amend the structure plan was lodged in September 1997.

The proposed amended Structure Plan is shown in **Figure 2.2**. The plan shows in general terms lake forms, lake uses, public recreation areas, future urban areas, possible realignments for Castlereagh Road, and heritage precincts. The Structure Plan shows the overall concept of the recreational lake system. Detailed lake and landform design details are included in the two yearly plans subject to approval of the Department of Urban Affairs and Planning. This incremental approval system provides the flexibility necessary for minor changes as the design is further refined during implementation.

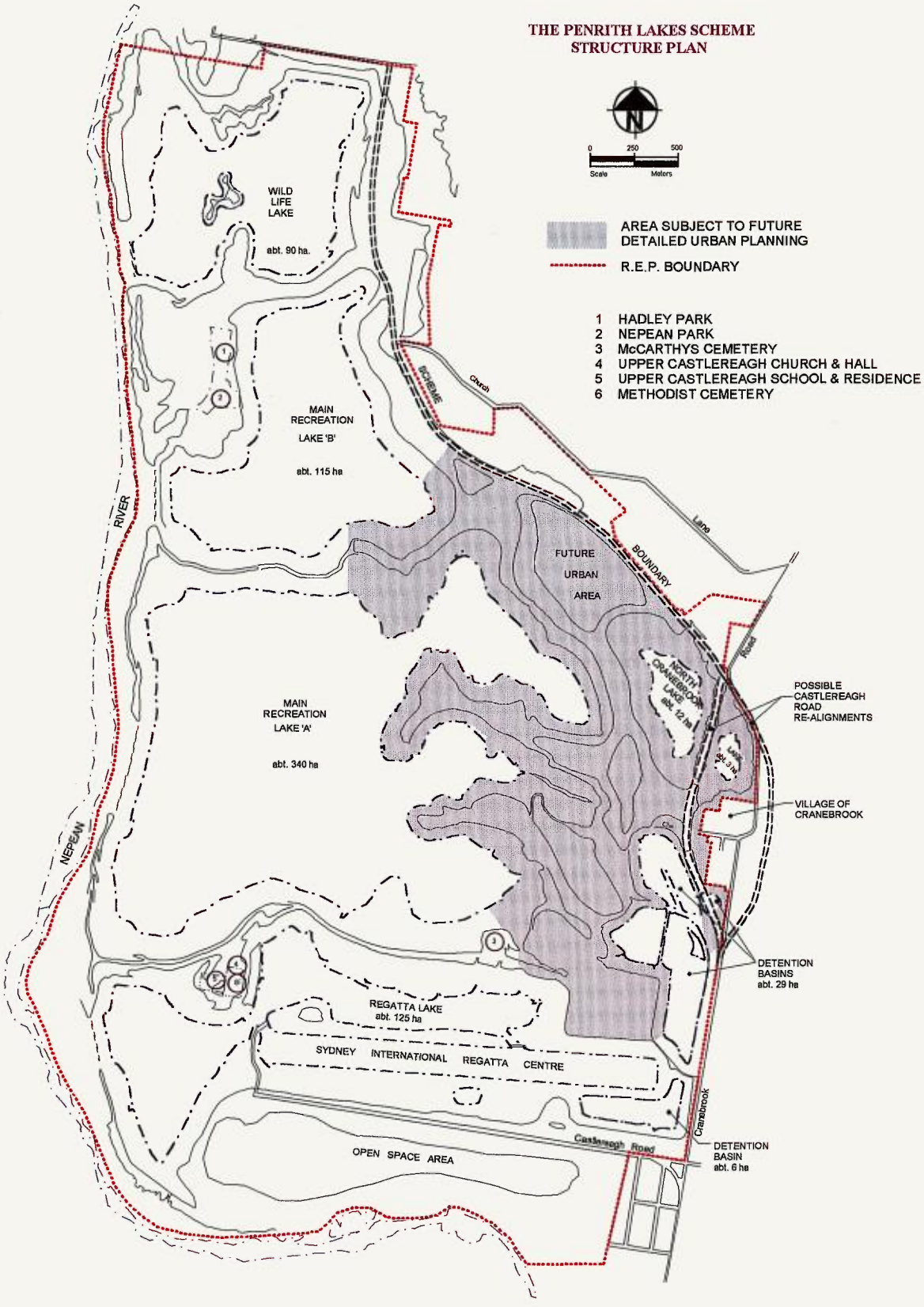


Figure 2.2 Proposed Structure Plan

2.8.2 Scheme Design Considerations

The Corporation needed to address the Scheme design as a result of the resource evaluation investigations discussed in **Section 2.3.1**. In doing so, it took the opportunity to address a number of related issues.

Volumetric Issues

The resource evaluation investigations indicated a significant downgrade of resource reserves and an upgrade of overburden availability. Significant areas within the Scheme, which were to be extracted, were identified as having little or no resource. These areas would not be quarried.

Based on the new geological information, the currently approved Structure Plan was evaluated to determine if sufficient overburden resource was available for its construction. Calculations indicated that there is a 3.3 million m^3 deficit and the currently approved Structure Plan could not be built with the remaining overburden resources.

A phased approach was adopted to assess other implications and opportunities in seeking a balanced design. The proposed Structure Plan shown in **Figure 2.2** can be constructed with the remaining overburden resources.

Aboriginal Heritage

Extensive discussion and interpretation of recent archaeological investigations in the Scheme area has lead to the concept of identifying Aboriginal archaeological conservation zones within the Scheme area. The areas where archaeological artefacts are most likely to be found have been detailed in the many reports prepared since works began in the very early 1980s. These possible conservation areas are shown on **Figure 2.3** and discussed in detail in **Section 7.2**.

European Heritage

European heritage items are found throughout the DA4 area and are described in **Section 7.3**. To assist in deliberations on European Heritage matters for its application, the Corporation established a Heritage Advisory Group consisting of local historical groups, specialist consultants, Government and Council representatives.

The purpose of the group was to provide community input for consideration by the Corporation, recognising that the planning process will seek their comments on detailed proposals during the exhibition period of the application.

For the Scheme design, the following issues were raised for assessment:

- the possibility of retaining Minnaville,
- the possibility of restoring part or all of the Hadley Park property,
- the possibility of retaining the northern part of Castlereagh Road, and
- the possibility of retaining Landers Inn.

Figure 2.3 Possible Aboriginal Archaeological Conservation Zones.

Heritage issues and the impact of the Scheme design are addressed in **Section 7.3**. In regard to Scheme design, these possibilities were assessed in the design process and considered in conjunction with other design variables. The location of each of the above sites is shown on **Figure 2.4** in relation to the currently approved Structure Plan.

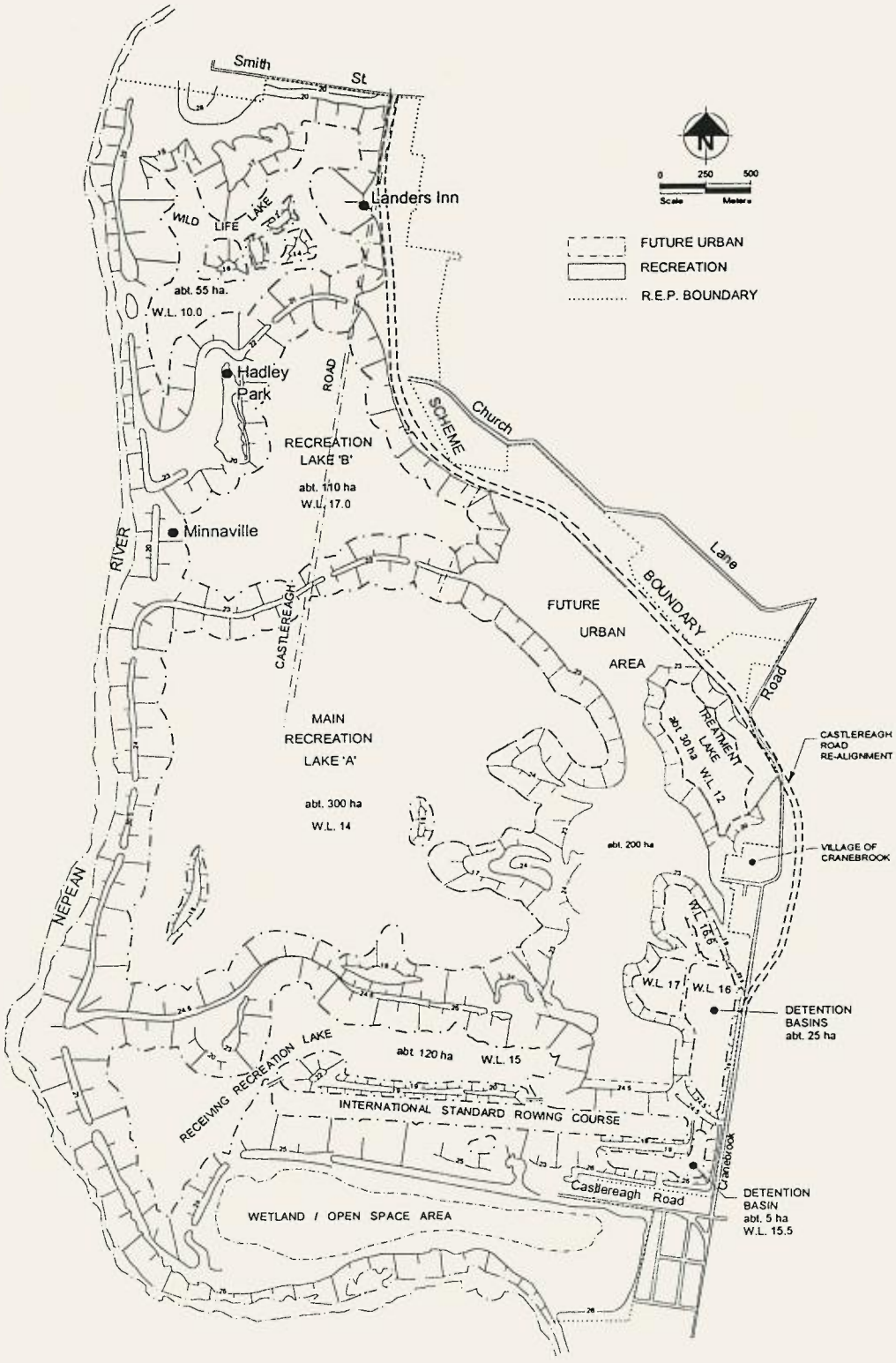


Figure 2.4 Currently Approved Structure Plan showing location of European heritage Items referred to in Section 2.8.2

Urban Development

The Scheme is premised on the construction and development of landforms in the eastern area for urban uses. Detailed planning of these areas for urban development will be undertaken as part of the re-zoning and urban planning process. These works are expected to commence early next year and will provide details of development layouts, land uses and the like.

For forward planning requirements, the Corporation needs to define bulk landform design, topographic relief and construction standards which are appropriate for future urban development. Two distinctly different issues have required a review of future opportunities in respect to urban development.

The first of these related to the probable location of the relocated Castlereagh Road around Cranebrook Village. Preliminary designs for the currently approved location to the east of the Village indicated that some private lands would need to be purchased on the east side of Cranebrook Road, immediately north of the Village. In seeking alternatives to this proposal, the Corporation examined the feasibility of relocating the road to the west of the Village. The amended design provides for the western option. The final decision on the location of the road will be the subject of further detailed investigations associated with the urban development planning process. If the eastern route is to be retained, then landforms constructed for the western route can be used for either internal roads or some other form of development.

The second issue related to the proximity of "no resource" areas uncovered during the DA2 extraction operations. In circumstances where the "no resource" areas occurred near the urban area landforms, the most appropriate solution is to integrate these areas into the urban area, and provide amenity in the lower foreshore area.

Recreation Uses

A recreation management study (Department of Environment & Planning - May 1988) found that the landform designs at that time limited recreational utility around the foreshores. In general, the landforms were a fairly uniform slope from crest to water level. This general design approach was developed from the concept of best use of the overburden resource and application of agreed landform drainage standards.

The existence of "no gravel" areas near the foreshores presented opportunities to add recreational utility to the foreshore areas. Increasing recreational utility at the foreshore area has been considered in the design review of the Scheme.

A key feature of the currently approved Structure Plan is that it provides for club sailing courses on the main recreation lake. Generally, club sailing courses are equilateral triangles with 1.25 to 1.5 kilometre legs. The course needs to be able to be set out in any direction around a central pivot to account for changes in wind conditions. This was seen as a key feature to be retained in the design review.

Drainage

As part of its rehabilitation proposals, the Corporation has introduced a concept of perched ephemeral wetlands to enhance the establishment of frog populations. These wetlands are integrated into the landform drainage systems and include the provision of native wetland flora such as sedges and the like.

2.8.3 The Proposed Structure Plan

The proposed amended Structure Plan is shown on **Figure 2.2** and some of its features are described below.

Water Management

Water management for the amended design will be very similar to the currently approved Structure Plan. A minor difference is the splitting of the lake to the north of Cranebrook Village and the raising of the water levels in these lakes from RL 14m AHD to RL 18 m AHD.

The lakes will be interconnected by pipeline and operate in a similar manner as the single lake. The water levels have been increased to provide improved amenity in a small urban lake situation. It is expected that the water quality performance of this lake will be similar to that of the shallower lake.

Water Area

Table 2.3 indicates the total water areas for individual lakes that have been presented in previous Structure Plans of SREP 11 developed during the design stages of the Scheme. A principal aim of the design review is to maintain the integrity of the original concept drafted during the early planning stages of the Scheme. This can be monitored by comparison of lake areas.

TABLE 2.3
LAKE AREAS (HECTARES)

Lake	Original Design	Amendment N°. 3	Proposed Design
Main Lake 'A'	365	380	340
Main Lake 'B'	143	110	115
North Cranebrook	33	30	15
Detention Basin	22	30	35
Wildlife Lake	98	55	90
Regatta Lake	112	120	125
Totals	**773**	**725**	**720**

The total combined area has remained approximately the same through the amendments. The proposed design is slightly less in total lake area than the currently approved Structure Plan although there is some variation between individual lakes. As the recreational amenity has been maintained in the principal recreational lakes, the adjustment to the individual areas presents no potential reduction in overall quality and utility.

Urban Area

The Corporation has commenced preliminary planning associated with the urban development. This planning was necessary to provide guidance on landform design and topographic disposition. The early planning has identified a very strong synergy between the recreational area, the urban area and other features in the Penrith area. Potential opportunities for both future urban and recreational development, particularly at the open space/urban and adjoining lands/urban interfaces warrant exploration in detail to identify the most appropriate level of development.

Future detailed planning, as part of the re-zoning process will firm up the necessary details associated with the development. This formal planning process will provide the opportunity for community input into the development. As detailed planning has not yet commenced, it would be premature at this stage to raise specific design issues related to the urban development. These issues will be addressed in separate studies prepared for public comment and assessment when complete.

Flooding

Detailed studies of flooding of the Scheme (University of NSW 1992 and 1997) indicate that the proposed design will maintain the Scheme's flood protection system. As the lake area has not significantly changed between designs, the integrity of the overall protection system will be maintained in the new design. There may be minor adjustments required to weir sizes and downstream slope. These will be assessed during the final design stages of the flood protection system.

2.8.4 Relationship of DA4 to Existing Development

Extraction and rehabilitation in the DA4 area will complete the Penrith Lakes Scheme. The area adjoins the northern and western boundaries of the existing DA3 area and principally encompasses land between the existing extraction areas and the Nepean River. During operations in the DA4 area, Castlereagh Road will be relocated to the base of the Castlereagh escarpment.

3.0 JUSTIFICATION AND ALTERNATIVES FOR DEVELOPMENT OF THE DA4 AREA

3.1 ECONOMIC CONSIDERATIONS

3.1.1 Uses of Quarry Products

Extractive operations in the Penrith Lakes Scheme area yield a resource comprising a mix of various sizes of gravel and coarse sand. The material forms the raw feed for the processing plants where the sand sized material is separated from the river gravel by a complex series of crushing, washing and screening processes to form various sizes and blends of quarry products. The resultant washed sand and crushed and screened aggregate form the basic materials used in concrete, asphalt, foreshore protection, and railway ballast.

River Gravel

River gravel may range from pebble to boulder size and generally produces a high-quality aggregate whether crushed or uncrushed. Gravel used in concrete and asphalt must comply with Parts 1 and 2 of Australian Standard 2758-1985 and generally for high strength concrete and asphalt products, crushed aggregate is preferred because of its larger surface area and adhesion value. Factors such as the shape of the crushed gravel, its density, strength, porosity and permeability, chemical stability, and grading are important is assessing the quality and use of the aggregate and it must be clean, hard, tough and durable.

Crushed aggregate produced from the floodplain of the Nepean River has traditionally produced a consistent high quality concrete aggregate used throughout the Sydney Region.

Coarse and Fine Sand

Construction sand is used in making concrete and mortar, and for filling and other general construction purposes. The dominant application is in concrete where it is used as a fine aggregate and where sand with different grain sizes and grain shapes is needed. As with crushed aggregate, the sand must meet stringent specifications and standards for the particular use to which it is applied.

As with crushed aggregate, the Penrith Lakes Scheme has continuously produced a high quality coarse sand for use in concrete. Recent investigations have shown that a resource of fine sand also occurs in particular resource units within the DA4 area and can be economically exploited to supplement dwindling supplies of this type of sand in the Sydney Region. (See **Section 3.1.5**).

3.1.2 Locational Factors

Extractive materials are a resource, which cannot be replenished. In terms of weight and volume more construction materials have to be quarried and moved to construction sites than any other type of resource material. It is for these reasons that extractive material source areas need to be located as close as possible to their point of usage. The value to weight ratio is very low, making transport costs to the market highly sensitive. Any increases in transport costs are eventually passed on to the community through higher prices and thus higher building and construction costs.

The low unit values also mean that there is limited potential for use of alternative or recycled materials, because of the greater handling and processing costs involved.

3.1.3 Demand and Production

The NSW Department of Urban Affairs and Planning in association with the Department of Mineral Resources have undertaken detailed investigations to identify the demand for aggregate and sand from existing and future sources of these materials. These investigations are detailed in working papers prepared for Sydney Regional Environmental Plan N°. 9(2) - Extractive Industry (Department of Urban Affairs and Planning, 1995) and a briefing paper prepared by the Department of Mineral Resources on construction sand (Oakes, Lishmund and Paterson, 1996). These documents provide the principal sources of the following information.

Factors affecting the future demand for sand and hard rock aggregate products are complex. Short-term demands are generally affected by the market fluctuations in the building and construction industries, while long-term demands are more influenced by the population growth and variations in per capita consumption. **Table 3.1** details projected demand for sand and hard rock aggregate in the Sydney Region to the year 2011.

TABLE 3.1
DEMAND FOR SAND AND HARD ROCK AGGREGATE
(Million Tonnes)

Year	Sand		Hard Rock Aggregate (Sydney Region)
	Low	High	
1993/1994	5.23	5.23	7.70
1994/1995	5.23	5.29	7.72
1995/1996	5.23	5.35	7.74
1996/2001	26.15	27.60	38.94
2001/2006	26.15	29.04	39.39
2006/2011	26.15	30.49	39.83

Source: Sydney Regional Environmental Plan N°. 9(2) (1995)

The Sydney Region uses about 7.5 million tonnes of hard rock aggregate and 6 million tonnes of sand per annum.

Of the total sand demand, approximately 37% comprises medium/coarse sand (2.3 million tonnes), 33% fine/medium (2.1 million tonnes), and 30% clayey sand (2 million tonnes). (Oakes, Lishmund and Paterson, 1996). The Penrith Lakes Scheme has to date, provided medium/coarse sand to the market, and at an annual production rate of 1.7 million tonnes provides 74% of the medium/coarse sand requirements.

The Scheme produces in the order of 3 million tonnes of coarse aggregate per year and provides approximately 40% of the Sydney Region's requirements for these materials.

3.1.4 Existing Sources and Remaining Reserves

Table 3.2 identifies the existing sources and estimated reserves of coarse aggregate and medium to coarse sand in the Sydney Region.

TABLE 3.2
ESTIMATED AGGREGATE AND MEDIUM TO COARSE SAND RESERVES
(Million Tonnes)

HARD ROCK AGGREGATE	Secured	Total
Sydney Region Quarries	9.5	9.5
Somersby Plateau Quarries	41.0	64.0
Penrith Lakes	89+	89+
Illawarra Region Quarries		
Existing	77.5	161.0
Potential	59.0	2119.0
Total	**276.0**	**2433.5**
MEDIUM TO COARSE GRAINED SAND	**Secured**	**Total**
1. Penrith Lakes	53.2+	53.2+
2. Hawkesbury Nepean River		
* Penrith to Pitt Town	11.0	30.0
* Downstream of Pitt Town		46.5
1. Richmond Lowlands		114.0
2. Colo River		25.9
3. Berowra Creek		2.0
Total	**64.2**	**271.6**
FRIABLE SANDSTONE	**Secured**	**Total**
1. Newnes Plateau	34.2	500.0+
2. Somersby Plateau	11.4	75.0+
3. Maroota	3.8	40.0
Total	**49.4**	**615.0**

Notes:

- Secured reserves are identified reserves in company ownership that have development consent for extraction, or in the case of Penrith Lakes, company ownership with a separate planning instrument for extraction.
- Total deposit size includes secured reserves, those in company ownership without development consent and those not in company ownership.
- Friable sandstone varies in grainsize from fine to coarse. It can be used as a substitute for both medium-coarse and fine-medium sands traditionally obtained from rivers, floodplains, estuaries and beaches. For this reason, it has been included in the above table.
- Richmond Lowlands contains substantial reserves of coarse aggregate but is primarily regarded as a sand resource.

\+ These figures are to be reduced in line with **Section 3.1.5**

As indicated in **Table 3.1**, the Sydney Region will require in the order of 118 million tonnes of coarse aggregate between 1996 and 2011. Secured reserves are in the order of 267 million tonnes providing adequate reserves well into the next century.

Adopting the low demand figure of **Table 3.1**, the Sydney Region will require approximately 78.5 million tonnes of medium to coarse sand between 1996 and 2011. **Table 3.2** shows that secured reserves of medium to coarse sand in the Sydney Region are only 64 million tonnes of which 53 million tonnes (83%) are located within the Penrith Lakes Scheme area confirming the importance of the Scheme as a medium to coarse sand resource.

The Department of Mineral Resources has recently reviewed the availability of sand, and in particular fine to medium sand for the Sydney Region (Oakes, Lishmund and Paterson, 1996). The major source of fine-medium sand has been Kurnell, which has been supplemented by supplies from Chipping Norton/Georges River and the clayey sand deposits of Elderslie, Londonderry and Maroota. Kurnell is expected to cease production within 10 years, while Chipping Norton and Londonderry are expected to cease production in the near future. Elderslie has reserves available for extraction until about the year 2010. While reserves in the Maroota area are in the order of 40 million tonnes, environmental constraints are expected to limit large-scale extraction of sand from this area. Other sources are at increasing distances from the Sydney Region and include Newnes Plateau, Somersby Plateau, and Stockton Bight.

The Department of Mineral Resources (Oakes, Lishmund and Paterson, 1996) predicts that unless major new resources become available, the Sydney Region will be obtaining up to 50% of its supplies from other regions within 10 years. This is viewed as a serious concern, since the increased costs of transport from the more distant sources will result in increased building and construction costs. The Department recognises a need for a coordinated strategy within state and local Government agencies if the predicted shortages in supply and associated increased costs to the community are to be avoided or minimised.

Recommended in this strategy is the need to optimise the utilisation of supply within the Region.

3.1.5 Reserves Remaining in the Penrith Lakes Scheme

Remaining reserves of sand and gravel within the Scheme have recently been re-evaluated (Valerie Smith & Associates, 1995). These investigations have shown that the sand and gravel occurs within a series of resource units representing different depositional periods of the Nepean River. Each of these units comprise different and variable proportions of sand and gravel in the resource horizon, and have variable thicknesses of resource and overburden. Most of these units are separated by former channels that are predominantly devoid of resource material. Recent geological investigations have identified a resource of fine sand within one of the units (Unit H), which has the potential to be exploited to provide additional resources to the Sydney Region. **Figure 3.1** shows the distribution and variability of the resource units within the remaining Scheme area.

The re-evaluation has assessed remaining sand and gravel reserves within the balance of the DA3 and DA4 areas as at July 1996 at 80 million tonnes, comprising approximately 51% gravel (41 million tonnes), 41% sand (33 million tonnes) and 8% silt/clay (6 million tonnes).

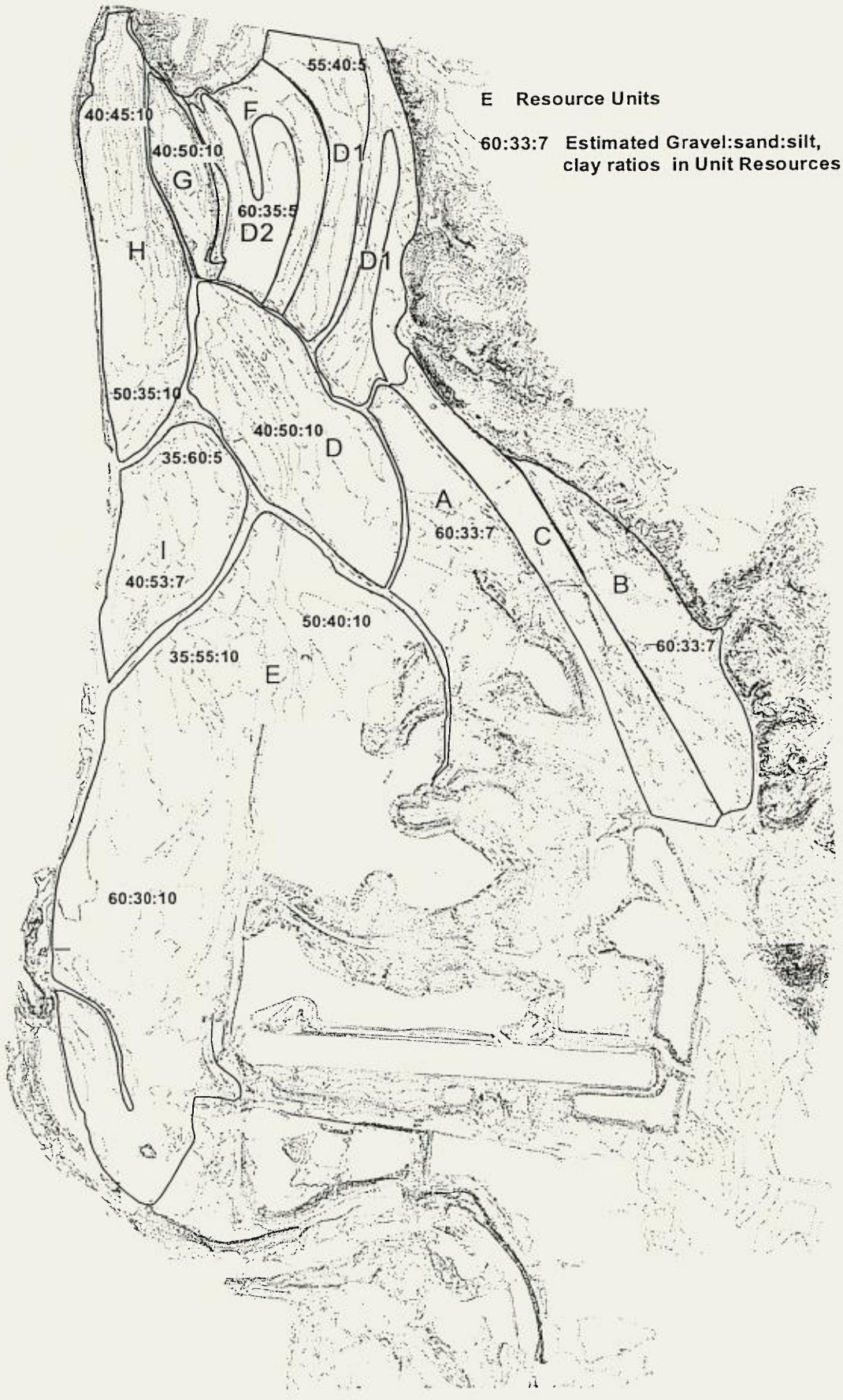


Figure 3.1 Geomorphic units.

At current consumption rates, it is estimated that the Scheme resources will be exhausted by 2010 or 2011 during which time the Scheme will provide more than 80% of the Sydney Region's demand for medium to coarse sand. Actual completion date of the Scheme will depend on future consumption rates experienced, which vary considerably in response to Sydney's building and construction activity. It is expected, however, that the Penrith Lakes Scheme will continue to be the major source of coarse aggregate and sand to the Sydney Region over this period.

Approximately 6 million tonnes of fine sand, of which 4 million tonnes is capable of being processed to market quality, occurs in Unit H. Previously this material was interpreted as overburden. The current application proposes extraction and utilisation of this resource to assist is addressing the acute shortfall of this material in the Sydney Region. Extraction rates in the order of 600,000 tonnes per annum are proposed with the operation having a life of approximately 10 years.

The variability of the Penrith Lakes deposit requires that commercial matters must be considered in determining supply arrangements to shareholder plants. The different ratios of sand to gravel in the resource horizon require consideration. With the increasing ratios of sand to gravel, sand determines the commercial strategies of the shareholders by balancing extraction rates from the Scheme with resources available from other deposits. Proposed raw feed extraction rates, adjusted for these commercial strategies, are provided in **Table 3.3.**

TABLE 3.3
PROPOSED EXTRACTION RATES FROM PENRITH LAKES
(Million tonnes)

Year	Annual tonnes of 'raw feed'	Fine Sand	Total Extraction
1997-1998	6.0	-	6.0
1998-1999	6.0	0.3	6.3
1999-2000	6.0	0.6	6.6
2000-2001	5.7	0.6	6.3
2001-2002	5.6	0.6	6.2
2002-2003	5.3	0.6	5.9
2003-2004	4.8	0.6	5.4
2004-2005	5.1	0.6	5.7
2005-2006	4.8	0.6	5.4
2006-2007	5.0	0.6	5.6
2007-2008	5.3	0.6	5.9
2008-2009	5.4	0.3	5.7
2009-2010	5.1	-	5.1
2010-2011	3.5	-	3.5
TOTALS	**73.6**	**6.0**	**79.6**

3.2 SOCIAL CONSIDERATIONS

The Penrith Lakes Scheme has a positive impact on direct and indirect employment in the Penrith area.

The Corporation, its shareholders, and long-term contractors, directly provide employment for approximately 450 personnel in extraction, haulage, processing, transporting, administration and on-site contract employment, and is a major and significant private employer in the area. Its direct and indirect expenditure in the Penrith local government area is $38.2 million, and $114.3 million per annum in the Greater Western Sydney Region.

Indirectly, the operation provides employment for support services, such as fuel and equipment suppliers, specialist contractors, business services, and retail trades. Both labour and support service needs are drawn from the Penrith area wherever possible. In situations where specialist services and material are required from outside the local area, spin-offs are received in terms of provision of accommodation, meals, entertainment and the like, which are a positive benefit to the Penrith region.

Already the Sydney International Regatta Centre (SIRC) is providing positive economic and social impacts on the Penrith community. This area represents less than 10% of the Scheme area and a completed Scheme will make an enormous contribution to the local community.

The creation of the Lakes Scheme will provide an extensive recreational resource for the population of the Sydney Region and a much-needed regional water-based facility. The Olympic Rowing Course will be used in the 2000 Olympic games attracting an estimated 30,000 people per day to the Penrith area, with the resultant economic and social benefits that will flow to the region.

3.3 ENVIRONMENTAL CONSIDERATIONS

The environmental requirements of the Department of Urban Affairs and Planning, other Government agencies, and those required to be addressed under Sydney Regional Environmental Plan N°. 11 (Amendment N°. 3) have been addressed in this document.

Potential adverse impacts on natural and man-made environments as a result of quarrying operations within the Scheme area have been taken into consideration and mitigated by the adoption of quarry plans and environmental management procedures as outlined in this Statement of Environmental Effects.

3.4 ALTERNATIVES

3.4.1 Constraints

A wide range of factors affects the selection of the optimum resource and quarry site. These include the availability of resource material of suitable quality and quantity to support an economic quarrying operation, proximity to market, suitable access over sealed roads, topographic suitability for the extractive technique, ability of the site to be satisfactorily rehabilitated, planning and environmental constraints.

Geological Constraints

Rock types and sand suitable for concrete and asphalt must be clean, tough and durable. The sand and gravel occurring intermingled in the resource horizon must be generally present over the area to be quarried and to the depth of the proposed operation. Variations in material quality result in poor quality control and inconsistent products that cannot meet appropriate standards and specifications on a consistent basis. The project manager on a construction project has to have confidence in the quarry products that are used in the project to ensure they can consistently meet the project requirements.

The Penrith Lakes Scheme has traditionally provided a high quality and consistent aggregate suitable for a wide range of concretes and asphalt. There are no other known approved alternatives in close proximity to Sydney.

Planning and Economic Constraints

A quarry operation is industrial by nature; it uses heavy machinery, involves a processing procedure, and utilises road routes for transporting its products. These features are common with most industrial users of land. But it also has several unique characteristics that make it different from other forms of industry; viz:

- It can function only where nature has deposited the raw material.
- It is self-consuming-the longer it operates at any one location the shorter is its remaining life span.
- The value to weight ratio of its products is very low, making the transport distance and hence transport cost to the market of particular significance in establishing its utility.

For these reasons, the quarry needs to be located as close as possible to potential markets and for the industry to require strategic consideration in any regional landuse planning.

Environmental and Social Constraints

In selecting the optimum quarry site, consideration needs to be given to environmental constraints imposed on this type of operation. These include the proximity of residences and landuses that may be affected by noise or dust; measures to reduce the visibility of the quarrying operation; the ability to rehabilitate the quarry site to a sustainable landuse; protection of sensitive flora, fauna and archaeological/heritage sites; access to a suitable road system to reduce impacts on roads and traffic; and the appropriateness of the site for the incorporation of control measures for water quality, noise, dust, flooding, and visual amenity.

3.4.2 Alternative Scheme Designs

The Regional Environmental Study (1984) evaluated over 27 Scheme alternatives in terms of Scheme objectives, technical considerations, and environmental implications. These are discussed in **Section 2.3.1**.

The Corporation and the Government, following community consultation, made commitments in 1986 to implement the large Main Lake Scheme. Approved work over the last 10 years preclude the possibility of implementing either of the other two schemes. Minor design changes are possible, but the principal concept needs to be maintained.

3.4.3 Alternative Sources

The 1995/96 utilisation rate from the Scheme area was 5.2 million tonnes, producing 3.12 million tonnes of gravel and 1.67 million tonnes of sand with the balance being discharged as tailings. This generally reflects the consumption of the 60:33:7 ratios expressed in Units A & B.

The geomorphological units shown on **Figure 3.1,** indicate that there is substantial variation in the gravel:sand ratios. If, for example, the 1995/96 extraction were undertaken in Unit D, then resource yields would have been 2.1 million tonnes of gravel and 2.6 million tonnes of sand. This would create problems as too much sand would be generated for the market and would require extensive stockpiling with the shortfall in gravel being made up from other regional deposits.

With the new information it is possible to develop extraction strategies which better suit market conditions, with such strategies having sufficient flexibility to accommodate shifts in the various market components. The Corporation established criteria for the development of an extraction strategy. These criteria identify the Scheme's role in meeting regional demands for sand and gravel resources and accounts for probable movements in other regionally significant resources. The development of such criteria is essential to ensure that component parts of the market are supplied in the most efficient and cost effective manner. The basic criteria adopted by the Corporation are:

(a) maintain the current sand production rate of 1.67 million tonnes per annum and the gravel rate of 3.12 million tonnes per annum,

(b) between mid 1997 and 2000 the production of sand is not to exceed 2.0 million tonnes per annum,

(c) from 2000 onwards the sand production should not exceed 2.2 million tonnes per annum, and

(d) gravel production should not exceed present levels.

Production levels were determined from existing mine schedules using two basic cases, holding gravel production constant or holding sand production constant.

Using the currently planned sequence of extraction operations would yield significant variations in total extraction levels. For constant gravel production extraction rates would yield a variation of 2.6 million tonnes per annum.

Under this strategy, sand would become a major issue, as there would be 7 continuous years where sand production would exceed market demand. This would require the development of major stockpiles, which is economically and environmentally unacceptable. For constant sand production, the variation would be less, at around 1.9 million per annum. However, there would be 9 continuous years where gravel production fell short of market demand. Other regionally located hard rock quarries could supply any shortfall in gravel production.

An alternative strategy was developed to address these market issues. The underlying principle of the strategy is to blend gravel rich resources with sand rich resources to match the expected market.

This strategy yields much less variation and meets expected sand market requirements and only requires minor supplementary gravel "top up" to meet gravel market requirements.

The alternative strategy involves the early access into resources west of Castlereagh Road, commencing just south of the intersection with the former Farrells Lane. The deposit is then extracted in both a northerly and southerly direction. The main advantage of this strategy is that it can readily accommodate any marked shifts in sand or gravel requirements.

The re-sequencing of the extraction operations can significantly influence the final design form of the Scheme, as it must remain a sequential operation and areas cannot receive fill until they are extracted. This issue must be addressed along with other design variables in determining the most appropriate final design.

The proposed development for DA4 is an orderly extension of works already undertaken by the Corporation and is consistent with the overall development of the Penrith Lakes Scheme. Scheme development is progressing generally in accord with plans and concepts, environmental safeguards are working and sand and gravel supplies are being maintained to the Sydney market. **Section 3.1.3** highlights the significance of the Penrith Lakes deposit in terms of contribution to the Sydney market for medium-coarse grained sand and hard rock aggregate.

If approval to this development application is not granted, or if it is delayed, there would be a number of serious economic and environmental consequences.

SREP N°. 9 (2) identifies possible alternative sources of supply and these are listed in **Table 3.4.**

TABLE 3.4
ALTERNATIVE SOURCES OF SUPPLY

Medium to coarse grained sand	• Hawkesbury Nepean River • Richmond Lowlands • Colo River
Friable sandstone as substitute	• Newnes Plateau • Somersby Plateau • Maroota
Hard rock aggregate	• Somersby Plateau (Kulnura/Peats Ridge) • Illawarra Region • Mittagong

Source: SREP N°. 9(2) 1995

It should be noted that Draft SREP N°. 9 (2) did not consider Richmond Lowlands as a potential source of significant volumes of hard rock aggregate.

While SREP N°. 9(2) identified sufficient resources of hard rock aggregate well into the next century, the depletion of the Nepean River gravels will result in increased supply from the more distant quarries in the Illawarra, Mittagong and Somersby areas.

Studies by the Department of Mineral Resources (Oakes, Lishmund and Paterson, 1996) have established that there are few undeveloped major source of sand in the region which could be considered as alternative sources of supply. These are: Richmond Lowlands (230 million tonnes), the Maroota deposits near Wisemans Ferry (80 million tonnes), the Wrights and Wellums Creeks deposits (resources large but not quantified). All of these deposits are affected by difficult, unresolved environmental and other issues, and only the Richmond Lowlands deposit could be regarded as having both major resources and convenient location.

The Department of Mineral Resources has also identified large sources of sand within deeply weathered (friable) sandstone deposits in adjacent regions in the Southern Highlands and on the Newnes Plateau. Significant quantities of sand are already being supplied to the Sydney Region from these deposits, and it seems likely that they will become the main sources of construction sands in the longer term, whether major additional sources are made available within the region itself or not. Increased reliance on these deposits will increase the cost of construction sand within the Region, primarily as a consequence of increased transport and processing costs, and incur significant environmental costs if road transport remains the preferred choice for delivery to Sydney.

Optimising the usage of current sources of supply of hard rock aggregate and sand within the Penrith Lakes Scheme will partly address the issues and aid in minimising the predicted costs to the community in the short to medium term.

If there is a delay, consequences will depend on the extent of delay. Pre-stripped reserves can continue to be extracted but no further reserves will be exposed. Reduction in pre-stripped reserves leads to unsafe working conditions. Prior to the pre-stripped reserves being totally exhausted, the Corporation shareholders would implement contingency plans to continue supply from existing sources. In respect of sand, this would involve increased production from the Hawkesbury-Nepean River, Newnes Plateau, Somersby Plateau or Maroota. In respect of hard rock aggregate, supply would be from Somersby Plateau or the Mittagong and Illawarra Regional quarries.

If this development application is not approved then the market would need to be satisfied from alternative sources, albeit applications would need to be lodged for those which are secured at present. In respect of sand, Richmond Lowlands and Colo River are potential sources, while extension of Hawkesbury-Nepean River deposits, Newnes Plateau, Somersby Plateau or Maroota deposits are also possible. Choices for hard rock aggregate are limited to the Somersby Plateau and quarries in the Illawarra Region.

In either case, consequences of delay or non approval are similar, increased cost of supply or increased pressure for development on other deposits. Infrastructure already exists for the Penrith Lakes deposit to supply more than 5 million tonnes of product annually. At this level of production there is approximately 800 truck loads per day leaving the Penrith area. These truck movements would be transferred to routes associated with other deposits, most of which are not capable of supporting such traffic loads. The Richmond Lowlands, Maroota and Hawkesbury-Nepean River deposits are in environmentally sensitive areas and careful consideration will need to be given to their potential development. Development of other areas will increase the cost of supply as they are much more remote from the market. In economic terms, it is estimated that if other sources had to be used, the cost of pre-mixed concrete would increase by more than 20%, which will cause substantial increases in building costs.

This development application is an orderly and logical extension of an existing development. The likely environmental and economic consequences of being forced to use other sources make the approval of this development application essential if building and construction in the Sydney metropolitan area are to continue without serious financial implications.

3.4.4 Alternative Materials

Apart from some 'natural' rock materials which find use in local roadworks but not in high quality aggregate uses, only one other material can be used successfully as a substitute to hard rock aggregate; slag.

Blast furnace slag produced at the Newcastle and Port Kembla steelworks is a direct replacement for natural rock as a quarry product. As with all bulk materials used in construction, transport distance limits the use of slag to areas surrounding the steelworks. The long haul distance from Newcastle or Port Kembla to Sydney renders the use of slag in these areas as generally uneconomic.

The Department of Mineral Resources (Oakes, Lishmund and Paterson, 1996) has evaluated alternative sources of fine sand, including slag and quarry sand. Slag sand (ie, granulated blast furnace slag) and quarry sand (ie, sand produced by crushed gravel and hard rock-generally as a by-product of the production of coarse aggregate) have only limited potential to contribute to Sydney's future construction sand needs in the foreseeable future.

The chemical instability of slag sand makes it much less desirable than natural sand, which mostly comprises relatively inert quartz. Also, slag sand is generally only considered an alternative to coarse sand, as processing to yield fine to medium-grained particles would be energy intensive and therefore expensive.

While quarry sand is available in a range of sizes it is a 'sharp' product (ie, angular) and therefore is limited to applications where grain shape is of little importance or where angular grains are preferred. It is not considered an acceptable alternative to naturally occurring sand where rounded or sub-rounded sands such as dune sands are required. In addition, supplies are generally dependent on demand for other products (mostly crushed gravel or hard rock) as crushing and/or grinding solely to produce sand is rarely economically justifiable.

Sintered fly ash has been investigated by Pacific Power as a potential alternative to natural fine aggregates. However, the fine sized material is 'sharp' (angular and would have to be transported from power stations in the Hunter Valley or Lithgow areas and hence would incur considerable transport costs. In addition, industry has demonstrated that in practice the material is unsuitable for use as sand.

3.4.5 Alternative of Not Proceeding with the Development

The sand and gravel deposits in the Penrith Lakes Scheme are highly suitable for use in concrete and asphalt and occur in large quantities to enable economic extraction. The area is close to the growing Sydney metropolitan area and major road networks. The environmental studies presented in this document demonstrate that there are no significant environmental constraints to development.

To haul materials from more distant sources results in higher transport costs, which are passed on to the general public through increased charges for materials. The

more distant the source, the longer the haul distance, and the higher the impacts on roads and road users. If the development does not proceed:

- Sydney will have an immediate crisis in the supply of aggregates to the concrete and building industry in the region.
- Alternative, more distant sources will need to be developed or upgraded with resultant increased costs to the community.
- The cost of concrete and associated products could be expected to rise as material is required to be hauled from more distant sources increasing transport costs. This would lead to higher impacts on roads and road users.
- There will be a significant loss of jobs and revenue to the Penrith and Greater Western Sydney regions and the construction industry.
- The integrity of the Penrith Lakes Scheme would be jeopardised and the opportunity to develop a significant recreational resource and flood mitigation system for the population of Sydney would be significantly reduced.
- Works already completed in the Scheme including the SIRC would not be sustainable. Flooding cannot be managed unless the Large Main Lake Scheme is completed.

4.0 DESCRIPTION OF THE PROPOSED DEVELOPMENT

The extent of the Development Application for DA4 is to enable the continued extraction and rehabilitation of the Penrith Lakes Scheme. The principles of overburden stripping and placement, quarrying of the resource, tailings management, dewatering, and rehabilitation as established in previous DA areas will be maintained during development of the DA4 area. These methodologies are constantly being revised in light of new technology, new information on the performance of the Scheme, and changing views, and where these occur are described in each subsequent Development Application. In **Section 4.1**, the current methodologies are described as a prelude to the description of the proposed development in the DA4 area.

4.1 EXISTING OPERATIONS

4.1.1 Rate of Extraction

The rates of sand and gravel extraction from the Scheme area are shown in **Table 4.1.** Prior to 1982/83 resources available to the Corporation were contained in lands over which Penrith City Council had granted consent to extract to individual quarry companies. The timing of consents is shown in **Table 4.1**.

TABLE 4.1

RATES OF EXTRACTION, PENRITH LAKES SCHEME 1980/81 - 1997/98

Year	Tonnes (millions)	Area of Extraction
1980/1981	3.9	Previous Consents
1981/1982	4.3	Previous Consents
1982/1983	2.8	DA1
1983/1984	3.2	DA1
1984/1985	4.0	DA1
1985/1986	4.4	DA1
1986/1987	4.9	DA1+DA2
1987/1988	5.0	DA2
1988/1989	5.5	DA2
1989/1990	6.2	DA2 + DA(Rowing Lake)
1990/1991	5.8	DA2 + DA(Rowing Lake)
1991/1992	5.8	DA2 + DA(Rowing Lake)
1992/1993	5.0	DA2 + DA(Rowing Lake)
1993/1994	5.0	DA2 + DA(Rowing Lake)
1994/1995	5.3	DA2 + DA(Rowing Lake) + DA3
1995/1996	5.5	DA3
1996/1997	5.7	DA3
1997/1998	6.1*	DA3

* *Forecast*: Based on actual extraction to date plus forecast to year-end.

The DA3 resource was expected to yield 35 million tonnes, providing sufficient supplies for 7 years based on an assumed extraction rate of 5 million tonnes per annum. Average extraction rates since extraction commenced in DA3 is 5.8 million tonnes, bringing the theoretical completion date to the end of 2000/01.

However, the actual yield of 35 million tonnes has been significantly downgraded as a result of the detailed geomorphological studies. Sufficient resources remain in the DA3 area to provide volumetric requirements until about the end of 1999. Additionally, as **Sections 3.4.3** and **4.4** explains, there is an issue with quality and optimum utilisation of the resource. This issue is relatively new in respect of the Scheme, as quality information has not previously been available.

4.1.2 Overburden Stripping

Volumes of overburden stripped by the Corporation are show in **Table 4.2**. Annual variations generally reflect changes in depth of overburden, rate of raw feed extraction and adjustment to pre-stripped reserve levels.

Prolonged periods of wet weather cause difficulties in maintaining adequate stocks of pre-stripped reserves. During such periods overburden stripping operations cease because the site conditions deteriorate to the extent that stripping machinery cannot operate satisfactorily or safely. However, gravel extraction can continue during such periods. This results in a consumption of the pre-striped reserves.

TABLE 4.2

OVERBURDEN STRIPPING 1982/1983 TO 1997/1998

Year	Volume Stripped (million cubic metres)
1982/1983*	1.12
1983/1984	1.37
1984/1985	1.69
1985/1986	1.24
1986/1987	1.01
1987/1988	1.46
1988/1989	2.18
1989/1990	3.11
1990/1991	2.46
1991/1992	2.47
1992/1993	3.51
1993/1994	2.79
1994/1995	3.00
1995/1996	2.62
1996/1997	4.21
1997/1998**	3.73

* Estimate: detailed recording commenced late 1982

** Forecast: based on actual plus year-end forecast.

In general, the Corporation aims to maintain at least six months pre-stripped reserves available. Extended wet periods in 88/89 necessitated an extension in operating hours to 11:00 p.m. to enable pre-stripped reserve levels to return to normal operating conditions. Since that time climatic conditions have been such that there has been no incidents which caused pre-stripped reserve levels to decline to unsatisfactory levels.

4.1.3 Tailings Management

Raw feed extracted from the Scheme area is washed in the three processing plants to remove clays and silts. This washing produces residues known as tailings. These are pumped as slurry from each of the processing plants to a long-term disposal area just south to Castlereagh Road. Here the clays, silts, and fine sands are allowed to settle with clarified water being recycled to the washing process at the plants. The Corporation is responsible for the operations and management of this system.

Since the Corporation took over responsibility for the long-term disposal of tailings in 1988 approximately 4.6 million dry tonnes of tailings were pumped to the area just south of Castlereagh Road by the end of 1996/97.

4.1.4 Dewatering

The Corporation is responsible for the total dewatering management of the areas of operations. It has an obligation to the shareholder companies to ensure the quarry pits are dry to aid in the extraction and screening processes. Geotechnical requirements, when placing fill places constraints on operations. Fill areas have to be dewatered prior to the placement of overburden to ensure agreed geotechnical standards are achieved.

Water from these operations is generally used within the site to meet requirements of the processing plants, maintain water levels in lakes and for dust control. There have been periods when surplus water accumulates on the site, particularly after prolonged wet periods. In these circumstances stored water is discharged from the site to neighbouring creek systems. These discharges are made under conditions attached to an Environment Protection Authority (EPA) Licence.

No discharges have been made since March 1994 as after this time sufficient fill areas became available to contain the water within the Scheme.

4.1.5 Haul Roads

The Corporation is responsible for the construction and maintenance of haul roads within the Scheme. Haul road locations as at September 1997 are shown in **Figure 4.1** and are generally in accord with raw feed traffic arrangements detailed in the DA3 Statement of Environmental Effects.

There has been an overall decrease in trucks using the haul roads with a general trend of replacing 50 tonne payload trucks with 85 tonne payload trucks.

4.1.6 Rehabilitation

The total land area involved in previously approved extraction and rehabilitation areas represent approximately 60% of the total Scheme area. The scope and standard of rehabilitation works varied depending on when consents were issued.

In areas where consent was issued prior to DA1, rehabilitation requirements were relatively limited in scope and were not coordinated. The standard of rehabilitation works under these consents did not meet the standards currently required. The Corporation gave undertakings that these areas would be rehabilitated in accord with the same rehabilitation standards as apply to the total Scheme area. The timing of these works is dependent upon their location in respect to the active quarry operations. Such rehabilitation works are more economically undertaken when quarry operations are nearby.

Areas affected by DA1 consents were rehabilitated to Scheme standard, even though no formal requirement had been agreed as to standards at the time the works were undertaken. Areas affected by DA2 and DA (Rowing Lake) and DA3 have been or will be rehabilitated to agreed standards.

Figure 4.1 shows the general layout of quarry and rehabilitation areas as at September 1997. General features are:

- Only areas containing sand and gravel resources are designated as "Remaining Resource" - Area 1 is in northwest corner near Church Lane. Area 2 is just to the north of Cranebrook Village.
- The tailings operations described in **Section 4.1.3** uses the area immediately south of Castlereagh Road as a site for the permanent disposal of tailings. The eastern cell of the system is almost filled and will be decommissioned within the next two years. The western cell will be reconfigured to accommodate further tailings disposal.
- Between the tailings area and the Nepean River, special works have been undertaken to ensure the long term stability of this section of Nepean River Bank. These works are described in **Section 4.1.8**.
- Immediately to the north of the tailings area is the Corporation's Site Office area. The Corporation's new administration centre was completed in July 1994. A large shed was constructed in 1987 to house a flood model. The area also contains various structures and equipment used to service the Corporation's day to day activities.
- South of the Model Building is Long's House (RES Heritage Item N°. 19) which is used as a training centre by Mission Employment. This issue is described in **Section 1.6.2**.
- Immediately east of the Administration area is the Penrith Lakes Environmental Education Centre. This issue is further described in **Section 1.6.3**.
- Just north of the Administration area is the Sydney International Regatta Centre. The SIRC is the first completed rehabilitated area open for public usage. The Olympic Coordination Authority is responsible for the management of this area. Features of the SIRC are further described in **Section 1.5**.
- On the eastern side of the site is the detention basin system constructed to divert upstream drainage into the SIRC lakes and to provide wash water for the Pioneer Plant. This matter is further discussed in **Sections 5.1.3**.
- The main recreation lake is commencing to take shape north of the SIRC lakes. The southern portion has stored excess water from SIRC overflows.
- Almost all of the old extraction areas approved prior to SREP 11 have been rehabilitated.

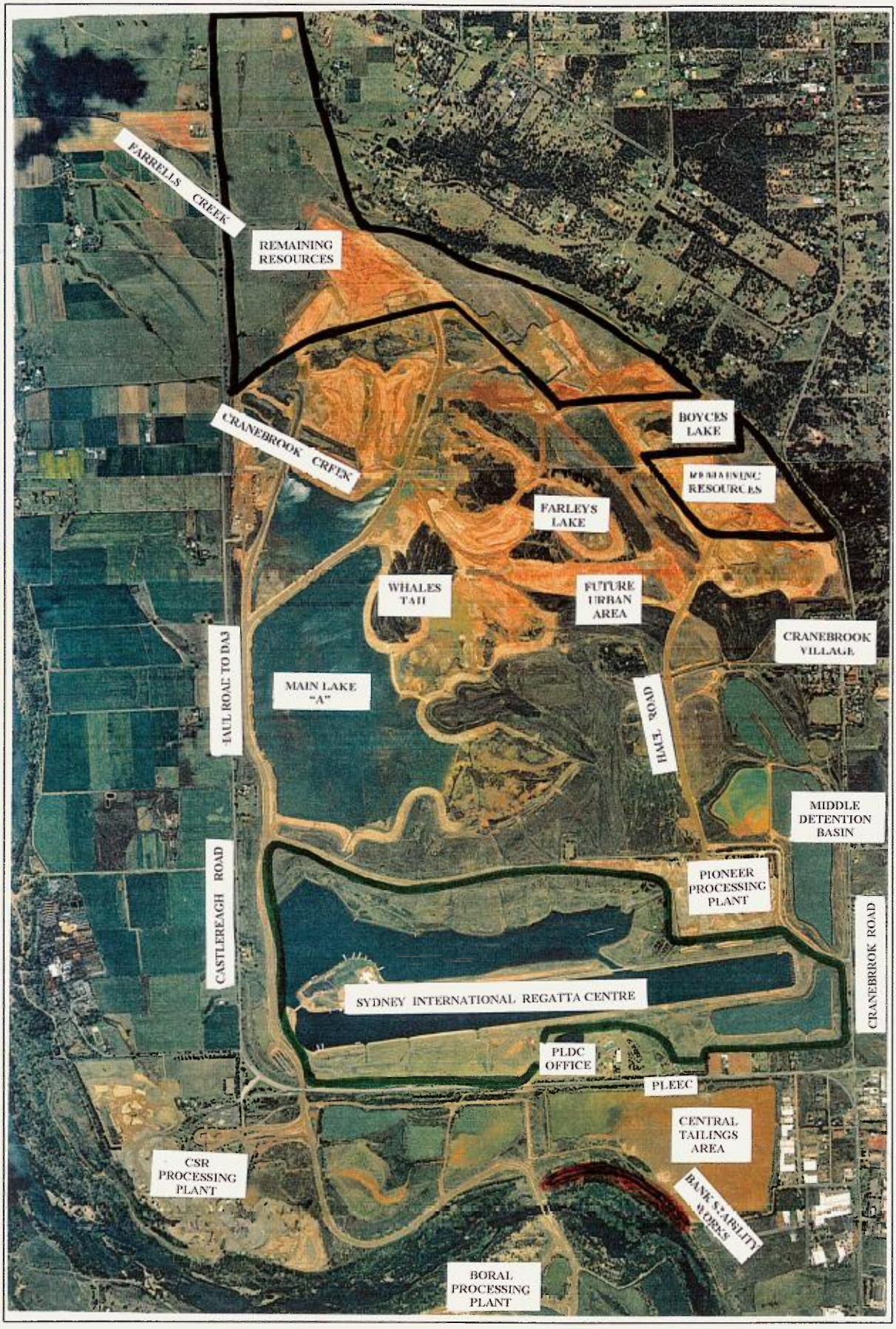


Figure 4.1 Quarry Rehabilitation Areas, September 1997

4.1.7 Geotechnical Considerations

Landforms constructed in the Scheme have specific geotechnical requirements. In general, the main components are:

- Foreshores: toe of foreshore slope to be compacted to minimum 95% Standard dry density ratio.
- Cores: central cores in water retaining embankments to be compacted to minimum 98% Standard dry density ratio with initial 1 metre layer to be lime stabilised.
- Urban area: top 4 metres of fill to be compacted to a minimum of 98% Standard dry density ratio and bulk fill to average not less than 95% Standard dry density ratio.
- Structures: special design requirements are placed on drainage structures/roads and the like.

The Corporation undertakes compaction tests at the rate of 1 test per 2500 m^3 in 95% Standard zones and 1 test per 1000 m^3 in 98% Standard zones, and 1 test per 2000m^3 in bulk fill below the top section in urban areas. Results of these tests are routinely forwarded to the Penrith Lakes Scheme Monitoring Committee for its review.

The Corporation also installs and monitors settlement plates in particular areas following completion of rehabilitation works. These plates, installed at a frequency of 1 plate per hectare, are used to monitor the settlement characteristics of the deep fill.

Settlement information is essential to determine the fill's capacity to adequately support buildings. Survey information of these plates is routinely forwarded to the Monitoring Committee.

4.1.8 Bank Stability

Special protection works are undertaken to ensure the long-term stability of the foreshores. Foreshore configuration is considered during the design process and is varied in slope and plan view depending on exposure to prevailing winds. Following placement of overburden, the foreshore is capped with a 500mm layer of sand and gravel (raw feed), and small hard headlands are constructed in key positions to trap littoral sediments mobilised by storm winds. This combination of measures will provide long term stability to constructed foreshores.

In the SIRC regatta course, special consideration was given to foreshore stability. Construction of headlands along the length of the course is not appropriate if international standards for the course are to be maintained. In this circumstance the fine materials which would make up the littoral sediments were screened from the raw feed prior to placement as wave protection material.

Foreshore protection works constructed to date are shown on **Figure 4.1**. All foreshores in the SIRC area and the Detention Basins adjoining Cranebrook Road have been completed. Further north, protection works have been completed in the Main Lake A area from the very south east corner to a point north of where Farrells Lane used to be.

In addition, the foreshores of Farleys Lake immediately north of Farrells Lane, which were constructed before DA1, have been removed because they did not meet agreed rehabilitation standards. They have been replaced with foreshores that comply with standards.

The Corporation has examined the stability of the southern portion of the Nepean River bank in detail. Groundwater wells, to track groundwater movement through the bank, were installed in several sections of the bank during 1989. Results indicated that water moving from the tailings area through the bank toward the river could induce instability in the bank's overburden.

Vertical drains have been constructed along the length of the bank show in **Figure 4.1**. These drains extend through the overburden into the underlying sand and gravel. This will direct groundwater from the overburden to the sand and gravel and prevent the overburden from becoming saturated. Monitoring has continued since these drains were constructed. Results indicate that the drains are performing their intended purpose.

4.1.9 Revegetation/Soil Erosion Control/Landscaping

The design of landforms takes into consideration a range of inter-related issues. Prominent among those issues is the long-term stability of the bank from the effects of erosion. All landforms are designed and constructed in accord with the provisions of the "Land Rehabilitation Manual" prepared by the Soil Conservation Service for the Corporation.

Landforms include the specially designed erosion control drains. Once the basic landforms have been constructed, topsoil taken from adjacent stripping areas is spread on the landform and trimmed by a grader. Particular attention is given to levels in the drains to ensure that it is free draining. Large rocks are then removed from the area and pasture grasses sown. The mix of seed is varied according to the time of year. During autumn and winter cover crops such as oats are used to provide temporary cover and the area re-sown with permanent pastures in the following spring.

Operational experiences gained by the Corporation during the wet period from 1989-91 indicated that greater emphasis needed to be given to erosion control during the general landform construction phase. The Soil Conservation Service was engaged to look at this particular issue and advised on techniques to reduce sediment losses from partially constructed landforms during intense rainfall periods. These techniques have now been incorporated into routine construction works.

Along with trees planted by the Olympic Coordination Authority, approximately 63,500 trees have been planted in the Scheme area since commencement of works.

4.1.10 Water Management

As part of its DA2 consent conditions, the Corporation was required to prepare and submit a Water Plan detailing future studies, monitoring and associated works. This Plan provided the framework for assessment of water management issues related to the development of the Scheme. Studies associated with this plan will continue through to the completion of the Scheme.

Major studies undertaken as part of the Water Plan are shown in **Table 4.3**. These studies form an integral part of the Corporation's activities and are either reported to the Monitoring Committee as required, or form the basis of applications to amend Scheme design if findings of the studies warrant such actions.

TABLE 4.3

WATER STUDIES

Water Source	Completed. Sampling program has provided sufficient information for final design of pump station and future quality modelling works.
Flooding	Completed. Physical model testing provided information on final designs. Structure Plan amended to suit findings.
Lake Behaviour	In progress. UWS contracted to develop model to test management strategies.
Local Runoff	Completed. Detailed monitoring report by UNSW finalised. Results essential for Lake Behaviour studies.
Aquatic Biology	Completed. Works now directed toward establishment of favourable aquatic biological structure in lakes after rehabilitation work completed.
Stormwater	Completed. Structure Plan amended to suit findings. Farrells Creek drainage diverted into SIRC lakes.
Nutrients	Completed. Results used in lake behaviour studies.
Groundwater	Ongoing. Monitoring undertaken to identify any possible adverse impacts caused by development of Scheme.

The Corporation is responsible for water quality management within the Scheme area. The SIRC area was handed over to the State Government in July 1995. The Olympic Coordination Authority (OCA) is currently the authority that manages the site on behalf of the Government. A close working relationship has developed between the OCA and the Corporation for the land and water management of the site.

The original intention of this lake in terms of water management was to provide facilities to protect the water quality of the downstream recreation lakes. In regard to water quality objectives it was intended that this lake achieve "Secondary Contact" standards which are appropriate for rowing, canoeing and the like. Current usage of the lake includes triathlons and long distance swimming events. In this circumstance "Secondary Contact" is not appropriate. Water quality objectives for this lake is "Primary Contact" and ANZECC guidelines have been adopted for quality management of the lakes.

The Corporation has entered into a contract with AWT EnSight to undertake water quality monitoring on its behalf. The sampling and analytical program has two basic components, the first being focussed on public health aspects. The second component provides information on lake chemistry and behaviour to enable better management decisions. Public health results obtained for 1996/97 are shown in **Figures 4.2** and **4.3**.

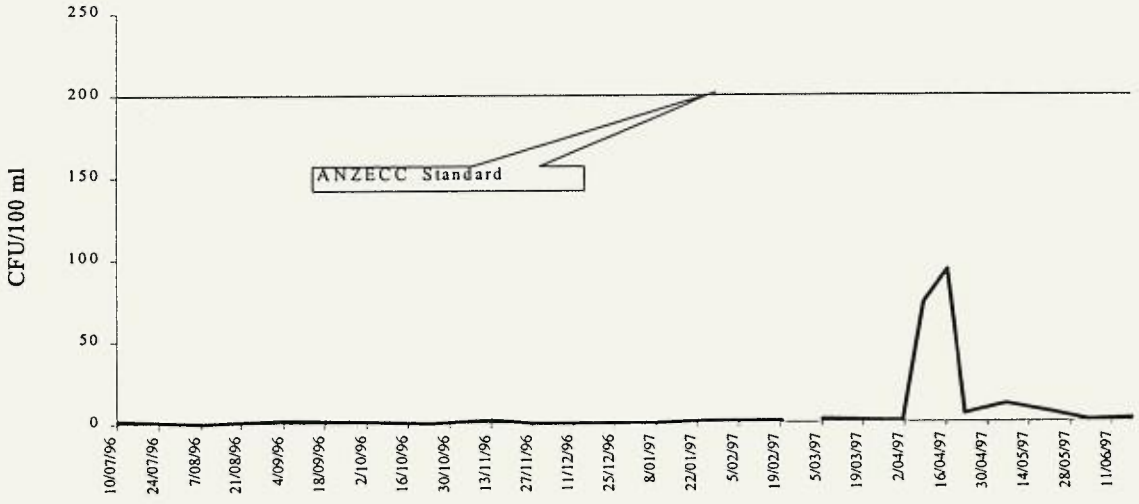


Figure 4.2 Faecal Coliforms 1996/97

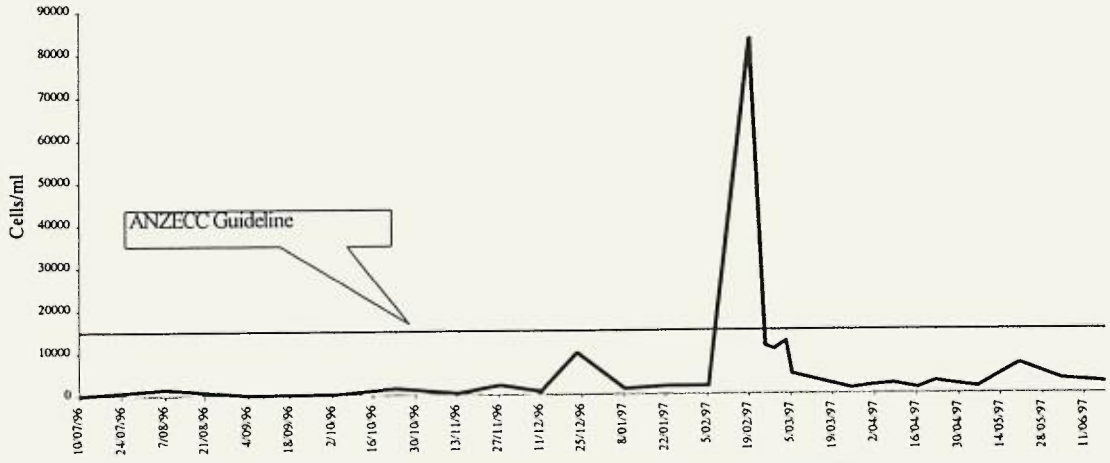


Figure 4.3: Blue-Green Algae Counts 1996/97

The above results in public health terms indicates that the SIRC Lakes met "Primary Contact" criterion during 1996/97 in respect of Faecal Coliforms. The criterion was achieved in respect of Blue-Green Algae counts, except for a short period in late February 1997. This criterion was achieved throughout all of 1995/96.

Extremely heavy rainfalls occurred during February 1997. Overflow infrastructure from the SIRC Lakes to the Main Lake A was blocked to allow major earthworks to be completed in the downstream lake. As a result the SIRC Lakes stored the majority of water draining from the upper catchment during February. The height of the SIRC Lakes rose and stayed at about 1.6 metres above normal water level for about two weeks. During this period oxygen depletion occurred in the bottom sediments, nitrogen to phosphorous ratios changed and thermal stratification established. These rapid changes created conditions conducive to blue-green algae growth.

The SIRC Lakes are still relatively immature and appear to be very responsive to shock loads. Such rapid responses will diminish as the lake ecosystem develops and contributes to the stabilisation processes. Management experience gained by this phenomenon provides valuable insight into the complexity of shallow freshwater lake behaviour.

In terms of public health management during the February period, the following immediate actions were implemented:

- frequency of sampling was increased,
- toxicity testing was undertaken, and
- the OCA were regularly advised of results.

Longer-term management strategies include the acceleration of the establishment of aquatic ecosystems using the processes mentioned in **Section 5.1.4** and the application of Total Catchment Management principles to the upper catchment as described in **Section 5.1.3**.

4.2 LOCATION AND PROPERTY DETAILS

The extent of the area subject of the current DA4 is shown on **Figure 1.1**. It adjoins the existing DA3 area and represents progression of the Scheme's activities to the north and west. The size and boundaries of the DA4 area are in accordance with the staging of the overall Scheme as detailed in the Planning Report accompanying SREP 11 - Penrith Lakes Scheme. The total area encompassed by DA4 is 737 hectares, of which approximately 649 hectares (88%) will be extracted.

The boundaries of the DA4 area are formed by the eastern bank of the Nepean River from approximately Smith Street, south to the previous Sheens Lane. The boundary trends north along the eastern boundary of Sheens Lane to Castlereagh Road then east along the southern side of Castlereagh Road to the eastern abutment of the bridge at Birds Eye corner. The boundary extends in a northerly direction along the eastern side of Castlereagh Road and then in an easterly direction along the northern boundary of private property to the Castlereagh escarpment. From there, the boundary trends in a northerly direction to Wilchard Road West and then west along the southern side of Wilchard Road and Smith Street.

It is estimated that the DA4 area will yield in the order of 63 million tonnes of sand and gravel which, with the remainder of the DA3 resource, is sufficient to meet the requirements of the Sydney market to about the year 2011 when reserves will have been exhausted.

Figure 4.4 and **Table 4.4** show property details for the lands included in the application. About 649 hectares will be new extraction and rehabilitation areas and the balance, while not required for quarry purposes, is required to maintain Scheme integrity and for rehabilitation purposes. Most of the latter land is along the bank of the Nepean River.

The table shows that approximately 21 hectares of land is owned by the State and local Government. These lands are to be acquired for quarry purposes with the titles remaining vested in the Minister for Urban Affairs and Planning.

Within the DA4 area, all freehold land is owned by the Corporation or its shareholders with the exception of Nepean Park Pty Ltd, who have agreed to be included in the application but not to quarrying at this stage. The Corporation will respect the wishes of the owners of Nepean Park and negotiate access to the resources if agreed. The lands listed in **Table 4.5** and shown on **Figure 4.4** are excluded from the DA4 application. If negotiations on these properties are successful in the future, then a separate Development Application will be lodged for extraction.

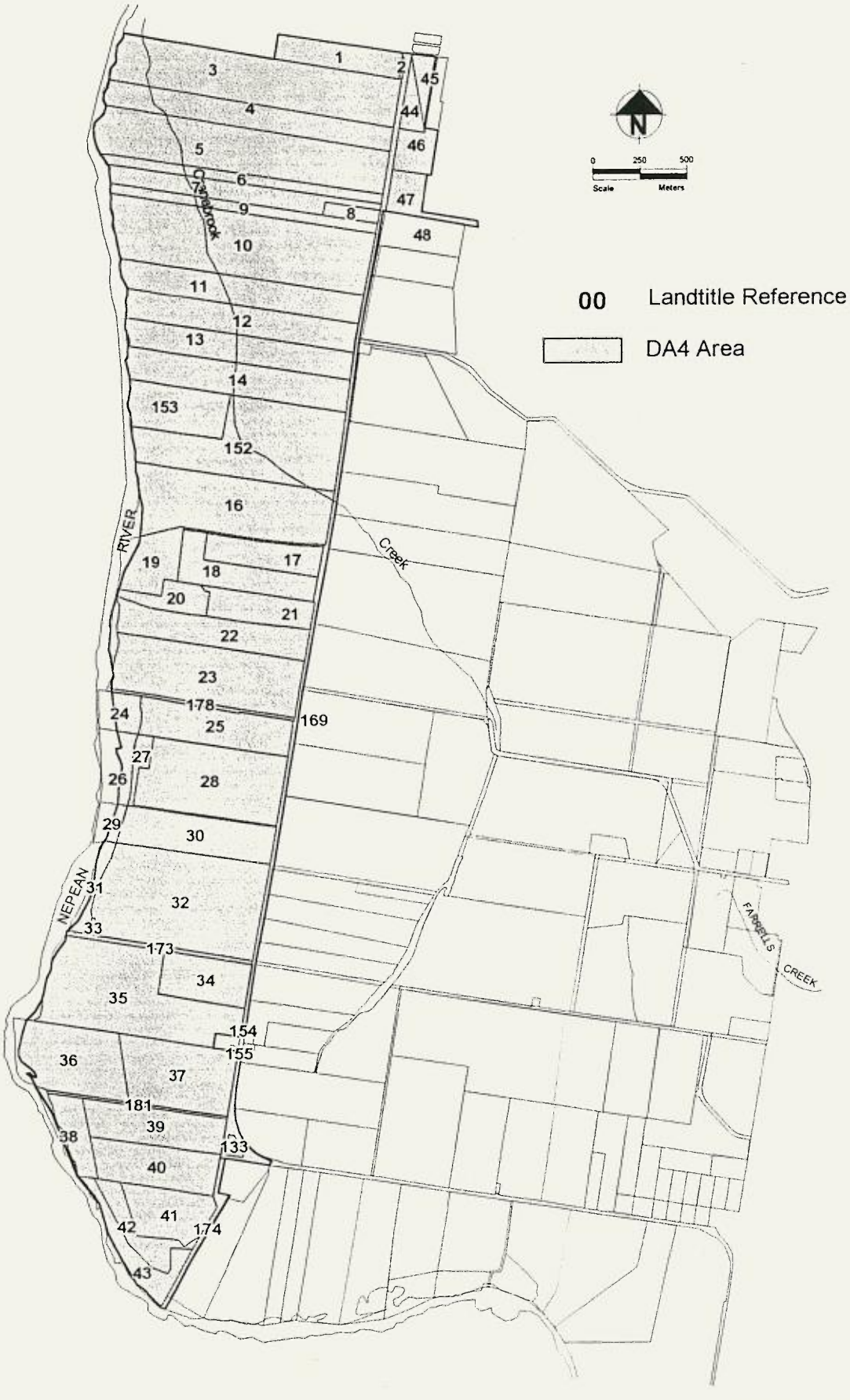


Figure 4.4 Property Details

TABLE 4.4
PROPERTY DETAILS - DA4 (Figure 4.4)

PLDC Land

Ref	Description	Torrens Register	Vol.	Fol.	Conv	Bk	Area (ha)
1	Lot 471 DP 558416	471/558416	12116	85			9.146
2	Lot 470 DP 558416	470/558416	12116	84			0.101
3	Part Por 42				988	3192	32.375
4	Lot 1 DP 63308	1/63308	11693	241			19.350
5	Por 43				852	3702	36.130
6	Lot 1 DP 73955	1/73955	3460	31			7.845
7	Lot 1 DP 120891	1/120891	7777	57			13.000
8	Lot 1 DP 120872	1/120872	7777	56			2.023
9	Part Por 44				130	3136	6.475
10	Lot 300 DP 752021	300/752021	7074	206			45.190
11	Part Por 46				422	3462	18.129
12	Lot 1 DP 60859	1/60859	15175	87			18.720
13	Lot 1 DP 87060	1/87060	6733	116			17.820
14	Lot 2 DP 87060	2/87060	6733	115			20.230
16	Lot 1 DP 219895	1/219895	9849	93			32.390
17	Lot 21 DP 530256	21/530256	10914	62			8.966
18	Lot 45 DP 545813	45/545813	11695	145			11.530
19	Lot 44 DP 545813	44/545813	11695	144			11.220
20	Lot 42 DP 546220	42/546220	11695	157			5.373
21	Lot 23 DP 530256	23/530256	10974	64			8.650
22	Lot 3 DP 219895	3/219895	9849	95			15.950
23	Lot 1 DP 436198	1/436198	12771	89			29.690
24	Part Por 51				687	2228	4.705
25	Lot 4 DP 2223	4/2223	13771	232			15.710
26	Part Por 298				709	1948	9.308
27	Lot 2 DP 348979	2/348979	5446	194			2.668
28	Lot 2981 DP 128099	2981/128099	8258	233			27.980
29	Part Por 52				386	2236	3.237
30	Lot 1 DP 2223	1/2223	916	35			16.130
31	Part Por 53				917	2240	3.490
32	Lot 2 DP 236125	2/236125	10784	45			43.563
33	Lot 1 DP 236125	1/236125	10784	44			0.355
34	Part Por 54				491	2973	11.470
35	Part Por 54				483	2050	39.651
36	Lot A DP 374807	A/374807	13771	231			20.390
37	Lot B DP 374807	B/374807	6614	133			20.890
38	Lot 1 DP 128036	1/128036	7209	143			5.911
39	Lot 2 DP 128036	2/128036	7209	142			14.120
40	Lot 56 DP 78686	56/78686	7209	144			14.770
41	Lot X DP 421674	X/421674	8380	19			11.090
42	Lot Y DP 421674	Y/421674	8380	20			6.370
43	Order N$^{o.}$ F151934 Part Por 57		6178	202			7.285
44	Lot 104 DP 599725	104/599725	13906	14			2.587
45	Lot 103 DP 599725 (Part Only)	103/599725	13906	13			2.716
46	Lot 2 DP 630803	2/630803	15010	63			5.287

Ref	Description	Torrens Register	Vol.	Fol.	Conv	Bk	Area (ha)
47	Lot 34 DP 241197	34/241197	11624	62			5.136
152	Lot 481 DP 849952	481/849952	4558	110			35.284
174	Sheens Lane Lot 1 DP 47720	1/47720	15721	175			1.920
		Subtotal					**702.326**

Private Land

Ref	Description	Torrens Register	Vol.	Fol.	Conv	Bk	Area (ha)
133	Comm. for Main Roads	1/419190	8168	52			0.749
153	Nepean Park Pty Ltd	482/849952	4558	110			13.727
		Subtotal					**14.476**

Roads

Ref	Description	Torrens Register	Vol.	Fol.	Conv	Bk	Area (ha)
169	Castlereagh Road (Part) MR N°. 155 (Pen.C.C.)	Govt. Gaz. 9.10.1942 N°. 136					14.40 by scale
173	Jacksons Lane (Pen.C.C.)	Govt. Gaz. 26.2.1964 N°. 79					1.970
		Subtotal					**16.37**

Crown Land

Ref	Description	Torrens Register	Vol.	Fol.	Conv	Bk	Area (ha)
178	Non Public Crown Road	Road between Pors 50 & 51 rem.					2.630
181	Crown Subdivision Road	Road between Pors 55 & 56					0.964
		Subtotal					**3.594**

TABLE 4.5
LAND EXCLUDED FROM THE DA4 APPLICATION

Ref	Description	Torrens Register	Vol.	Fol.	Conv	Bk	Area (ha)
48	Mary Saliba Camenzuli	2/617921	10934	210			7.639
154	Min. for Health & Comm. Service	1/735602					0.180
155	Min for Public Works & Services	2/735602					0.746
TOTAL							**8.565**

The DA4 operations provide for the relocation and closure of Castlereagh Road between Smith Street and West Wilchard Road in the north to the existing bridge on Castlereagh Road near Birds Eye corner together with the closure of Jacksons Lane.

4.3 RELATIONSHIP TO THE OVERALL SCHEME

The overall Scheme design as defined in SREP 11 - Penrith Lakes Scheme - Structure Plan represents the broad framework for the implementation of the Scheme through to its completion. The main features of the Scheme are a large main lake intended for a variety of recreational activities complemented by several small lakes which will provide for both recreational and conservation activities. When fully implemented, the Scheme will include both land-based recreation and potential future urban areas located in the eastern part of the Scheme area adjacent to Cranebrook Village. An immediate benefit of the Scheme has been the completion of the Olympic rowing/canoeing course. This precinct has been available for public use since 1995.

The Corporation has sought amendments to the SREP 11 - Penrith Lakes Scheme - Structure Plan over a period of time. More recently, an amendment to the Structure Plan was sought to account for results of detailed technical studies and the consequences to landforms arising from unexpected inconsistencies in the sand and gravel formation. The proposed amended Structure Plan is shown in **Figure 2.2**. It is apparent that the Scheme design is a dynamic process, which must account for variations in assumptions/estimates as time and development progresses.

An orderly sequence of extraction and rehabilitation is required to achieve the progressive construction of the lakes and landforms. Factors that were considered and are subject to regular review in the development of the sequence of extraction and rehabilitation include the following:

- public access to completed stages should be available as soon as practicable after completion of quarrying and associated works, but should not be allowed to uncompleted stages,
- Castlereagh Road should be retained in its present position until the requirements of extraction require its relocation. The proposed route for relocation of Castlereagh Road must be extracted and rehabilitated prior to the relocation of the road.
- stockpiling and double handling of overburden should be avoided where possible.
- raw feed haul distances and routes should be chosen to minimise cost and possible environmental impacts.
- roads for the haulage of raw feed must be able to reach the various plants by direct routes, free of public access and without interfering with the SIRC area.
- areas adjacent to the Scheme boundaries should be quarried as early and as quickly as practicable to ensure that impacts of quarrying and rehabilitation are quickly reduced, and that benefits of the Scheme are offered as early as possible to adjoining landholders.
- the operations must be affordable to maintain the viability of the Scheme.
- internal road access for private landowners within the total Scheme area, and access to the Church and cemeteries need to be maintained.
- commitments given in the formulation of SREP 11 related to overall development and staging need to be met.

Based on consideration of these factors, the fourth stage (DA4) of the Scheme's development is immediately to the north and west of the third stage (DA3).

4.4 STAGED SEQUENCES WITHIN DA4

The sequence of quarrying and rehabilitation has been formulated to complete the Penrith Lakes Scheme. This staging is shown on **Figure 4.5**. The sequence is the result of a number of factors:

- The need to quarry in areas for the three shareholders that is consistent with likely future demands for sand and gravel in the Sydney market as higher demands for sand is predicted during the time frame to complete the Penrith Lakes Scheme.
- Extensive investigation of the resource remaining undertaken by the Corporation has indicated that the resource quantity has been reduced and the composition of the resource is likely to become more variable with higher proportions of sand, silt and clay within the gravels than has been experienced to date, especially in the northern half of the deposit.
- Processing problems will be experienced by some existing plants with the varying nature of the resource requiring capital expenditure to maintain efficiency with payback period available for capital investment reduced as a result of the reduction in the resource quantity.
- The need to access fine sands in the northern section of DA4 area at the same time as accessing southern high gravel areas of DA4.
- Develop the urban lands by staging the operations so that areas are extracted at the appropriate time to permit fill operations without stockpiling.
- Timely relocation of Castlereagh Road for quarrying and rehabilitation and integrated into the urban land development.
- Scheduling operations to ensure any impacts on adjoining neighbours are minimised.
- Recognising the heritage value of features remaining within the Scheme area.

Based on these factors, a yearly plan to Scheme completion has been developed commencing 1998/99 to sequentially quarry the remaining resource and rehabilitate the lands in accord with the agreed Scheme principles. DA3 will continue to be quarried in conjunction with the DA4 area to meet the market demand for product, particularly sand.

Quarry operations will continue north in the northern half of DA3 for about 18 months, at which time quarrying will have commenced on the western side of Castlereagh Road and be progressing south towards the CSR plant simultaneously with quarrying in DA3, which will be nearing completion. At this time, quarrying west of Castlereagh Road will have turned to the north and will continue until the west side is completed at Smith Street. At this time quarrying will turn south removing Castlereagh Road to just north of the historical precinct, to then complete the area currently occupied by the CSR plant. Quarrying in the northern deposits east of Castlereagh Road is dependent upon access arrangements. If access is negotiated early then it will be extracted as an extension of DA3. If access cannot be provided in this time frame then it will be extracted in the latter part of DA4.

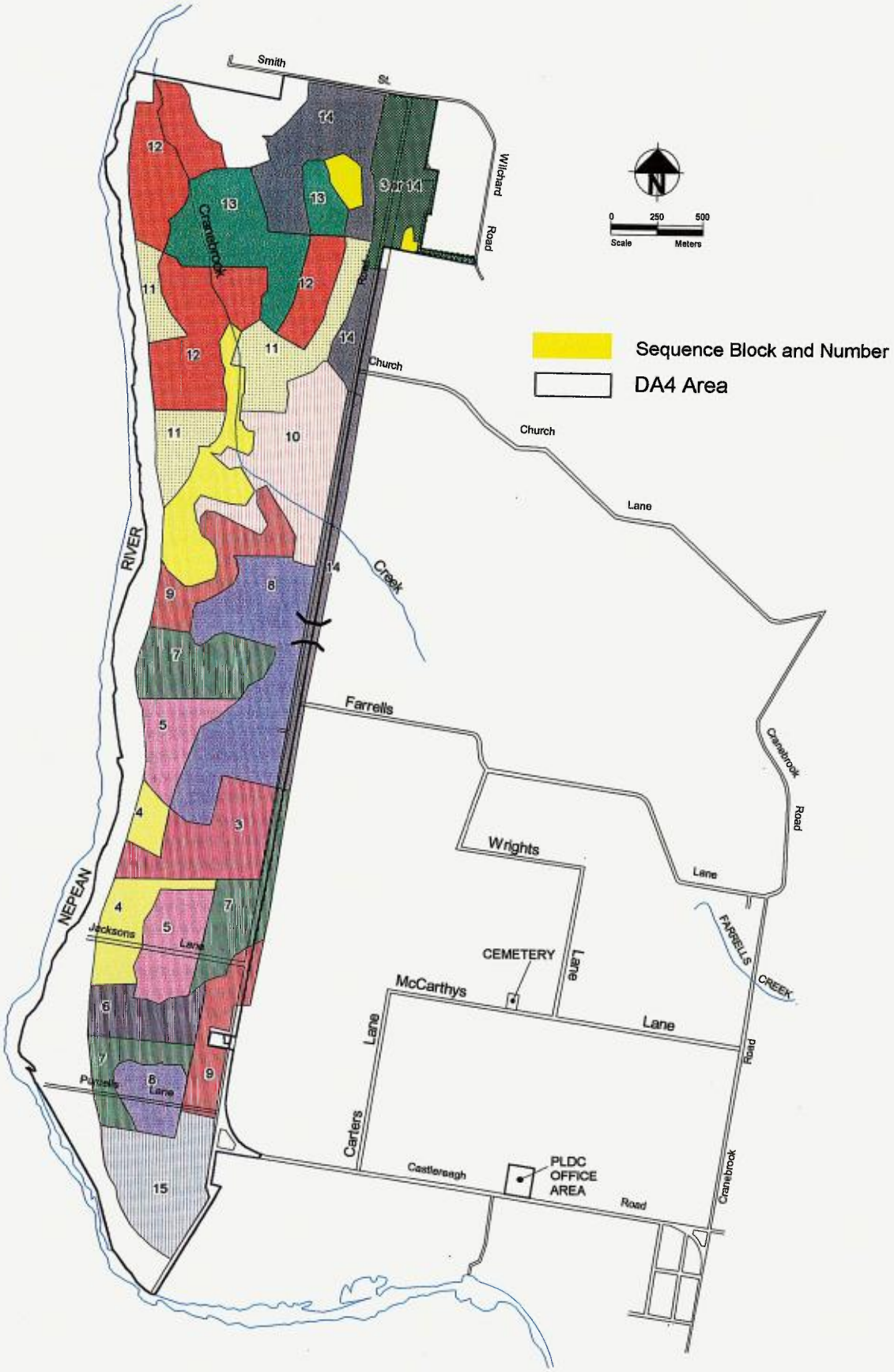


Figure 4.5 Staging Sequence

Extraction of fine sand will commence early in the extraction of the DA4 area prior to extraction of the sand and gravel resource unit. Operations will commence at the southern end of the defined resource area and proceed in a northerly direction until the sand is exhausted. In the first year, 300,000 tonnes of sand will be extracted, rising to 600,000 tonnes in subsequent years until the material is exhausted in approximately 10 years. The fine sand occurs immediately above the resource unit in the lower part of the 'overburden' horizon. Once extracted, the resource of sand and gravel will be quarried during the sequence of operations outlined above.

4.5 EXTRACTIVE OPERATIONS

It is proposed that the extraction operations will be a continuation of current operations using similar plant and equipment.

4.5.1 Topsoil Removal and Placement

Topsoil will be stripped in a separate open-bowled scraper operation prior to overburden stripping, and transported directly to specific rehabilitation locations for immediate placement. Some stockpiling of topsoil may be necessary where rehabilitation has not been completed or where landforms are not intended to be constructed to their final profile. Any stockpiling will be for a short period of time (less than 4 weeks) in order to maintain the productivity of the soil. Aboriginal community representatives will monitor topsoil removal as discussed in **Section 7.2.**

4.5.2 Overburden Removal and Placement

As predicted in the DA3 application, a shortfall of overburden exists to complete the landforms in the DA3 area. This shortfall was proposed to be derived from the DA4 area. The plan now proposed is to move overburden from DA4 under Castlereagh Road via an underpass or overpass at about Farrell's Lane, to fill lands generally along the eastern boundary and from south to north within DA3, as well as fill areas available within DA4.

Overburden will be stripped by a combination of hydraulic excavators loading off-highway haul trucks to provide sequential blocks for the winning of raw feed. The margin by which the stripping of overburden precedes the extraction operations allows for factors such as wet weather, continuity of stripping and safe working conditions. The Corporation endeavours to maintain about five months of pre-stripped reserves to ensure the availability of adequate supplies. Levels below two months make the operating areas too small to provide safe working conditions. Heavy or prolonged periods of rain adversely impact on the levels or pre-stripping reserves.

4.5.3 Raw Feed Extraction

Raw feed extraction will be a continuation of current operations using hydraulic excavators and face shovels loading off-highway haul trucks. The Corporation provides designated pre-stripped areas for the three shareholders to extract raw feed. It is expected that two separate pits will be needed to supply raw feed. A single pit may eventually develop but will be dependent on the Corporation being able to supply the required mix of gravel and sand to the shareholders to meet market demand and processing plant requirements.

Each of the individual shareholder companies extracts the raw feed from these designated pre-stripped areas and hauls the raw feed to the processing plants. General haul road arrangements are shown in **Figure 4.6**. No raw feed will be hauled on public roads. Haul roads from the pits to the plants will be extended from existing routes where possible and new ones constructed. Haul routes will increase in distances for the majority of the Scheme resource life in generally a northerly direction. With the increasing haul route lengths, the Corporation will review the method of raw feed transfer from pit to shareholder plants.

The haul road configuration shown on **Figure 4.6** will require the construction of an underpass on Castlereagh Road just north of Farrells Lane. An additional underpass opposite Jacksons Lane might be required later in the sequence.

An alternative approach to the construction of underpasses on Castlereagh Road is the possible upgrading of, and diversion of Castlereagh Road to, the Church Lane road alignment. This alternative has some significant benefits that need to be assessed with Penrith City Council, the RTA and residents along Church Lane.

At this stage the Corporation is of the view that the underpasses on Castlereagh Road is the preferred option. It is willing to discuss alternative proposals using the Church Lane alignment with the view to seek best possible outcomes for authorities, landowners and the Corporation.

Figure 4.5 was prepared on the basis of blending resource deposits to match expected market requirements, balanced against maintaining an efficient and effective quarry and rehabilitation sequence.

Based on previous experience, plans and commitments must be adjusted in accord with practical realities. As quarry operations proceed, the extent and nature of material for rehabilitation becomes visible and day to day decisions must be made within the context of overall commitments and within keeping the Scheme affordable.

For this reason the staging sequence should be only used as a guide within the context that it is the Corporation's intention to quarry the entire area and build landforms consistent with the overall Scheme design using the volumes of overburden which are available. Significant inconsistencies within the overall strata need to be evaluated with the context of urgency related to quarry activities and overall commitments related to Scheme design.

Within the staging framework described above, and commitments to the Scheme's development, detailed rehabilitation plans will be developed each two years as the nature and extent of operations in the previous stage will affect the detailed planning of the next stages. These plans, to be submitted to the Department of Urban Affairs and Planning, will include design plans related to the various components of the overall Scheme, including landscape and engineering plans. Based on the timing of DA4 approval it is intended that the current two year interval is maintained.

4.5.4 Plant and Equipment

The size and mix of the raw feed fleet varies depending on production requirements, material type, operating conditions and haul distances. The average number and type of equipment used in the excavation, loading and haulage operations are listed below:

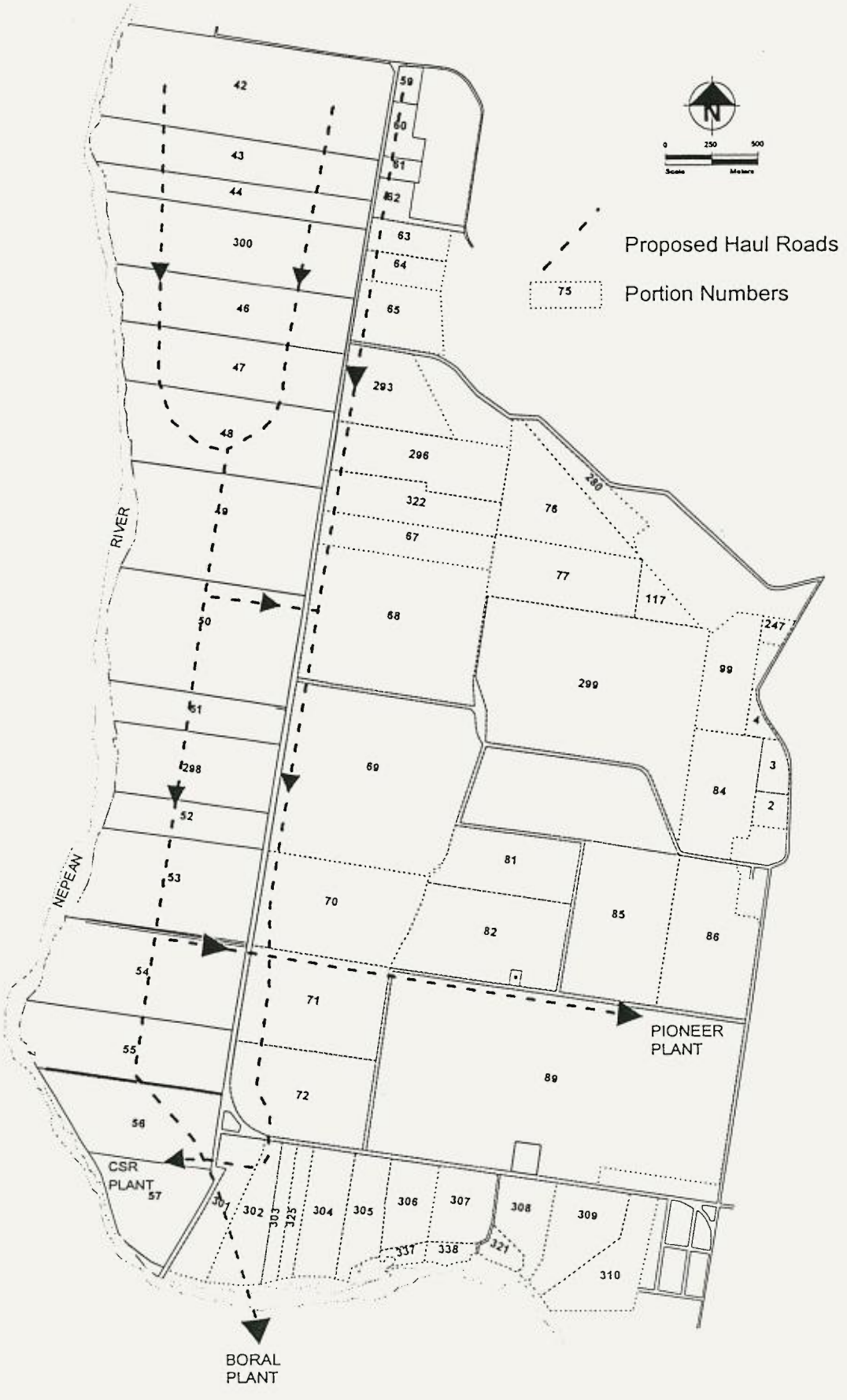


Figure 4.6 Haul Roads Arrangements

Equipment	Number
Excavator	2
Face-shovel	1
Grader	1
Off-highway trucks (50-85 t capacity)	11
Water Carts	2

These numbers vary to meet maintenance schedules, peak workloads and variations in haul distances.

Overburden and topsoil stripping operations are undertaken by contractors. The size and mix of the equipment fleet varies depending on production requirements, material type, operating conditions, haul distances and topsoil/overburden depth. A typical mix of equipment is listed below.

Equipment	Number
Dozer	2
Excavators	3
Open-bowl scrapers	2
Compactor/roller	2
Grader	2
Watercart	2
Trucks	13

4.6 HOURS OF OPERATION

Existing approved hours of operation are detailed below:

Non-Noise Sensitive Areas

Sand and Gravel Extraction including haulage to processing plants	6:00am to 7.00pm Monday to Saturday
Overburden stripping and rehabilitation	7.00am to 7.00pm Monday to Saturday

No works are undertaken on Sundays or Public Holidays.

Immediately north of Cranebrook Village

Immediately north of Cranebrook Village operating hours are restricted as detailed below:

Sand and gravel extraction including haulage to processing plants	7.00am to 6.00pm Monday to Friday 7.00am to 1.00pm Saturday
Overburden stripping and rehabilitation	7.00am to 5.00pm Monday to Friday 7.00am to 1.00pm Saturday

No works is undertaken on Sundays or Public Holidays.

Circumstances may arise where operations may need to be conducted outside these hours, eg, prolonged wet weather. Under these circumstances the Corporation is required to lodge an application to vary the hours of operation with the Department of Urban Affairs and Planning and the Environment Protection Authority. Such applications must detail the reason for variation and must be accompanied by a detailed assessment of potential noise impacts and control measures.

Current operating hours of the processing plants are determined by the need to service Sydney's building industry. These plants commence processing operations at 5:00am. As extractive operations do not commence until 6:00am, the plants are initially serviced by a separate machine delivering from a stockpile at the plant.

Commencing extractive operations at the same time as the plants will enhance productivity. It is intended in this application to seek approval for a 5:00am start in low impact areas. This is further discussed in **Section 6.5**.

5.0 LAND AND WATER MANAGEMENT

5.1 WATER MANAGEMENT

5.1.1 General

Water management arrangements during the currency of this development application will be directed toward providing infrastructure for the completed Scheme. Extensive and detailed water studies were undertaken for the RES. These studies identified the various component parts of the necessary infrastructure to provide adequate quantities of appropriate quality water to ensure both satisfactory water quality performances within the lakes and minimal impact on the Hawkesbury-Nepean River system. Details of these studies are contained within Volumes 2, 3, 4, 5 & 6 of the Working Papers associated with the RES. Infrastructure details that were envisaged, at the time the RES was prepared are outlined in **Table 5.1.**

TABLE 5.1
WATER MANAGEMENT INFRASTRUCTURE

Works	Item Description	Quantity/Capacity/Standard
Water Supply	Pump station and associated intake structure on Nepean River	Minimum pump capacity 1.7 m^3/sec. Intake structure to suit. Pump to be housed in full brick shed including facilities for electrical switching.
		Capacity to be made up of series of pumps, the smallest being 20% of total capacity or 0.3 m^3/sec whichever is the less.
	Pipeline and outlet structure	Capacity minimum 1.7 m^3/sec (1200 mm diameter reinforced concrete pipe) – approximate length 2800 metres.
Water Reticulation	Pipelines including provision for manual control of flow rates.	Reinforced concrete pipes (1500 mm diameter). Approximate lengths: SIRC to Main Lake 'A' 400 m Main Lake 'A' to Main Lake 'B' 350 m Main Lake 'B' to Wildlife Lake 400 m Wildlife Lake to Nepean River 300 m Cranebrook Lake to Main Lake 'A' 400 m
	Pipeline including provision for pumping.	Reinforced concrete pipe (900 mm diameter). Approximate lengths: Main Lake 'B' to Cranebrook Lake 500 m Pipeline fitted with pump unit capable of delivering 250 litres/sec from Main Lake 'B' to Cranebrook Lake. Manual flow control device fitted to allow gravity flow from Cranebrook Lake to Main Lake 'B'.

TABLE 5.1 (cont.)
WATER MANAGEMENT INFRASTRUCTURE

Works	Item Description	Quantity/Capacity/Standard
Flood Control	Flood Weirs	Gabion mattress 10 m wide, crest 1 m high. Downstream slope at 4H:1V with gabion mattress cover to 500 mm thickness. Downstream cover to extended 1 m below normal lake water level. Approximate lengths: Nepean River to SIRC 300 m SIRC to Main Lake 'A' 500 m Nepean River to Main Lake 'A' 500 m Main Lake 'A' to Main Lake 'B' 500 m Nepean River to Main Lake 'B' 700 m Main Lake 'B' to Wildlife Lake 500 m Nepean River to Wildlife Lake 500 m Smith Street to Wildlife Lake 500 m
	Flood outlet pipes to Nepean River including floodgates.	Reinforced concrete pipes, of the following dimensions: SIRC – 1 only 1500 mm diameter 300 m long Main Lake 'A' – 4 only 1500 mm diameter 200 m long Main Lake 'B' – 2 only 1500 mm diameter 200 m long Wildlife Lake – 2 only 900 mm diameter 150 m long
Stormwater Control	Low level outlet pipe.	Reinforced concrete pipe 1650 mm diameter – 4300 m long. Floodgates fitted at outlet.
	Overflow channel and low flow pipe.	Grass with concrete pipe 450 mm diameter with inspection and inlet pits every 250 m. Approximate length 4300 m.
	Farrells Creek diversion.	Drop structure into basin. Formal gabion mattress structure. Drop structure capacity 45 m^3/sec.

The Corporation has undertaken a number of detailed design studies to firm up infrastructure provisions since the original Water Studies were undertaken for the RES. In addition, the incorporation of the Sydney International Regatta Centre (SIRC) into the Scheme provided different opportunities to manage stormwater draining to the area from local upstream catchments. These issues are discussed separately in the following sections.

5.1.2 Water Supply and Reticulation

The Corporation applied for and obtained a licence to divert water from the Nepean River at a site just upstream of Penrith Weir. This licence is conditioned for diversion at a maximum rate of 1.7 m^3/sec but can only operate when flows over Penrith Weir exceed 170 megalitres per day. These licensing provisions are consistent with the RES Water Studies.

The principles underpinning water quality management of the completed lakes are based upon providing "flushing flows" through the lakes. During medium to high flows periods in the Nepean River, the pumps would be turned on and water would be diverted into the SIRC Lake via the 2.8 kilometre pipeline. The pumps would not be turned on until at least 170 megalitres per day were flowing over the weir. A staged start up to full capacity would apply to ensure that the 170 megalitres per day flow is maintained over the weir. A possible intake system and probable pipeline route are shown on **Figures 5.1** and **5.2**. The construction of these works will be the subject of a separate development application that will be lodged at least twelve months prior to the scheduled construction of the works.

The water studies indicated that flows of 170 megalitres per day over the weir could be expected to be equalled or exceeded on 60% of occasions. Diversions to the Scheme would not be possible for 40% of the time. The studies also suggested that for the historical period of stream flow records commencing in 1910, that the maximum drawdown in the lakes would be 600 mm during the worst drought on record. The lakes would be full or spilling for 78% of the time. For 2% of the time they would be between 250 mm and 600 mm below full supply level. This was judged to be satisfactory performance for the planned uses.

Average annual diversions to the Scheme would be 26,000 megalitres per year of which 85% would be returned to the Nepean River via discharges from the Wildlife Lake in the north. Diversions to the Scheme represent less than 2% of the average annual flow at Penrith.

The above volumetric issues were assessed on the basis that there were no other contributions to the Scheme. Since the RES Water Studies were completed, arrangements for managing stormwater discharges to the Scheme area have been addressed in final design works. This assessment is discussed further in **Section 5.1.3**. These works addressed the possibility of using stormwater discharges from the local upper catchment as a supplementary source to the Scheme. The assessment was presented in a proposed amendment to SREP 11 (Amendment N°. 3), which provided for the diversion of Farrells Creek into the SIRC lake.

Expected yield from this catchment is about 1000 megalitres per year. This will contribute to the lake performances mentioned above. The amendment was approved in November 1994 and the works were completed toward the end of 1995.

In regard to the facilities described in the Water Supply and Reticulation section in the **Table 5.1**, the timing of the provision of such works is determined by the extent of lake area open for public usage and the sequence of rehabilitation operations.

Originally, it was envisaged that an external source of supply would be required when the lake area opened for public usage exceeded 300 hectares. The diversion of drainage from the Farrells Creek system works would defer these works.

Table 5.2 identifies Water Supply and Reticulation Works necessary to complete the Scheme. The works are shown on **Figure 5.3** and include the provisions for managing stormwater drainage from the Farrells Creek catchment.

The construction of the Pump Station will be undertaken in two stages. The first stage will include pumps of sufficient capacity to meet the evaporative and seepage losses associated with the lakes available for public use. As discharges back to the Nepean River will not be possible until the Scheme is almost completed, there is no sound reason to provide full pump capacity early.

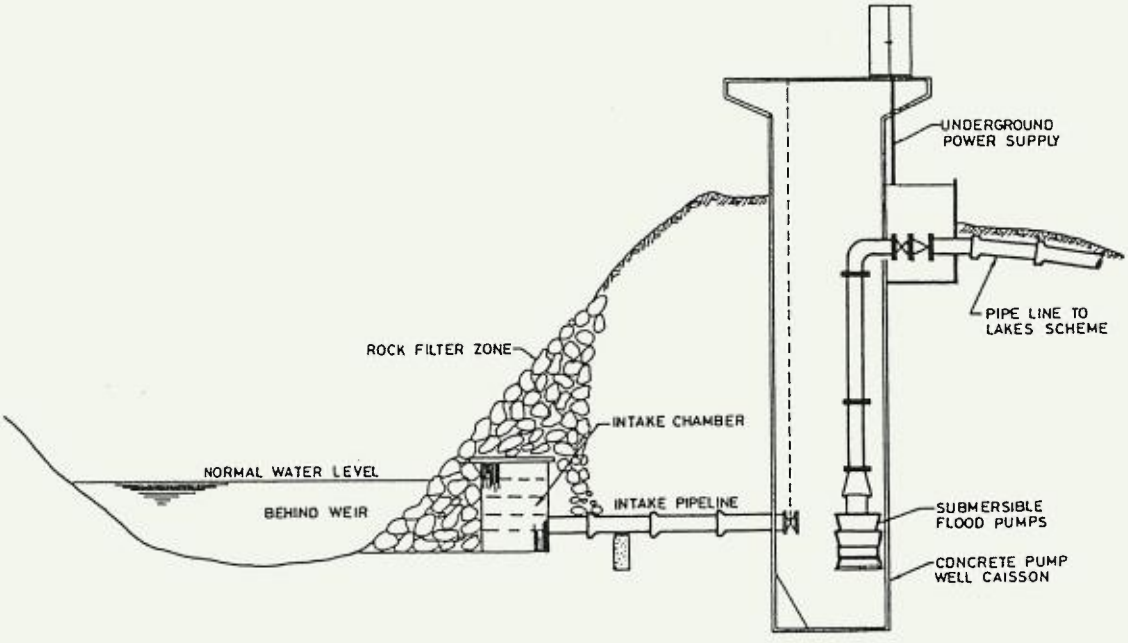


Figure 5.1 Possible Intake System

Figure 5.2 Pipeline Route

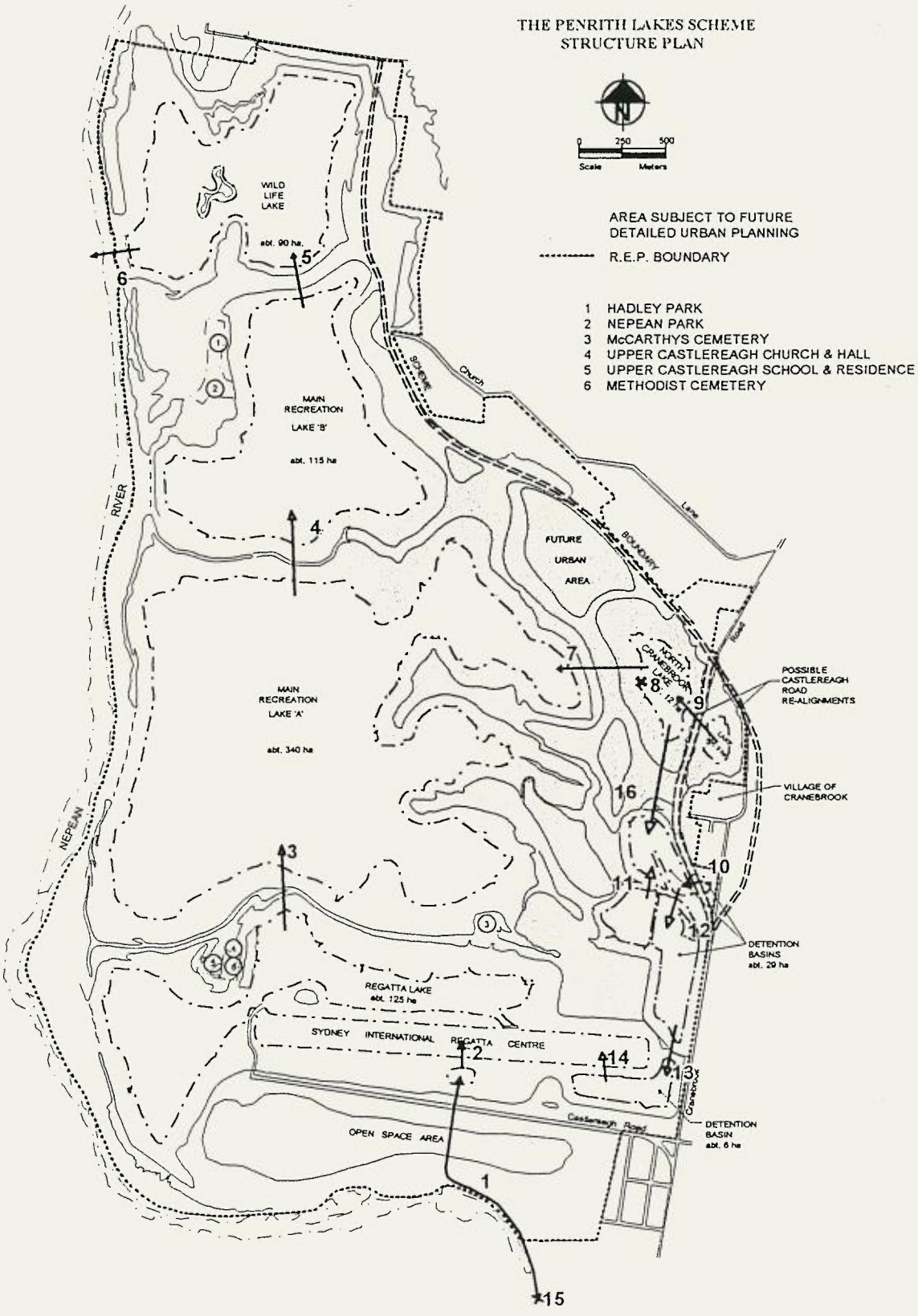


Figure 5.3 Water Supply and Reticulation Works (see **Table 5.2**)

TABLE 5.2
WATER SUPPLY & RETICULATION WORKS

Reference N°.	Description	Approximate Timing
1	1200 mm diameter pipeline from Nepean River	2003/2004
2	1200 mm diameter pipeline to SIRC	Completed
3	1500 mm pipeline SIRC to Main Lake 'A'	Completed
4	1500 mm pipeline Main Lake 'A' to Main Lake 'B'	2003/2004
5	1500 mm pipeline Main Lake 'B' to Wildlife Lake	2009/2010
6	1500 mm pipeline Wildlife Lake to Nepean River	2007/2008
7	900 mm pipeline Cranebrook Lake to Main Lake 'A'	1998/1999
8	Pump unit associated with Item 7.	1998/1999
9	3 m x 1.8 m culvert connecting Cranebrook Lake.	1998/1999
10	Overflow weir 20 m crest width on Farrells Creek	Completed
11	2 x 450 mm culverts connecting west & north basins	Completed
12	2 x 450 mm culverts plus weir connecting north & middle basins.	Completed
13	3 m x 1.8 m culvert connecting middle & south basins	Completed
14	3 m x 1.8 m culvert connecting south basin & SIRC	Completed
15	Stage 1 Pump Station	2003/2004
15	Stage 2 Pump Station	2009/2010
16	1500 mm pipeline Cranebrook Lake to Detention Basin	

The second stage will be completed at the end of the Scheme bringing the discharge rate to full capacity.

In regard to the original water management concept, all items have been retained except for the following items:

- Pipeline Main Lake 'B' to Cranebrook Lake plus pumping unit.
- Low level outlet pipe 1650 mm diameter.
- Overflow channel and low level pipeline 450 mm diameter.
- Drop structure into basin. Capacity 45 m^3/sec.

The following items have been added to the water management facilities:

- 1200 mm diameter pipeline to SIRC
- 900 mm pipeline Cranebrook Lake to Main Lake 'A' plus pumping unit.
- 3 m x 1.8 m culvert connecting Cranebrook Lake
- Overflow weir 20 m crest width on Farrells Creek.
- 2 x 450 mm culverts connecting west & north basins.
- 2 x 450 mm culverts plus weir connecting north & middle basins.
- 3 m x 1.8 m culvert connecting middle & south basins.
- 3 m x 1.8 m culvert connecting south basin and SIRC.

The above facilities will enable the proper circulation of water throughout the completed Scheme, giving future water managers a high degree of flexibility to operate the lakes in a manner to achieve both volumetric and quality objectives.

5.1.3 Stormwater Management

Amendment N$^{o.}$ 3 to SREP 11 modified the Structure Plan to accommodate changes to the concepts for managing stormwater drainage originating from the Farrells Creek catchment. The original concept was to collect the drainage water in a large detention basin next to Cranebrook Road and re-direct it to the Nepean River via the Wildlife Lake.

The works associated with this included those items listed in **Table 5.1** under Stormwater Control. These works are no longer required as works listed as Items 10 to 14 in **Table 5.2** replaces them.

The environmental gains achieved by changing the concept were described in the "Planning Report Associated with Proposed Amendments to REP 11 Structure Plan Penrith Lakes Scheme" January 1994. These gains were:

- more efficient use of available resources,
- a reduction in urban run off entering the Nepean River,
- the Scheme will be less reliant upon the Nepean River for water supply,
- future water managers of the Scheme will have greater flexibility in achieving goals,
- better drainage of the Environs Area will be provided,
- localised flood management during quarry/rehabilitation operations will be simplified, and
- the system will be far simpler to construct and will be operational much sooner than the RES concept.

A trade off with these gains is the admission of urban stormwater drainage into the lakes. Quality testing and modelling suggested that although nutrient levels are higher than those expected from the Nepean River source, the levels could be managed through application of sound water management principles. Monitoring of drainage water flowing into the system and in-lake water suggests that, although key nutrient levels are relatively high, the detention basin system strip out about 70 per cent of the nutrients entering the system.

Additionally, monitoring of Nepean River water during periods of high flow indicates that source water nutrient levels are about half the level of those assumed in the RES Water Studies. Mixing of Farrells Creek drainage and Nepean River water would yield high quality water in the lakes.

The Corporation, the Olympic Coordination Authority, Penrith City Council and the Middle Nepean Hawkesbury Catchment Management Committee have commenced preliminary discussions regarding the possibility of applying Total Catchment Management principles to the catchment draining to the Scheme. The objective of the process would be to reduce the pollutant loads entering the Scheme from the upper catchment. It is expected that this process will commence early in 1998 with results being measured by the Corporation monitoring at the downstream end of the catchment.

5.1.4 Water Quality Management

One of the primary targets of current water management is the early establishment of a complete, diverse and well-balanced aquatic ecosystem.

It is important to recognise that lakes undergo a maturing process. Indeed, in the case of the Scheme, the lakes constructed are biologically sterile after major earthworks are completed. The gradual filling of the lakes establishes the aquatic environment in which biological systems will develop. Left to their own devices, the aquatic system that develops will generally reflect opportunistic or invasive species of flora and fauna that may or may not provide the ultimate aquatic ecosystem desired for the uses envisaged.

The Corporation has taken a positive direction in this process by cultivating, harvesting and planting out large numbers of *Vallisneria gigantea*, a native plant that is capable of growing leaves up to three metres long. By establishing these plants as pioneer stock they may be able to out compete the invasive less desirable plants. These plants have been established in all completed lakes to date.

Additionally, 24,000 Australian Bass have been introduced to the lakes for similar reasons. The Bass will not reproduce in the lakes and it will be necessary to continue the stocking program until a sufficient population is achieved. Monitoring of fish stock will be undertaken to ensure that an adequate population exists and potential high populations of European Carp are avoided.

Monitoring of the SIRC Lakes has indicated that the young system is stabilising and primary contact standard has been consistently achieved with the exception of one brief period. In the lakes formative years it could be expected that the biological systems would react indifferently to rapid changes in circumstances.

The original RES Water Studies identified the SIRC Lakes as a key water management facility for protecting the amenity of the downstream main recreation lakes. The intent of the SIRC Lakes was to improve the quality of water spilling into the recreation lakes. Water quality objectives for the SIRC Lakes is secondary contact. Given the current uses of these lakes, the water quality objectives have been upgraded to primary contact.

5.1.5 Flooding

The Scheme area is subject to flooding from both the local catchment and the Nepean River system. Local flooding is managed through the Farrells Creek diversion works described in **Section 5.1.3.**

Nepean River flooding was assessed in the RES process. A concept plan was developed which admitted floodwaters into the Scheme during the early stages of Nepean River flooding. The objective was to fill the lakes prior to over bank flow to eliminate potential damage caused by scouring out of the lakeside banks. The facilities described in **Table 5.1** were derived from these early conceptual studies.

The RES studies were sufficient to establish Scheme feasibility; however, they were not sufficient for final design purposes. The Corporation contracted the University of NSW to undertake detailed design studies that involved the construction, calibration and operation of a physical flood model. These studies were completed in 1992, with the results being incorporated into Scheme design via Amendment N$^{o.}$ 3 to the REP.

Final design elements are shown in **Figure 5.4** and listed along with construction timing in **Table 5.3**:

TABLE 5.3
FLOOD PROTECTION WORKS

Reference N°.	Description	Approximate Timing
1	400 m Grass Slope Weir at RL 24.0	2010/2011
2	250 m Scour Protected Weir at RL 21.0	2010/2011
3	500 m Scour Protected Weir at RL 20.6	1999/2000
4	500 m Grass Slope Weir at RL 22.0	2006/2007
5	300 m Scour Protected Weir at RL 20.0	2006/2007
6	500 m Grass Slope Weir at RL 21.0	2007/2008
7	200 m Scour Protected Weir at RL 10.8	2007/2008
8	500 m Grass Protected Weir at RL 21.0	2009/2010

The weirs linking the Nepean River to the Lakes will require special protection works. Scour protection needs to be extended from at least one metre in level below the crest on the upstream approach, over the crest and down the backslope to the normal lake water level. There is a wide range of scour protection options for these weirs – e.g. reinforced grass systems, gabions or mattresses, roller compacted concrete, artificial blocks and/or riprap rock. Detailed design of each weir will be necessary to ensure that the hydraulic capacity of the weir is effective. These designs will be undertaken at least two years prior to construction, to make use of best available protection material available at the time. A typical weir cross section is shown in **Figure 5.5**. The outlet pipe shown is required to bring the lakes back to normal water level after the flood has receded in the Nepean River. Initial flows to the river will be back across the flood weir until the lake drops to the crest level. From this point all discharges will be to the river via the outlet pipes. The capacity of these pipes is limited to ensure the stability of internal banks. Typically it should take about three weeks to return to normal water level after a major flood.

Scour protection requirements for between lake weirs are much less as the lakes would be partially filled by the time flood flows commence to spill from one lake to the next. A typical section of a lake-to-lake weir is shown on **Figure 5.6**. These weirs will be integrated into the normal rehabilitation works.

5.1.6 Interim Management

The Corporation will maintain responsibility for all water management matters through until Scheme completion. In this regard it will need to service the needs of:

- the quarry processing plants,
- the quarry operations,
- public use of lakes, and
- aquatic ecosystem development and maintenance.

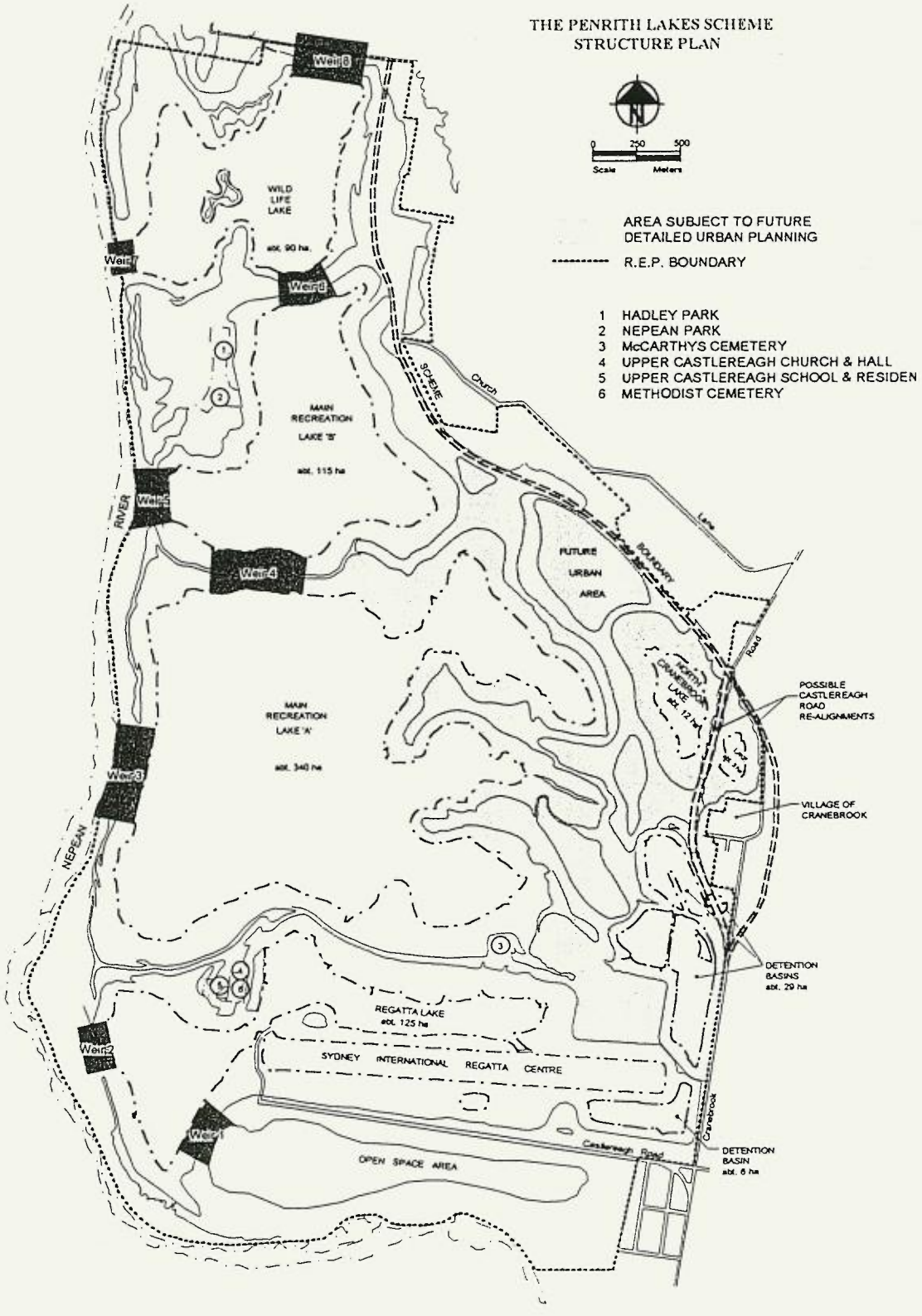


Figure 5.4 Flood Protection Weirs

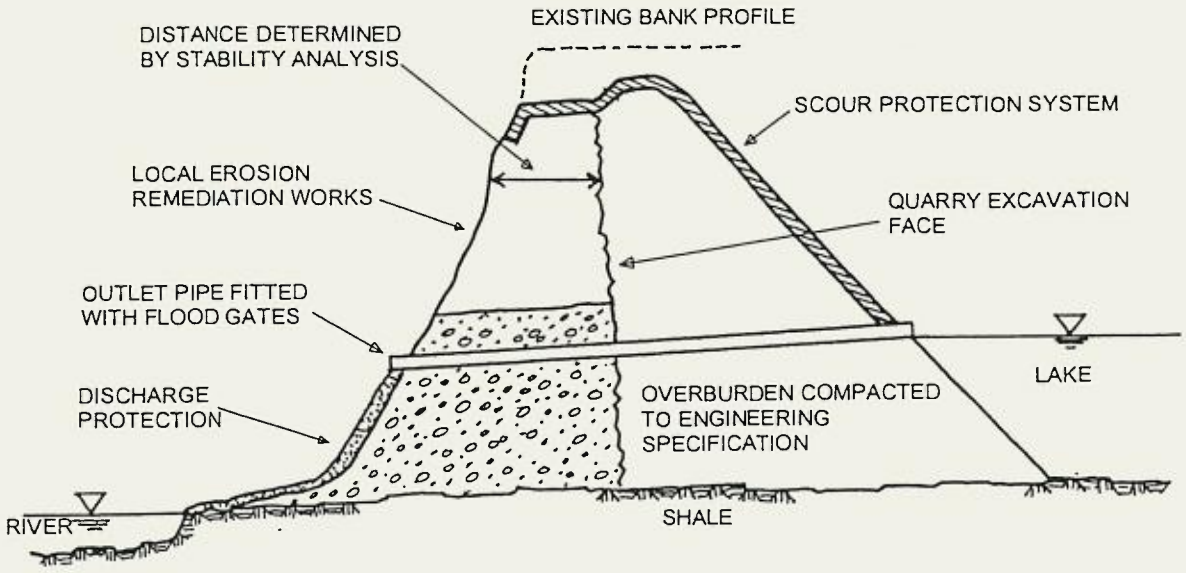


Figure 5.5 River-to-Lake Weir - Typical Section (Weirs 2, 3, 5 and 7)

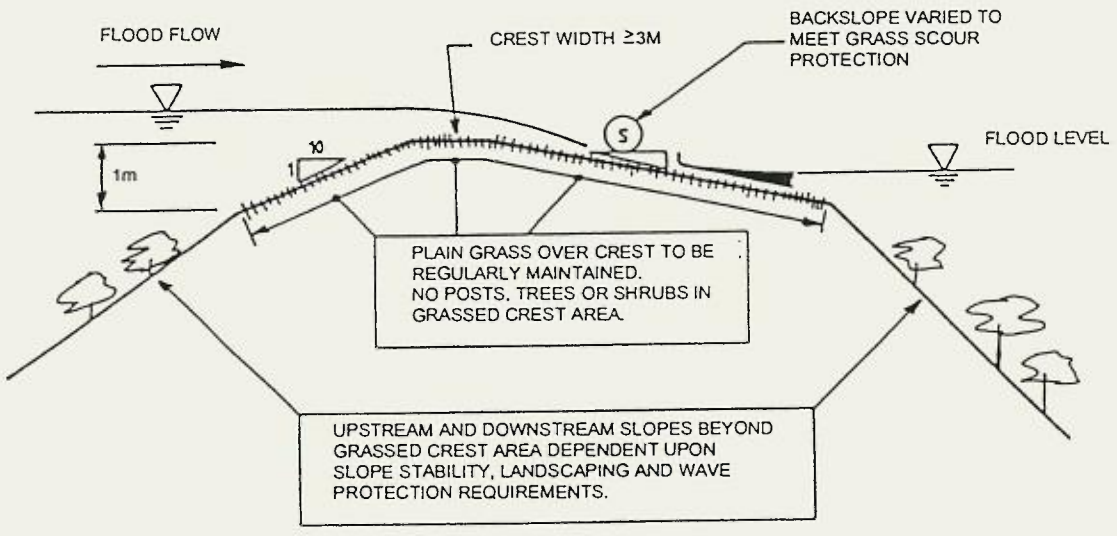


Figure 5.6 Lake-to-Lake Weir - Typical Section (Weirs 1,4,6 and 8)

The Corporation discharges these responsibilities now and will continue to do so in the future. Given that it will be another 14 years before the Scheme is completed and that climatic conditions may considerably vary during that time, management of these issues needs to be very responsive. As a set of principles, the following matters will be included in the Corporation's risk management and recovery plans:

- Discharges from the site should not occur unless there is no alternative and such discharges must be authorised by an EPA licence.
- Flood protection of all works will be set at the 1 in 100 year flood level until such time that the flood protection system is fully functional.
- Water quality objectives are in accordance with ANZECC Guidelines, with duty of care maintained for users with lake closure as an option if standards are not achieved.
- Water quality management to focus on the establishment and maintenance of a healthy, diverse and well structured aquatic ecosystem.
- Quarry operations have priority over public recreation in respect to both water quality and quantity matters.
- Recovery plans to have regard to re-establishment of quarry operations and public usage.

Both risk management and recovery plans will vary significantly throughout the period as the quarry and operations move throughout the development area. Threats and opportunities will vary depending on location and these need to be factored into such plans. The Corporation will develop such plans each financial year in association with the normal budgetary process.

5.2 DEWATERING

The Corporation is responsible for the total dewatering management of the quarry areas on site. Quarry pits are required to be dewatered to aid in the extraction process. Geotechnical requirements place constraints on filling operations and fill areas have to be dewatered prior to the placement of overburden.

The increased capacity of the finished Regatta Lake and the completed portion of the Main Lake "A" allows all the water entering the Scheme to be retained on site. As a result, two previously licenced discharge points used in earlier periods were discontinued in March 1994. It is expected that during the currency of extractive operations in the DA4 area, that all water will be retained on site.

5.3 TAILINGS MANAGEMENT

Raw feed extracted from the Scheme area is washed in the processing plants to remove clay and silt material, which comprises approximately 7-8% of the raw feed. This washing process produces residues known as tailings. These are piped to dams where the clay, silt and fines settle out. Surplus water is then recycled to the washing operations in the processing plants.

The Corporation is responsible for the long-term management of tailings generated by the washing process. An initial settlement pond is established at the individual processing plants. This settlement pond is used to collect tailings at the plant and form part of the wash water re-cycle system. A dredge operates full time within the Scheme, rotating between individual settlements ponds. It removes tailings from these ponds and disposes of them in an area specially set aside for the ultimate disposal of tailings. This area is located in the southern portion of the Scheme between Castlereagh Road and the Nepean River. The total area south of Castlereagh Road was quarried as part of DA1 works and previous consents, and provides about 110 hectares for continued disposal of tailings until Scheme end. There is sufficient storage volume contained within this area to hold the estimated total volume of tailings, which will be produced by the processing of the remaining raw feed.

Tailings do not settle uniformly. Coarser particles settle first, close to the tailings discharge point, while other finer particles settle very slowly and further from the outlet. The particles gradually consolidate under their own weight. Although the tailings become firmer as they dry and consolidate, it can take several years for a tailings area to drain and consolidate sufficiently to support vehicular traffic. Potential for future land use of the tailings area is therefore limited. Several techniques are available for promoting a faster drying rate and enhancing consolidation rates.

Within a limited range of practical options, the Corporation arranges the tailings discharge points to be relocated within the disposal area at fairly regular intervals. This process allows for a more even distribution of particles, prompting a more uniform settlement over the area. Surplus water is removed from the pond by pumping to the plant settlement ponds at nights. This technique aids the consolidation rate and promote earlier use of the tailings area.

During DA4 it is expected that approximately 5 million tonnes of tailings will be produced by the processing of approximately 5 million tonnes per annum of raw feed over the remaining life of the scheme. The current configuration, which utilises two ponds, designated the eastern and western ponds, has sufficient capacity to retain all of these tailings.

5.4 REHABILITATION AND LANDFORM MANAGEMENT

As discussed in the DA3 application, there is a shortfall of overburden to complete the landforms within the DA3 area. The shortfall is to come from the DA4 area. Studies described **in Section 2.8.2** have shown that by some minor modifications to the landform separating the Main Lake 'A" and Main Lake "B" sufficient overburden exists in the DA3 and DA4 areas for completion of the scheme landforms. **Table 5.4** shows the distribution of overburden in DA3 and DA4.

TABLE 5.4
OVERBURDEN AVAILABILITY

DA3	Million cubic metres
Overburden Available	9.8
Overburden Required	24.8
Deficit DA3	15.0
DA4	
Overburden Available	45.3
Overburden Required	30.1
Surplus DA4	15.2
Net Surplus	0.2

The table shows that a modest surplus will be available at the completion of the scheme. Previous experience has shown that variations in overburden availability occur as operations progress and minor variations in the design are required to accommodate such variations. Given the variability experienced, it was considered prudent to budget for a small surplus as a safety margin. If not required, the small surplus could be added to landforms being constructed towards the end of the scheme.

Overburden from the DA4 area will be hauled under Castlereagh Road via an underpass or overpass near Farrells Lane to fill lands generally along the eastern

boundary within DA3 as well as landform creation in the DA4 area. The construction and use of a possible crossing on Castlereagh Road is discussed in **Section 4.5.3**.

Rehabilitation of extracted areas would be directed towards constructing the landforms shown in **Figure 5.7** in accordance with the principles and guidelines contained in the Scheme's Land Rehabilitation and Landscape Manuals.

The Land Rehabilitation Manual was developed for the Corporation by the NSW Department of Land and Water Conservation (formerly the NSW Soil Conservation Service) in 1986. The comprehensive manual provides detailed guidelines for the Corporation for the planning of rehabilitation, management of soils and overburden, erosion control, revegetation and maintenance of rehabilitated lands.

The Landscape Manual was developed by the Corporation in 1987. The manual expands the principles developed in the Regional Environmental Study (1984) and the design considerations presented in the working paper "Landscape Evaluation and Rehabilitation" on which the Regional Environmental Study was based. The manual examines the existing natural features of the Scheme area in the design of the final lakes and landforms. It examines specific structures and elements, revegetation, visual considerations, landform models, design details, and recreation considerations.

The principles and guidelines detailed in these manuals have been applied throughout the Scheme's development since their preparation in 1986 and 1987, respectively. Results of progress in the Scheme area indicate that these principles and guidelines are appropriate and accordingly should be carried out into the DA4 works.

It is proposed that the route for the relocation of Castlereagh Road be constructed to standards appropriate for the facilitation of future road construction. This will involve sub-basement compaction and provision of a functional profile. It will not include sub-grade compaction or provision of a pavement at this stage. Special drainage structures will be constructed appropriate for general landform rehabilitation. Some of these structures may be required to be upgraded appropriately for the standard of road to be subsequently constructed.

5.5 MONITORING

The Corporation undertakes on-going monitoring programs for air, noise, groundwater, and settlement.

5.5.1 Air Quality

Air quality monitoring is carried out at several locations around the site using eight deposition gauges, five directional gauges and one high volume sampler. The location of monitoring stations is shown in **Figure 6.1**. All monitoring results are routinely forwarded to the EPA and Penrith City Council. Monitoring and air quality issues are considered each six months by the Scheme Monitoring Committee. Results obtained by the monitoring stations have been used to assess potential impacts from dust in the DA4 area (see **Section 6.4**).

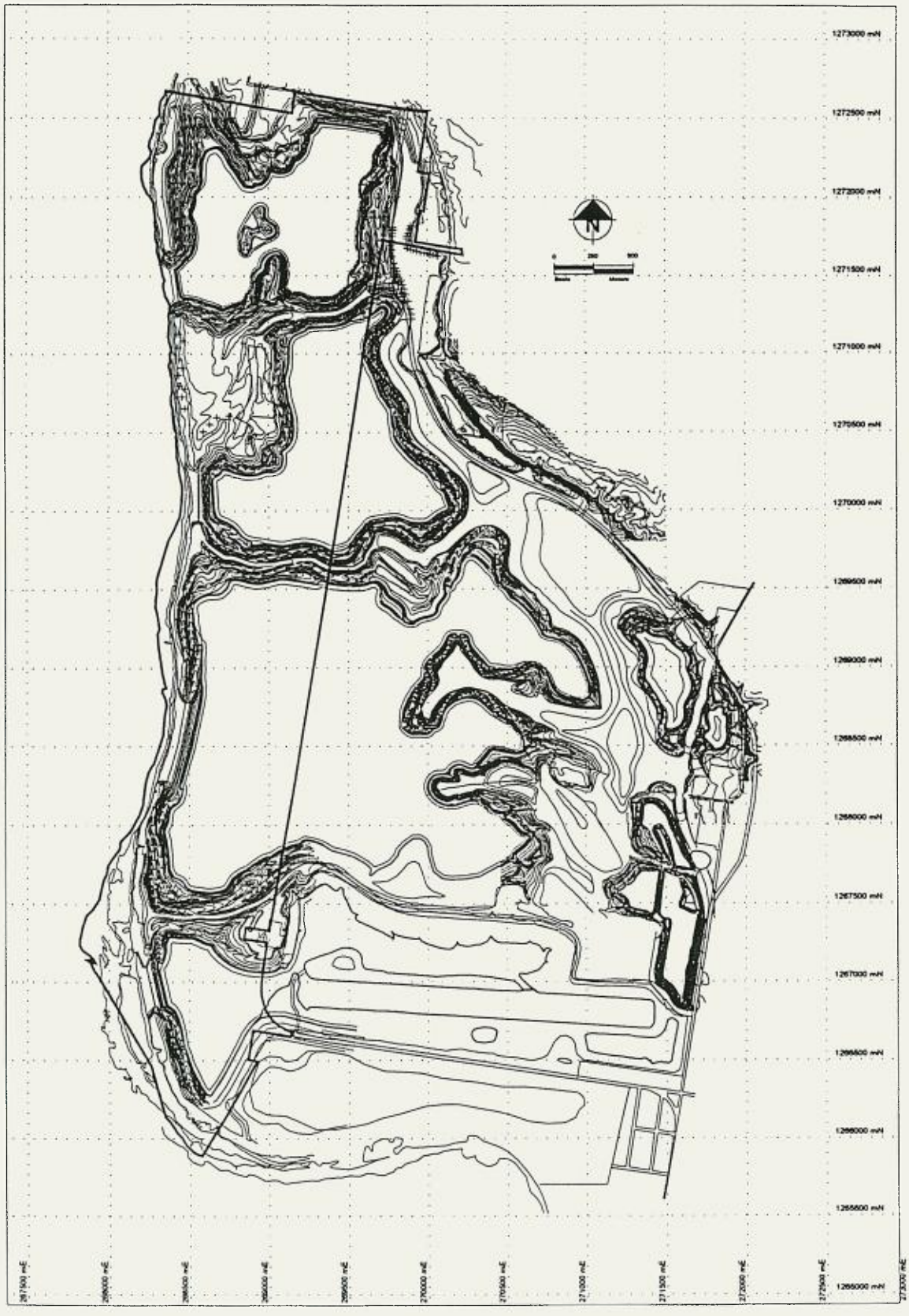


Figure 5.7 DA4 Landform Design

Wind

The Corporation has maintained a wind anemometer on the site since 1983. The wind capture program was initiated to provide long-term statistics for wave protection studies for the foreshores. More recently, the program has provided information to assist in the design and use of the regatta course. The station also provides information for use in predicting potential impacts from dust in the DA4 area.

5.5.2 Noise

Noise monitoring is conducted at several locations around the site as shown in **Figure 6.11**. As with dust, all monitoring results are routinely forwarded to the EPA and Penrith City Council. The Scheme Monitoring Committee considers monitoring and general noise issues each six months. Results obtained from the noise monitoring have been used to assess potential impacts from the DA4 operations (see **Section 6.5**).

5.5.3 Settlement

The Corporation monitors settlement in proposed urban and open-space areas by the use of settlement plates and gauges. In all, 50 settlement plates, 3 magnetic settlement gauges and 3 settlement plates in open-space areas are measured whether on a monthly or quarterly basis. In addition, pre-loading trials are undertaken as required. Assessments of records indicate that the rate of settlement in the area stabilises to satisfactory levels over time.

5.5.4 Groundwater

The Corporation has installed a number of piezometers adjacent to settlement plates in urban areas where landforms have reached design level. Monitoring is undertaken on a monthly basis. The results have shown that the monitored groundwater levels generally reflect the rainfall pattern. Extended low rainfall periods result in lowering of the groundwater, conversely, high rainfall results in a sudden rise in the water table. There is no evidence that groundwater levels external to the Scheme are rising or falling to unacceptable levels.

5.5.5 Water Quality

The Corporation has implemented an extensive water quality monitoring program. This program is discussed in **Section 4.1.10**.

6.0 ENVIRONMENTAL INTERACTIONS AND IMPACTS ON THE PHYSICAL ENVIRONMENT

This section describes the existing physical environment, the likely effects of the DA4 works, environmental management procedures to protect the environment, and environmental interactions and impacts. Aspects addressed include topography and landforms, soils and soil erosion, water resources, air, noise, and flora/fauna. Information has been derived from a number of sources, including detailed studies undertaken for the Regional Environment Study, previous Statements of Environmental Effect, specialist studies undertaken for the DA4 application, and the results of on-going monitoring.

6.1 TOPOGRAPHY AND LANDFORM

6.1.1 Existing Environment

The DA4 area essentially comprises the modern day floodplain of the Nepean River. Subject to inundation during floods, the area consists of flat alluvial terraces separated from the Nepean River by low levee banks that rise gently from the flats. The Nepean River forms the western boundary, with the alluvial terraces being some 15m higher than the river.

Several geomorphological units comprise the DA4 area. Each of these representing different erosional and depositional periods in the ancient Nepean River. Variations to the nearly flat topography of the Scheme area occur where streams or former flood and erosion channels cross the terrace. These streams flow from south to northwest and are characterised by a series of meandering low swampy areas flanked by former levee banks.

6.1.2 Environmental Management Procedures

Scheme Landforms

Detailed landscape studies were undertaken during preparation of the Regional Environmental Study. In designing final Scheme landforms, it was considered important that the Scheme design should complement and enhance the natural landscape character of the region.

Following an evaluation of the landscape resources of the site and its environs, it was concluded that the design of the Scheme should, as far as practicable, replicate the natural processes of lake formation usually associated with a river system meandering through a floodplain.

The design outcome will provide landforms, which are relatively low in level, in order to harmonise with the character of the surrounding floodplain and to avoid a conflict in height with either the Blue Mountains escarpment or the Castlereagh escarpment. The created landforms will reflect natural hill slopes and associated drainage patterns. Terracing will also be incorporated into the site landforms, particularly along lake foreshore areas. In accordance with natural floodplain characteristics, such terraces will vary in width with the potential to introduce a levee bank character along lake foreshores. Surface materials used in the Scheme are proposed to reflect the existing colours, textures and patterns of the landscape. These include gravel and sand, pasture grasses, and indigenous native trees and shrubs.

In the heritage precinct encompassing Hadley and Nepean Parks within the DA4 area, a section of natural floodplain from the residence of Nepean Park to the river may be retained or restored. Reformed lands adjoining this area will be designed to complement and replicate the floodplain landscape to create an area that, not only in landform will represent the historical landscape, but also provide an opportunity to re-establish former cropping and or pasture activities that were associated with the first settlers in the area.

6.1.3 Environmental Interactions and Impacts

The quarrying and rehabilitation of the DA4 area, will alter the existing landform from a relatively level alluvial plain into a recreational and wildlife Lake Scheme bordered by gently rolling and/or terraced landforms. The retention or restoration of a section of the original floodplain and its enhancement during the rehabilitation process will maintain the character and form of historical landscape elements.

The Lake Scheme will enhance the visual quality of the alluvial terrace by introducing to this relatively flat site, additional elements of interest, i.e. expansive water bodies, enclosed within a variety of landforms. The quality of views across the terrace will be enhanced by the topographic variation between the high and low land and the expansive areas of water, whether these views are from high land, from the shoreline or from the lakes themselves. The height, form, colour, location and development of land uses within the Scheme have been controlled to ensure that these do not detract from the visual quality of the Scheme area.

6.2 SOILS AND SOIL EROSION

Detailed studies of soils and soil types occurring in the Scheme area were undertaken by the then Soil Conservation Service in 1982 as part of the Regional Environmental Study. A wide range of different soil types were identified and mapped within the DA4 area. The study investigated the suitability of the soils as a medium for plant growth and the potential for erosion on the reconstructed landforms, recommended environmental procedures for erosion control, revegetation and maintenance of rehabilitated lands.

These procedures are detailed in a "Land Rehabilitation Manual" used by Scheme operators during extraction and rehabilitation procedures in the Scheme area. Application of these principles and procedures to date has resulted in stable, erosion free landforms throughout the Scheme area. Minor rilling following storm events is quickly repaired as part of maintenance procedures for rehabilitated landforms. The continued application of these principles and practices in the DA4 area will ensure the creation of stable, erosion free and useable landforms.

The bank to the Nepean River will, for most of its length will be retained intact. Works will be undertaken at pre-defined locations along the bank to provide for flood weirs as detailed in the Structure Plan (see **Section 5.1.5**). Quarrying will not proceed closer than 20 m to the bank with the reformed landform creating a minimum bank width of 40 m. The banks to the lakes and the river will be rehabilitated to form a stable landform.

6.3 WATER RESOURCES

This section describes the existing water resources and potential impacts of the proposed development in relation to dewatering, flood management, surface drainage and the water supply and quality of the interim lakes. The assessment of the Nepean River as a source of supply to the Scheme was exhaustively examined during the preparation of the Regional Environmental Study. That assessment considered the impacts on the Nepean-Hawkesbury River system. Thus no assessment of impacts on the Scheme water supply proposal has been included in this statement.

6.3.1 Existing Environment

The existing water resources of the Scheme area in general, and the DA4 area in particular, encompass both the groundwater and the surface drainage systems.

Groundwater

Below the 6 to 8 metre thick overburden layer, a groundwater table 4 to 6 metres in depth, generally lying in the sand and gravel deposit immediately above the impermeable shale or sandstone bedrock, carries water across the Scheme area to the west. Groundwater is depleted by natural aquifer drainage to the Nepean River and, to a lesser extent, by evaporation losses associated with lakes in previously extracted areas. Monitored water surface levels in these lakes indicate little variation, even in periods of low rainfall, which is evidence of the system's capacity to maintain groundwater levels in these areas. Groundwater quality is generally very good, but salinity tends to increase with increasing aquifer depth.

Monitoring of groundwater levels indicates a relatively responsive aquifer, which is very much influenced by immediate prevailing weather conditions.

Surface Water

The Scheme area is located within a relatively small and well-defined catchment that is subject to flooding from the Nepean River and from its own catchment. In general, the catchment drains in a northerly direction by way of three main creeks: Cranebrook, McCarthys and Farrells Creeks. No formal stormwater drainage system exists within the Scheme area. Works associated with previous and existing quarrying operations have introduced some form of drainage to the area utilising lakes and quarry operations as features in the system.

6.3.2 Environmental Management Procedures, Interactions and Impacts

The principal water management and water quality issues associated with the DA4 development would be essentially similar to those associated with the current activities. These issues are discussed below.

Dewatering

Removal of excess water from extraction pits and fill areas is essential for operational requirements. The proposed management system described in **Section 5.2** will be directed toward using dewatering volumes as an additional source of make up water the lakes.

Dewatering has an immediate effect on the surrounding aquifer. Experience in DA3 operations showed nearby surrounding wells being reduced by 1-2 metres as exposed aquifers were draining into adjacent dewatering areas. These wells recovered relatively quickly after the aquifer was sealed with placed overburden.

If any existing licensed groundwater users within the Scheme area are affected by dewatering operations, the Corporation undertakes to provide an alternative supply.

Due to the creation of the main lake, local water resources are now retained on site and it is not expected that surplus water will need to be discharged from the site. Only in extreme or unusual circumstances will it be necessary to discharge from the site. If necessary, these discharges will be made to Cranebrook Creek in accordance with provisions contained in EPA licensing requirements. Other sites might also be required from time to time, to meet immediate operational requirements. Again these will be subject to EPA licensing requirements.

Tailings

The existing tailings management system described in **Section 5.3** will be required to be upgraded during the period of operations in the DA4 area. This will be achieved by reorganising the walls of the existing ponds to accommodate the 5 million tonnes of tailings generated by the DA4 operations.

Completed Scheme Flood Management

The Scheme area is subject to flooding from the Nepean River. In the south of the Scheme area, a 1 in 100 year flood would generally be contained within the Nepean River banks, but floods of greater magnitude would overtop the banks and inundate most of the Scheme area. However, a study of flood gradients and bank slopes in the downstream sections of the river adjacent to the Scheme area showed that overbank flow into the Scheme area approximately between the midway point and the northem end could occur during smaller floods. In addition to overbank flow from the river, lands in the north of the Scheme area are subject to flooding from back-up water from the Nepean River and from stormwaters draining the local catchment.

In the completed Scheme, if floodwaters were permitted to overtop the Nepean River bank and flood the lakes and their environs, and if proper protection had not been provided for the river bank, failure of the bank could occur through scouring of the internal sides of the bank. A system of flood protection has therefore been formulated and incorporated into the proposed design of the Scheme. This system is described in **Section 5.1.5**.

The objective of the flood protection plan is to fill the lakes with water during the early stages of a flood. Should there then be any overtopping of the riverbanks the water level in the lakes would almost equal the water level in the river, thus minimising the are of bank that would be exposed to scouring flows. Control weirs connecting the lakes with the river and to each other would be required.

The overall concept of the proposed flood protection plan has been refined by further investigation, and it is considered that the proposed arrangements of spillways and levees should protect the lakes system from scour damage by floods. Final design studies have been completed and the Structure Plan of SREP N$^{o.}$ 11 has been amended to accommodate design implications arising from these studies.

Specific Scheme flood protection works to be undertaken within the DA4 area are described in **Section 5.1.5.**

Interim Flood Management

There is a risk that Nepean River floodwaters could enter the quarry and rehabilitation areas during the life of DA4, either by overbank flow from the Nepean River or via back up water from Cranebrook Creek.

If floodwaters do enter the quarry and rehabilitation area, the pits and lakes would be dewatered using pumps, in order to resume normal operations as soon as practicable. Emergency extraction areas may need to be provided outside the current operating area to maintain sand and gravel supplies until such time that the flooded operations areas are returned to normal. Risk management and recovery plans are prepared annually as part of the budgetary process using the principles described in **Section 5.1.6.** The issue of interim flood management is considered in the preparation of such plans.

Surface Drainage

The section of Cranebrook Creek contained within the DA4 area will be progressively removed by proposed quarry and rehabilitation activities.

The upper catchment of Cranebrook Creek has already been removed under previous consents. Its removal during DA4 will cause no additional impacts.

Lake Water Supply and Quality

Section 5.1 details water management arrangements during DA4. Included in this description is provision for water supply to the lakes.

Water quality performance of the lake systems will improve as the lakes become biologically mature. Desirable water quality goals can be achieved by reducing nutrient loadings and promoting the early development of the aquatic biological structure.

To this end, the detention basin system has been designed to reduce nutrient loadings entering the lake system. Monitored performance of these basins indicate that about 70% of nutrient loads are removed before waters flow into the SIRC lake.

Further details of water quality management are provided in **Section 5.1.**

6.4 AIR QUALITY

Detailed studies of impacts on air quality as a result of the DA4 operations have been assessed by ERM Mitchell McCotter (1997) and detailed in **Attachment A.** The contents of this section are a summary of these investigations.

6.4.1 Existing Environment

Air quality monitoring has been undertaken in the Scheme area since 1992 using eight deposition gauges, five directional gauges and one high volume sampler. The location of these gauges are shown on **Figure 6.1.** Results for the years 1995 and 1996 have been reviewed to establish existing air quality and are tabled in the consultant's report.

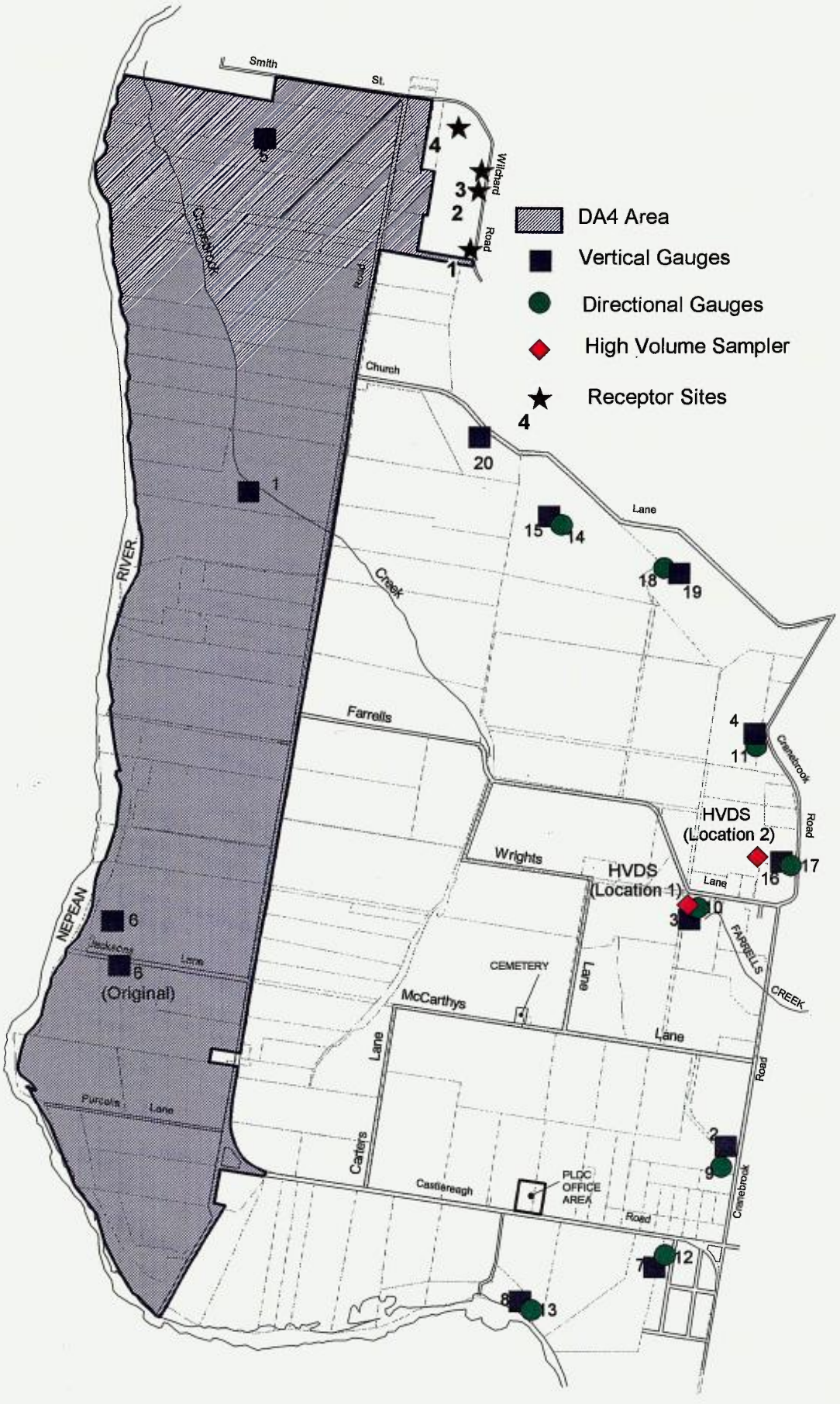


Figure 6.1 Dust Monitoring Locations

Results from a gauge (N°. 5) near the northern (Smith Lane) and eastern (West Wilchard Road) residences show an annual average deposition of 2.14 and 2.54 g/m^2/month for 1995 and 1996, respectively. The records from the nearest directional gauge (N°. 14) indicate that most of the deposition in 1996 was from the west and south directions, expected to be from the DA3 operations.

Existing air quality at central residences (N°. 1), show an annual average deposition between 3.19 and 3.38 g/m^2/month for the years 1995 and 1996.

The nearest gauge to residences in the south (N°. 8) is considered too distant from nearest residences to provide data representative of those available for other residences. The annual average deposition recorded at this gauge for 1995 and 1996 was 2.81 and 2.71 g/m^2/month, respectively. The nearest directional gauge (N°. 13) showed that depositions were mainly from the west in 1995, and west and north in 1996. Most gauges recorded high combustible contents (25-30%) indicative of organic material rather than dust produced from rock materials.

Total Suspended Particles (TSP) were measured at one location near the site (see **Figure 6.1**) using a high volume sampler. Mean results for 1995 and 1996 were 97.7 and 81.1 μg/m^3 which are above or close to the EPA criterion of 90 μg/m^3. The sampler is located within the DA3 area, and the concentrations reflect emissions from that source rather than general concentrations throughout the area. Although data indicating dust concentrations over a wider area are not available, these are expected to be substantially lower that those shown above, and are assumed to be in the order of 30 μg/m^3.

Air Quality Criteria

The effects of dust on health and amenity can be assessed by comparing dust deposition rates and dust concentration levels with recognised air quality criteria established in NSW and overseas.

The National Health and Medical Research Council of Australia (NHMRC) recommends a maximum atmospheric particulate concentration level of 90 μg/m^3 (annual average) to protect public health in residential environments. This level is generally endorsed by the Environment Protection Authority (EPA).

The EPA has established air quality goals for dust deposition. These are based on an incremental approach in which the acceptable increase in dust deposition depends on the existing level. **Table 6.1** summarises the criteria.

TABLE 6.1
NSW EPA DUST DEPOSITION GOALS

Existing Dust Level	Maximum Acceptable Increase over Existing Dust Level g/m^2/month (annual average)	
g/m^2/month (annual average)	Residential	Other Areas
2	2	2
3	1	2
4	0	1
>4	0	0

For example, in semi-rural areas with annual average deposition levels of 2 g/m^2/month, an increase of up to 2 g/m^2/month (annual average) would be permitted before it is considered that a significant degradation of air quality had occurred.

Based on this criteria and existing air quality in the Scheme area, the increase in the annual average depositions at the residences around DA4 should not be more than as listed in **Table 6.2.** However, it may be noted that existing levels of deposition and concentration appear to be mainly due to the DA3 operations, and therefore may vary with changes in the activities in the DA3 area and will reduce as the operations in DA3 come to end. Also, not all gauges are located in the immediate vicinity of the residences, and considering that the dust fallout generally is within a few hundred metres of the source, the existing levels at such residences are likely to be lower that those listed in **Table 6.2**.

TABLE 6.2
PERMISSIBLE INCREASE IN DEPOSITION RATE
g/m^2/month

Residences	Existing level of deposition	Acceptable increase in the level of deposition	Acceptable level of deposition
North	2.34	1.66	4.0
East	2.34	1.66	4.0
Central	3.29	0.71	4.0
South	2.76	1.24	4.0

6.4.2 Environmental Management Procedures

To minimise dust emission throughout the Scheme area, the Corporation will:

- Keep all unsealed roads used for material haulage sufficiently damp at all times to prevent wind-blown dust or traffic generated dust. Plant will be provided and operated to enable watering at least at a rate of 1 L/m^2/hour.
- Establish a grass cover on completed landforms as quickly as possible.
- Where wind speeds average 5 m/s, and nearby residences are likely to be affected by dust, overburden-stripping operations will cease.
- Minimise cleared land awaiting quarrying or rehabilitation but having regard to environmental noise management and safety aspects.
- Continue dust monitoring at the boundaries of the site and to take corrective action should dust levels exceed EPA and NHMRC criteria.

The additional safeguards below will be adopted when quarrying near the Camenzuli property and Nepean Park.

- Reduce the number of equipment items used where possible.
- Restrict use of certain dust generating equipment.
- Increase responsiveness to adverse climatic conditions.

The Corporation has recently introduced the use of latex sprays into its operations. These are used on raw feed haul roads and on areas exposed awaiting extraction. Anecdotal evidence suggests that their use is very beneficial in managing dust emissions. Monitoring results to date would not be influenced by their use.

6.4.3 Environmental Interactions and Impacts

Air quality impacts have been assessed using a computer-based dispersion model known as DUSTGLC and emission factors for various site activities and operations. DUSTGLC has been widely used in the Hunter Valley and has been validated for two operating mines in that area.

The estimated rates of dust emissions were applied with the meteorological data to calculate dust dispersion. A computer plotting routine was used to draw isopleths of the predicted dust deposition rates and concentrations of total suspended particulates in air.

Four different years of operation were modelled depending upon the proximity of each block of residences to the operations in that year. The residences and the year of operation in which they are likely to be most affected are listed in **Table 6.3**.

TABLE 6.3
MODELLED YEARS OF OPERATION

Residences	Year of Operation
Northeast of DA4	2005-2006
Centre of DA4	2006-2007
North of Smith lane	2009-2010
South of DA4	2010-2011

Contours indicating calculated levels of dust deposition and concentration for each year and presented in **Figures 6.2** to **6.9.**

In addition to these general contours, specific calculations were performed for four special receptor sites, representing residences along West Wilchard Road (see **Figure 6.1**). These residences are relatively close to the site, and it was considered appropriate to provide more precise predicted dust levels at these locations. Predicted TSP dust fallout and concentration levels for these residences are shown in **Table 6.4** and **Table 6.5**, respectively.

TABLE 6.4
PREDICTED INCREASE IN DEPOSITION RATES AT RECEPTORS ALONG WEST WILCHARD ROAD (g/m^2/month)

Receptor	Year of Operation			
	2005-2006	2006-2007	2009-2010	2010-2011
1	1.1	1.4	1.1	0.4
2	0.7	1.4	0.9	0.3
3	0.5	1.1	0.7	0.2
4	0.5	1.3	0.8	0.2

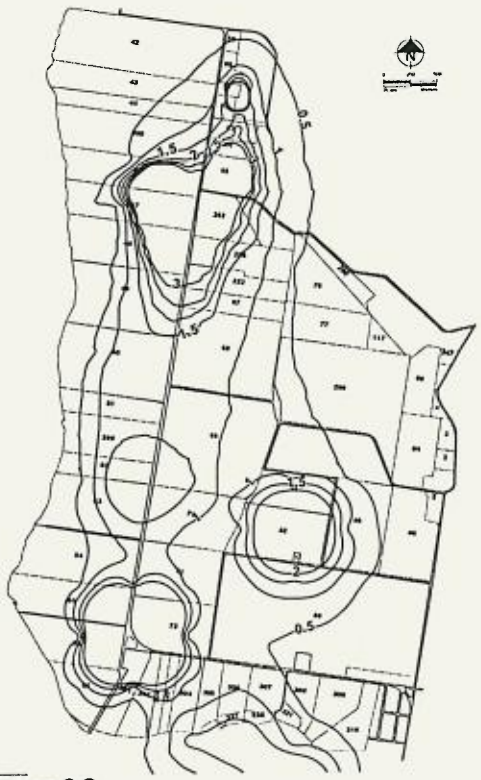


Figure 6.2
Predicted Dust Deposition Levels 2005-2006

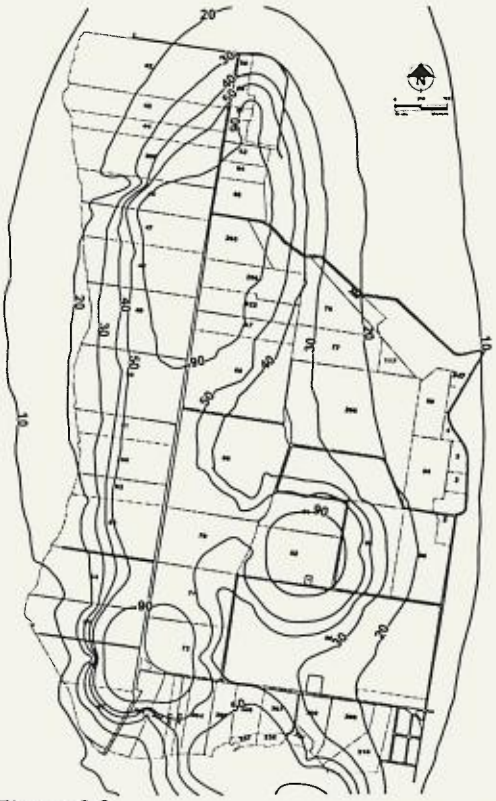


Figure 6.3
Predicted Dust Concentration Levels 2005-2006

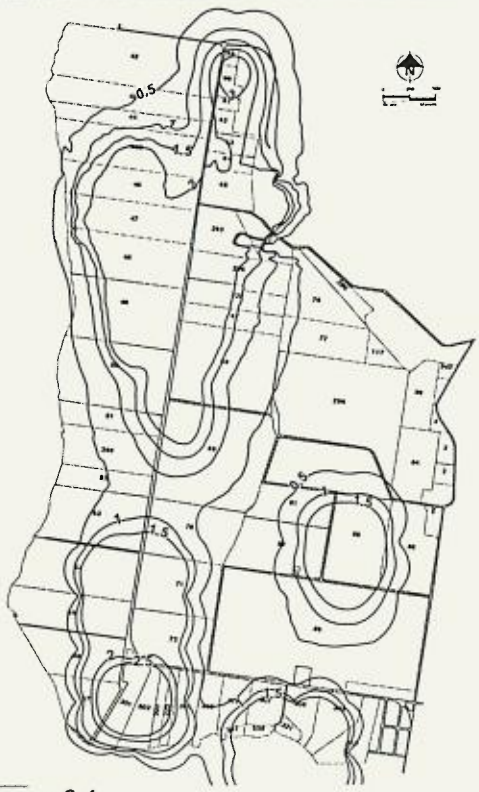


Figure 6.4
Predicted Dust Deposition Levels 2006-2007

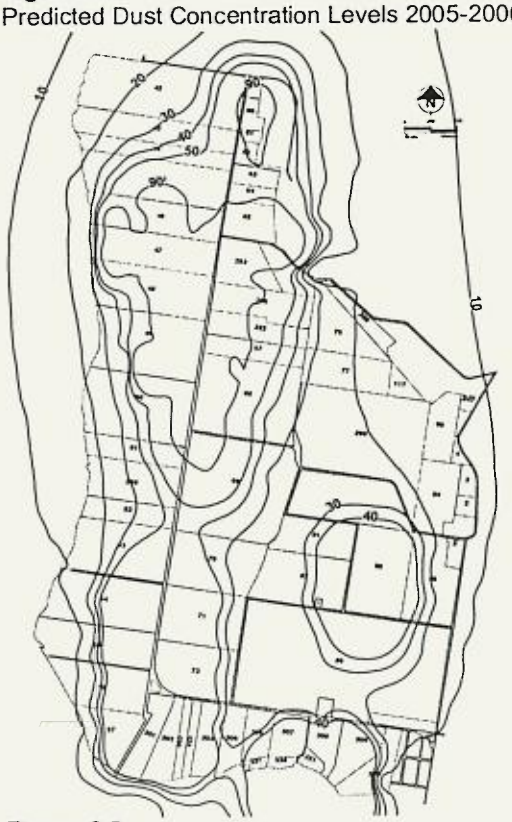


Figure 6.5
Predicted Dust Concentration Levels 2006-2007

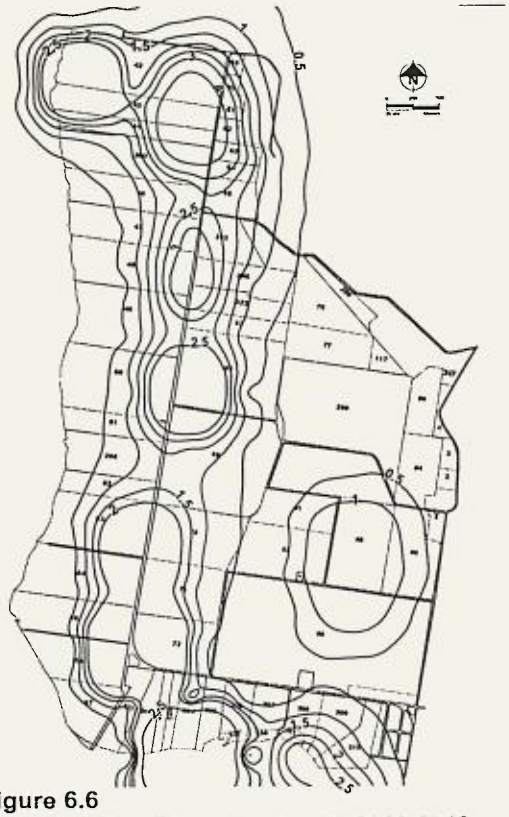


Figure 6.6
Predicted Dust Deposition Levels 2009-2010

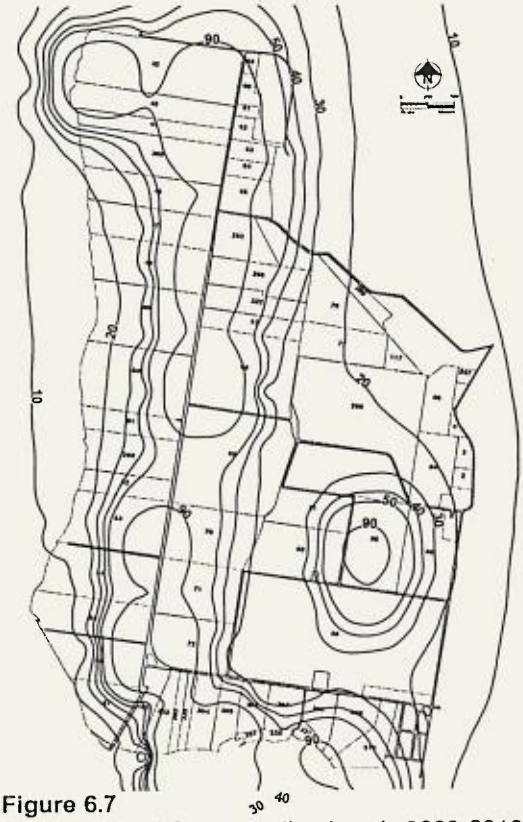


Figure 6.7
Predicted Dust Concentration Levels 2009-2010

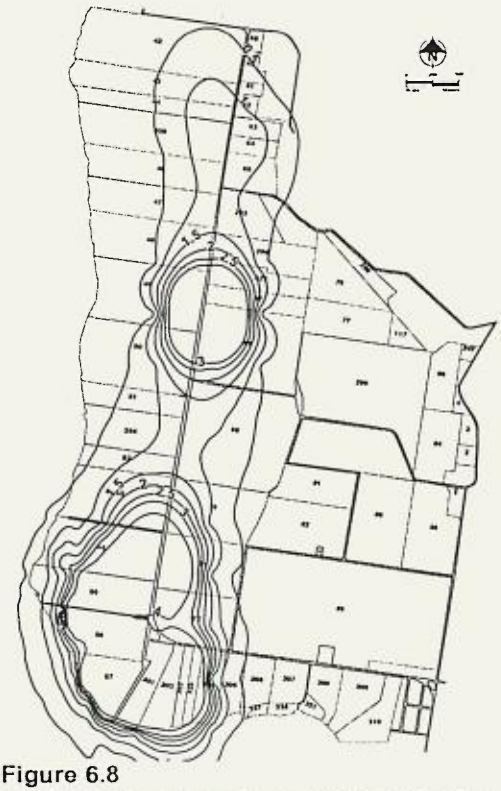


Figure 6.8
Predicted Dust Deposition Levels 2010-2011

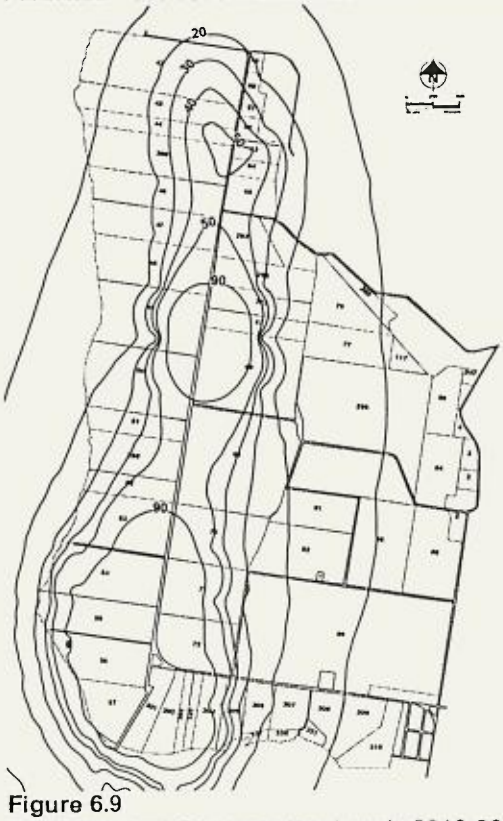


Figure 6.9
Predicted Dust Concentration Levels 2010-2011

TABLE 6.5
PREDICTED INCREASE IN TSP CONCENTRATIONS AT RECEPTORS ALONG WEST WILCHARD ROAD ($\mu g/m^3$)

Receptor	Year of Operation			
	2005-2006	2006-2007	2009-2010	2010-2011
1	60	64	54	21
2	42	57	45	17
3	35	51	40	15
4	31	59	45	14

Year 2005-2006

Operations in this year occur closest to the residences on the northeast side of DA4. It also covers the Camenzuli residence within the Scheme area. **Figures 6.2** and **6.3** show the isopleths for the annual average deposition and concentration, respectively, for this year. As seen from **Tables 6.4** and **6.5**, depositions at the West Wilchard Road residences range from 0.5 to 1.1 g/m^2/month. This rate of deposition is less than EPA criterion of 1.66 g/m^2/month applicable for this area. **Table 6.5** and **Figure 6.3** show that the increase in concentration of total suspended particles (TSP) near these residences range from 30 to 60 $\mu g/m^3$. Based on this, the total TSP concentrations are likely to remain below the NHMRC recommendation of 90 $\mu g/m^3$.

Due to the proximity of the Camenzuli residence to the quarrying operation, the permissible limits of TSP concentrations and depositions are likely to be exceeded. The Corporation is committed to undertaking discussions with residents prior to commencing work in this area. The additional safeguards described in **Section 6.4.2** will be implemented when works are in the vicinity of the Camenzuli property.

The deposition and concentration of TSP is nominal for residences to the north, south and centre of DA4, and predicted to be well below the relevant criteria.

Year 2006-2007

Operations in this year occur closest to the residence within the DA4 area near Nepean Park. **Figures 6.4** and **6.5** show the isopleths for the annual average deposition and concentration respectively for this year. **Figure 6.4** shows an increase of around 2.0 g/m^2/month near the residence. This rate of deposition exceeds the EPA criterion of 0.71 g/m^2/month applicable to this area. **Figure 6.5** shows the increase in concentration of total suspended particles (TSP) near this residence to be approximately 90 $\mu g/m^3$, which is equal to NHMRC recommendation of 90 $\mu g/m^3$ for total dust concentration.

The contours represent worst-case locations for equipment, and annual average values of deposition and concentration are expected to be somewhat lower than those shown. However, it is likely that for this year, annual average values of these parameters could exceed the relevant criteria at this residence. The Corporation is therefore committed to undertake discussions with the residents prior to commencing operations in this area. The additional safeguards described in **Section 6.4.2** will be implemented when works are in the vicinity of Nepean Park.

Tables 6.4 and **6.4** show predicted increase in depositions and TSP concentrations at the residences along West Wilchard Road during this year. The maximum deposition increase is 1.4 g/m^2/month, which is less than the acceptable increase for this area. The maximum TSP concentration increase is 64 $\mu g/m^3$. As noted above, the modelled dust concentration represents the maximum likely concentration for this period, and may not be sustained throughout the year. It is therefore likely that the total annual average concentration will not exceed the NHMRC recommendation of 90 $\mu g/m^3$.

At other residences to the north, south and in the centre of DA4, the deposition and concentration of TSP is nominal and is predicted to be well within the relevant criteria.

Year 2009-2010

Operations in this year occur closest to the residences north of DA4. **Figures 6.6** and **6.7** show isopleths for the annual average deposition and concentration, respectively for this year. **Figure 6.6** shows an increase of less than 1 g/m^2/month is likely to occur due to the quarrying operations for some residences in this area. This rate of deposition is less than the EPA criterion of 1.66 g/m^2/month applicable to this area. **Figure 6.7** shows that the increase in concentration of TSP near the residences will be less that 40 $\mu g/m^3$. The total TSP concentration is therefore likely to remain below the NHMRC recommendation of 90 $\mu g/m^3$.

As shown in **Tables 6.4** and **6.5**, the maximum predicted increase in the TSP concentrations and depositions at the residences on the northeast side of the site is 54 $\mu g/m^3$ and 1.1 g/m^2/month, respectively. Both these values are below the relevant criteria.

At other residences to the south and in the centre of the DA4 area, the increase in deposition and concentration of TSP is nominal and is predicted to be well within the relevant criteria.

Year 2010-2011

Operations in this year occur closest to residences south of DA4. **Figures 6.8** and **6.9** show isopleths for the annual average deposition and concentration, respectively for this year. **Figure 6.8** shows a maximum increase in deposition of about 0.5g/m^2/month is likely to occur due to the quarrying operation in this area. This is less than the permissible increase of 1.24 g/m^2/month for this area.

Figure 6.9 shows an increase in concentration of approximately 30 $\mu g/m^3$ TSP near the residences. This concentration level combined with the existing concentration level is unlikely to exceed the NHMRC recommendation of 90 $\mu g/m^3$.

Other residences on the north, northeast and in the centre of the DA4 area are not significantly affected by the operation in this year and therefore the deposition and concentration levels are expected to remain within the relevant criteria.

Episodic Impacts

Short-term dust episodes relate to temporary increases in the amount of dust raised mainly from disturbed surfaces and other dust-containing areas by strong winds in dry weather conditions. Winds above 5 m/s, which would at times be sufficiently strong to result in a dust episode, will most likely originate from the west.

The nature, strength and duration of a dust episode are determined by a variety of factors, which are not easily quantified. A realistic prediction of dust concentrations in the air during the episodic event is more difficult to achieve with accuracy than the corresponding prediction of annual dust levels.

Sensible management will minimise the potential of dust generation from the quarry. For example, the proposal to cease overburden placement during periods of high wind will limit impact. The Corporation has used, and will continue to use, latex compounds to reduce dust emissions.

Airborne Respiratory Dust and Silica

Detailed studies have been undertaken by Noel Arnold & Associates (1997) to assess respirable dust and airborne silica levels of the boundary of the Scheme area. A total of seven locations (shown on **Figure 6.10**) were monitored during operations in the DA3 area and results assessed against relevant exposure standard.

The investigations involved static monitoring of airborne respirable dust contaminants taken over a representative eight hour period at various locations within and adjoining the Scheme boundary. Results were assessed against current Worksafe Exposure Standards for Atmospheric Contaminants in the Occupational Environment (May 1996).

The investigations found that at all locations respirable dust levels were less than 0.1 mg/m^3, which is well below the Worksafe Exposure Standard of 5 mg/m^3. Total silica dust levels at all locations were less than 10 µg which is well below the maximum criteria of 100 $\mu g/m^3$ set by the Australian Conference of Government Industrial Hygienists-Exposure Standard. The results showed that health risks to nearest residents are not significant.

It is not expected that respirable dust or silica will be a cause for concern during quarrying in the DA4 area.

6.5 NOISE

Investigations to assess potential noise impacts during quarrying in the DA4 area have been undertaken by Wilkinson-Murray Pty Ltd (1997) and their detailed report provided in **Attachment B.** The results of these investigations are summarised below.

6.5.1 Existing Environment

In order to establish the impact of future noise from the DA4 area, it was necessary to establish the existing noise environment. Accordingly, background noise monitoring has been undertaken at residences that have the potential to be affected by the quarrying operations in DA4. Locations were chosen as representative and are shown on **Figure 6.11**.

Measurements were made using Automatic Environmental Noise Loggers which record the noise levels continuously. A summary for each 15-minute period is provided by the equipment which contains the L_{A1}, L_{A10}, L_{A90} and L_{Aeq} values. The L_{A1} and L_{A90} levels are the levels exceeded for 1% and 90% of the time and are the typical maximum level and background noise levels, respectively. The L_{Aeq} is the energy average, or the equivalent continuous noise level, over the measurement period and is a standard measure of traffic noise. The L_{A10} is the noise level exceeded for 10% of the time and is a descriptor used for industrial noise.

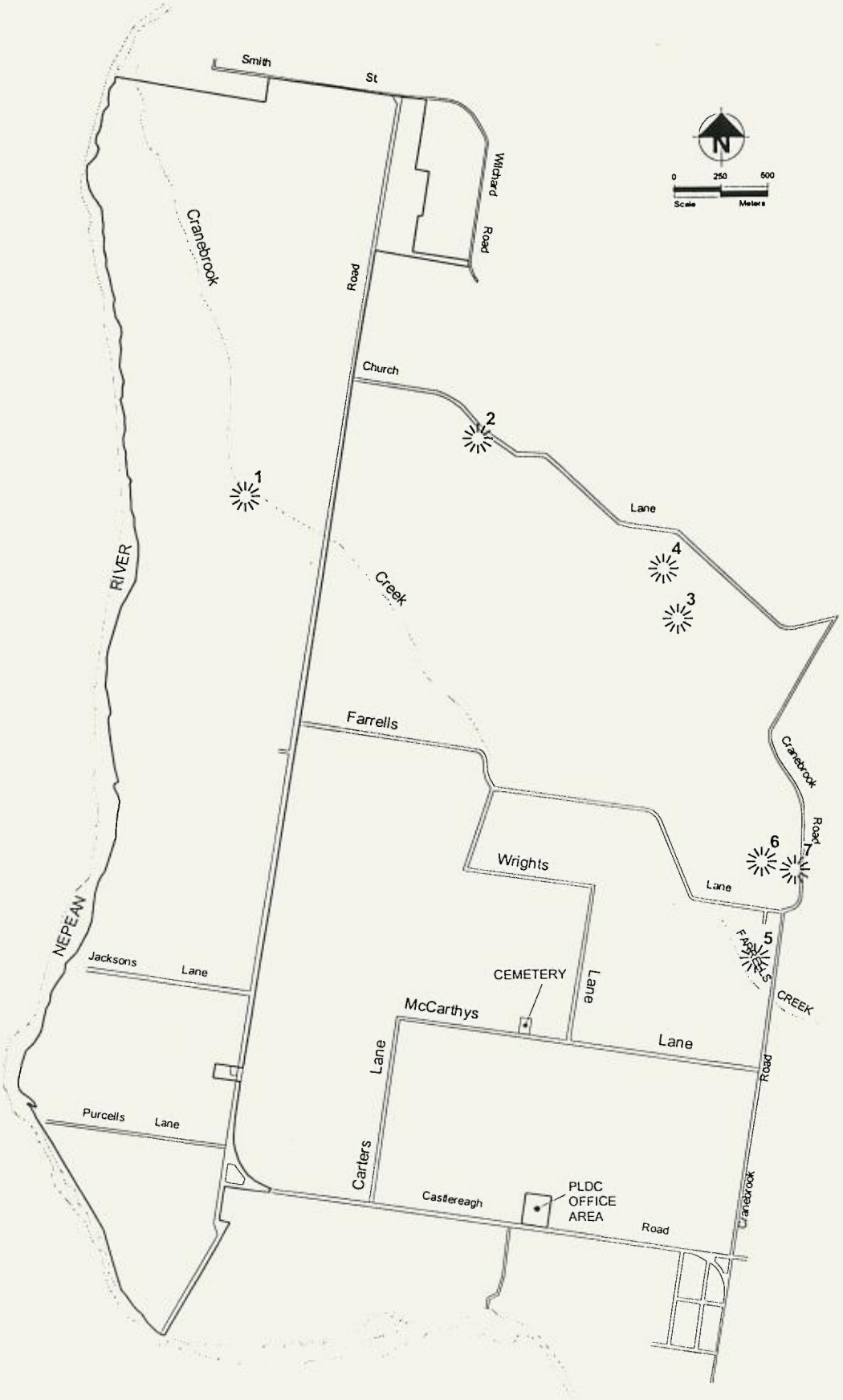


Figure 6.10 Monitoring Locations for Respiratory Dust and Silica

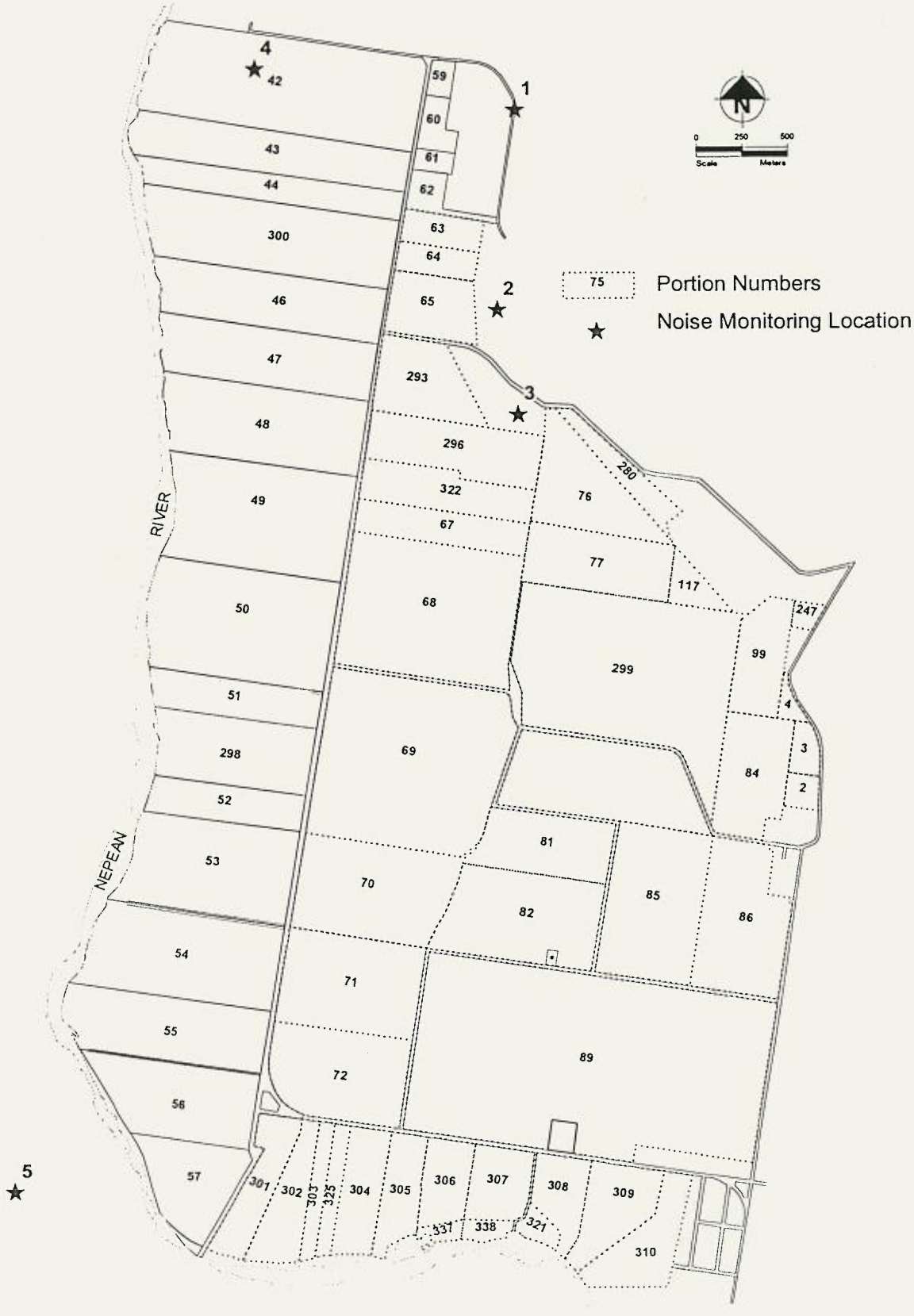


Figure 6.11 Noise Monitoring Locations

The loggers were calibrated before and after measurements to ensure correct functioning. They were located within 1m of the residential boundary closest to the DA4 area at each site.

Typical minimum background noise levels applying throughout the day at each measurement location are shown in **Table 6.6.**

TABLE 6.6
TYPICAL MINIMUM REPEATABLE DAYTIME BACKGROUND NOISE LEVELS

Location	Background Noise Level - L_{A90} dBA	
	1994	1996
1 (West Wilchard Rd, Castlereagh)	38	40
2 (385 Church Lane, Castlereagh)	31	Not Measured
3(Carlyle Pk, Church Ln, Castlereagh)	43	Not Measured
4 (Smith Street, Castlereagh)	Not Measured	37
5 (Strathdon Rd, Emu Heights)	Not Measured	37

Design Criteria

In selecting noise level design criteria, it is recognised there may be short periods of time when the noise level will be significantly higher, particularly when land forming takes place close to residences, as will be the case with Smith Street and Nepean Park. However, the nature of the operation is that quarrying is progressive and as such, noise from its activities will be transient.

Under the current consent conditions, the following levels are set in respect of noise for operations nearby the residents on the Castlereagh Escarpment.

"Maximum Noise Levels: Noise levels as measured at any one dwelling on the escarpment are not to exceed the following criteria:

Maximum Noise Limits (L_{A10})

Absolute Maximum	70 dB(A)
Greater than	65 dB(A) for 3 months
Greater than	55 dB(A) for 30 months
Less than	55 dB(A) for remainder of time"

Assumption: Extraction and rehabilitation approximately 200m from dwellings on the escarpment.

The Regional Environmental Plan specified that quarrying is the main land use in the area during development of the Scheme. Accordingly, it is recommended that the existing noise criteria be extended to cover the DA4 development. This is consistent with the notion that quarrying activities are changing in location only and not in scale.

Maintaining the existing criteria will constitute a more stringent operating condition for the Corporation as the quarrying and earthmoving equipment will be operating in more localised areas and closer to some residences but away from the bulk of the

residences of Cranebrook during DA4. It is expected that noise controls will be required in order to meet the existing noise criteria.

6.5.2 Environmental Management Procedures

The proximity and number of quarry related machinery dictates that noise control is required to mitigate the effects of noise at nearby residences. The design criteria represent a reasonable compromise between the need to extract sand and gravel and preserving the residents' amenity. The controls described below represent the best practical means for extracting sand and gravel whilst limiting noise emissions.

Noise controls are separated into two categories; general and specific, the second category providing benefit to certain localised groups of residents.

General Controls

The Corporation recently reviewed its mining strategy near the Cranebrook escarpment. Restricting the use of some particular items of machinery, separating working areas, and changing haul road directions, significantly reduced noise emissions. These studies were undertaken in consultation with affected neighbours and the EPA. The strategy was changed even though the previous strategy would have met established criteria.

Equipment Distribution

- generally trying to disperse operating equipment over larger areas. This can be achieved by increasing the level of pre-stripped reserves to separate extraction and overburden stripping equipment.
- the provision of a long gravel face to separate extraction equipment is also possible.
- extracting land forming and rehabilitation sites which are distant from both of the above operations, and if necessary, more than one fill site.

Gravel Faces

- extraction equipment to be operated at the lowest level possible to maximise shielding benefits from the gravel face. The gravel face should progress towards the nearest residence along an imaginary line between the excavator and the residence. The gravel face should be perpendicular to this line.

Haul Roads

- consideration in their design be given to keeping hauls roads as far to the west and as low as possible, and orientated directly away from extraction areas and boundaries.

Specific Controls

In order to reduce noise levels at the residence of Nepean Park, an earth bund 5 m above the existing ground level will be constructed around the property. No gaps in the bund are proposed, except to provide entrance to the property. Noise modelling has assumed a bund wall 50m from the residence to a height of 5 m. This matter will be negotiated with the owners of Nepean Park as they may not wish to have this bund constructed.

6.5.3 Environmental Interactions and Impacts

Noise levels for the three main quarry activities, overburden removal, gravel extraction, and land rehabilitation have been calculated for three stages of the DA4 development and assessed against the design noise criteria presented above. Octave band sound power levels for the equipment to be used were used in the predictions. Calculations have been carried out for three key operating scenarios. These represent times when the main quarrying operations are predicted to take place near to the closest residential locations.

Calculations have been made using the software "ENM" (Environmental Noise Model) distributed by RTA Technology. This model uses information about the noise output (sound power) and location of sources, the topography between source and receiver, and atmospheric conditions to calculate noise levels at a receiver location. Acoustic effects such as distance attenuation, shielding, air and ground absorption and atmospheric effects are included in the model.

2005-2007

Overburden removal, quarrying of the resource and rehabilitation will be located in the northeast corner of the DA4 area. In this scenario, the majority of equipment is located near to West Wilchard Road. Overburden is stripped prior to gravel extraction, with the overburden used to backfill previously extracted pits. Gravel is hauled directly west from the pit towards the haul road parallel to Castlereagh Road or south towards the Pioneer processing plant. Haul roads are maintained by the Corporation's equipment throughout the Lakes area. The scenario represented is generally a steady, long-term operation as extensive earthworks are required to complete operations in the area. The scenario modelled and the noise levels determined as a result represent a worse-case condition for the West Wilchard Road residents for the years 2005 to 2007.

2007-2009

Main quarrying activities will be concentrated to the northwest of DA4 just south of Smith Street. In this model, overburden stripping takes place within 250m of the nearest residences. Overburden haul routes and gravel haul routes are directed away from the gravel pits to the south. Haul roads are maintained throughout the Scheme area by the Corporation. Residences on the south side of Smith Street overlooking the DA4 area will be most affected by activities during this period. The noise levels calculated from this model are representative of levels that the few residents along Smith Street would experience when quarrying activities are concentrated nearby.

2010-2011

Overburden stripping to the far south of the DA4 area is taking place. This is adjacent to Strathdon Road, which is at an elevated position on the other side of the Nepean River. Gravel extraction is taking place to the north of this area and land forming on the southern-most tip of the DA4 area. All haul routes are aligned north and parallel close to Castlereagh Road. Gravel haul traffic and haul road maintenance vehicles are distributed throughout the Scheme area, as is the case with all model years. This situation yields noise levels, which will most affect residences in Strathdon Road, Emu Heights. The scenario represented is a worst-case condition for the residents for the latter end of the project.

Noise level contours for the three modelling years are shown in **Figure 6.12 to 6.14**. These Figures include the influence of the earth bund noise control proposed in **Section 6.5.2** and are based on an operational sequence plan for the quarry as indicated by the Corporation. These represent typical high noise scenarios for the residences involved.

Figure 6.12 shows that under worst-case conditions, noise levels for residences in West Wilchard Road will not be over 60 dBA for three months and 55 dBA for any significant longer time. Residences in Church Lane will be exposed to noise levels of approximately 60 dBA for up to 3 months. This is within design noise criteria.

Noise levels less than 60 dBA are predicted and indicated in **Figure 6.13** for the residents in Smith Street. These worst-case levels are likely to persist for the one month during overburden removal and less than 55 dBA for the periods in excess of two years. This is within design noise criteria.

Noise levels under 60 dBA are indicated in **Figure 6.14** for the residences in Emu Heights.

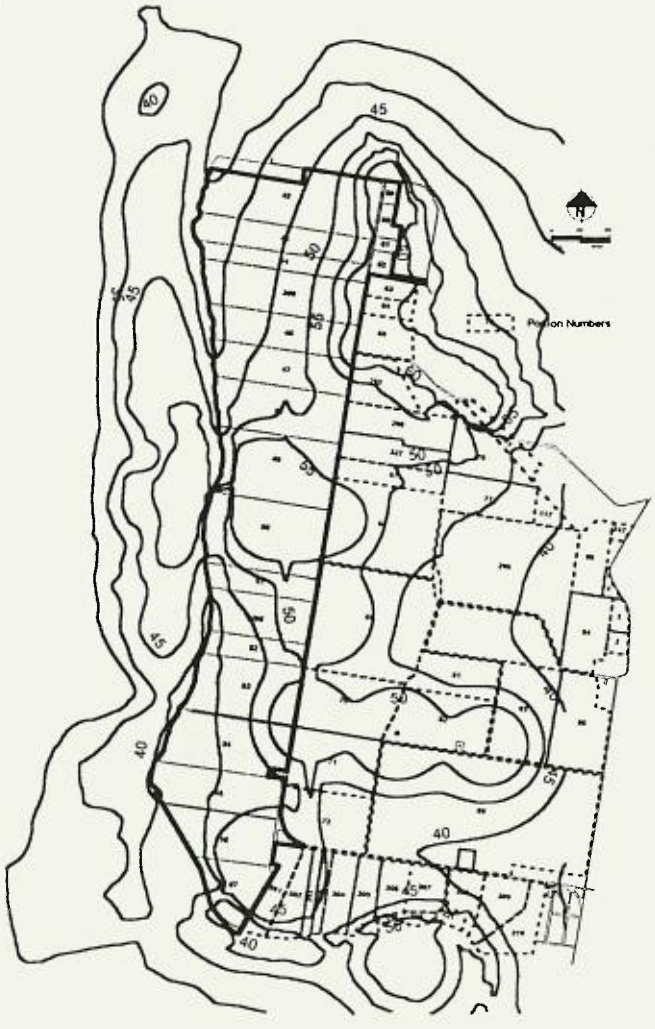


Figure 6.12 Worst-Case conditions Noise Levels for Residences in West Wilchard Road and Church Lane

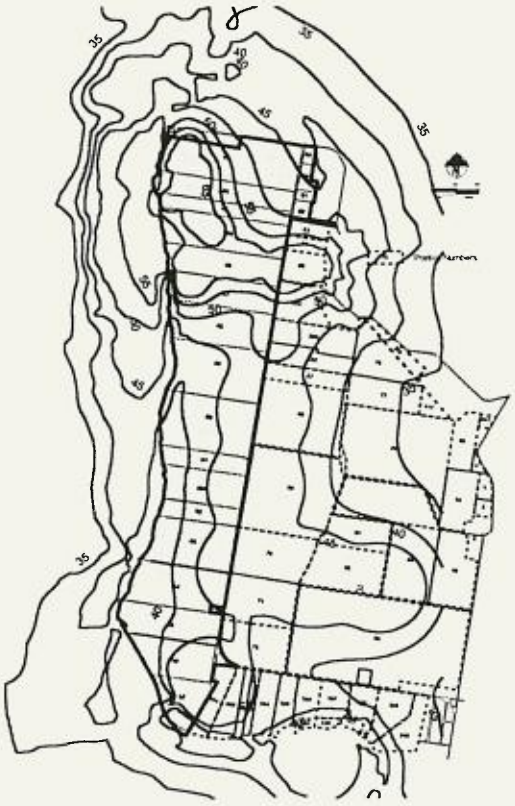


Figure 6.13 Worst-Case conditions Noise Levels for Residences in Smith Street.

Figure 6.14 Worst-Case conditions Noise levels for Residences in Emu Heights.

Nepean Park is likely to experience noise levels in excess of 55 dBA for periods of more than two years even with the construction of the bund wall. The Corporation will work with the owners of Nepean Park to ensure their overall amenity is maintained. Similar arrangements were implemented for a resident in DA2.

Previous noise investigations undertaken by the Corporation has shown that commencement of operations at 5:00am presents no adverse noise impacts at nearest residences. Advice from Wilkinson Murray Pty Ltd suggests that a 5:00am start might be appropriate if extraction is carried out no less than 1 kilometre from the nearest residence. Unshielded haul trucks need to be 2 kilometres away. With the exception of the Nepean Park and Camenzuli properties the majority of the DA4 area would fulfill this design limitations. The Smith Street/West Wilchard Road area would provide an exclusion envelope in the northern sector in which a 5:00am start would not be appropriate. Subject to negotiations with the owners of Nepean Park property and Camenzuli property the balance of the DA4 area would be extracted with a 5:00am start.

In summary, the predictions show that it is unlikely that 60 dBA short-term and 55 dBA long term will be exceeded for residents, for any extended time period, in each scenario considered (except the Nepean Park homestead). Proposed noise controls will limit the period that these exceedances occur to ensure compliance with the design criteria.

6.6 FLORA AND FAUNA

There have been several studies of the flora and fauna in and near the Penrith Lakes Scheme, including comprehensive studies undertaken for the Regional Environmental Study which provided the background to the Scheme design and implementation. Previous studies have been summarised in Kevin Mills & Associates Pty Ltd (1995a). Extensive flora and fauna studies of the DA4 area have been undertaken by Kevin Mills & Associates Pty Ltd (1996) and the following is a summary of the report provided at **Attachment C**. Detailed species lists are provided in the report.

6.6.1 Existing Environment

Native Flora and Vegetation Communities

The native flora in the DA4 area is very restricted because most of the land has been cleared for farmland. Although native plants were occasionally found in the paddocks, most was found either along the Nepean River corridor or in and around the small wetlands scattered across the site. A list of 55 native plant species have been recorded and listed in the detailed report.

Remnant plant community types include wetland flora and riparian flora.

Wetland Flora

There are many small areas of wetland on the low-lying parts of the floodplain. None is in a natural condition; while some of the wetlands have been greatly disturbed over the years, the others are artificial wetlands that were constructed to provide water for stock and perhaps to irrigate the paddocks.

The most common native species in these wetland areas are Cumbungi *Typha orientalis*, Tall sedge *Carex appressa*, Water Primrose *Ludwigia peploides*, Water Couch *Paspalum disttichum*, Common Rush *Juncus usitatus*, Spike-rush *Eleocharis*

? equisetina, Tall Spike-rush *Eleocharis sphacelata* and Knotweeds *Persicaria spp.* Introduced wetland plants also occur in the area, such as Umbrella Sedge *Cyperus eragrostis*, Water Hyacinth *Eichhornia crassipes* and Brazilian Milfoil *Myriphyllum aquaticum*.

Riparian Flora

The vegetation along the Nepean River is a native forest that has been heavily disturbed. The dominant tree species is River Oak *Casuarina cunninghamiana*. The following additional native trees and shrubs are characteristic of this area: Coast Myall *Acacia binervia*, White Sallow Wattle *Acacia floribunda*, Forest Red Gum *Eucalyptus tereticornis*, Hickory *Acacia implexa* and Parramatta Green Wattle *Acacia parramattensis*. There are few native plants in the understorey because of the dense weed growth. Flora include Small leaved-Bramble *Rubus parvifolius*, Dusky Coral-pea *Kennedia rubicunda*, Blackthorn *Bursaria spinosa*, Glycine *Glycine clandestina* and Bluebell *Wahlenbergia gracilis*.

The river verges are heavily infested with weeds, particularly shrubs and climbers. The most common species are Willows *Salix spp*, Balloon Vine *Cardiospermum grandiflorum*, Castor Oil Plant *Ricinus communis*, Lantana *Lantana camara*, Tobacco Bush Solanum mauritianum, Fennel *Foeniculum vulgare*, Wandering Jew *Tradescantia albiflora* and Kikuyu Grass *Pennisetum clandestinum*. Other troublesome, but less common, weeds in the area are African Olive *Olea europaea*, Large-leaved *Privet Ligustrum lucidum*, Small-leaved Privet *Ligustrum sinense,* Moth Vine *Araujia hortorum*, Cape Ivy *Delairea odorata*, Camphor Laurel *Cinnamomum camphora*, Pampas Grass *Cortaderia selloana,* Blackberry *Rubus sp.*, Honeysuckle *Lonicera japonica*, Giant Reed *Arundo donax*, Madeira Vine *Anredera cordifolia*, Blue Morning Glory *Ipomoea indica* and Tree of Heaven *Ailanthus altissima*.

The riverbanks and the moist low-lying alluvium beside the river support a mixture of native and introduced wetland plants. The native species include Common Reed *Phragmites australis*, Cumbungi *Typha orientalis*, march Club-rush *Bolboschoenus fluviatilis,* Water Couch *Paspalum distichum*, River Club-rush *Schsenoplectus validus*, Azolla *Azolla filiculoides*, swamp Millet *Isachne globosa*, Club-rush *Scheonoplectus mucronatus* and Ribbonweed *Vallisneria gigantea*. The introduced wetland species along the river include Willows *Salix spp*, Water Hyacinth *Eichhornia crassipes,* Dense Waterweed *Egeria densa*, Umbrella Sedge *Cyperus eragrostis* and Blue Water Speedwell *Veronica anagallis-aquatica*.

There are only very occasional native trees on most of the floodplain and these are, almost invariably, large old specimens of Forest Red Gum *Eucalyptus tereticornis*, Broad-leaved Apple *Angophora subvelutina*, Narrow-leaved Red Ironbark *Eucalyptus crebra,* Thin-leaved *Stringbark Eucalyptus eugenioides* and Blue Box *Eucalyptus baueriana.*

Fauna Habitats

There are four main fauna habitats in the DA4 area: river wetlands, modified riparian forest, floodplain wetland and non-native grasslands. The river wetlands consist of large pools, occasional riffle sections, and aquatic and fringing wetland vegetation. The modified riparian forest consists of native species and many weed species. The grassland is dominated by non-native species and is on cleared land retaining only occasional trees. Habitats and wetlands are shown on **Figure 6.15**. Each small floodplain wetland has been give an identification number (see **Figure 6.15**) and was surveyed. Details of the survey are provided in **Table 6.7.**

TABLE 6.7
FAUNA HABITATS

Number (See Figure 6.15)	Habitat
1	Supports a dense stand of Cumbungi and a few other wetland plants including River Club-rush, Water Primrose, Lesser Joyweed, Water Couch and the introduced species Umbrella Sedge and Brazilian Water Milfoil. The land around the drainage line is intensively farmed.
2	These three small drainage lines support various wetland plant species. The most western area has been heavily grazed and there is only a sparse coverage of Tussock sedge and other species. Most of the central area is composed of weeds, Common Rush and a few other native wetland species. The eastern area is wet and mainly supports a dense stand of Cumbungi; there are several other species near the small pond to the south, such as Water Primrose and common Rush.
3	This is a permanent billabong with various wetland plants around the edges, particularly Common Rush. The most prominent plant is the weed, Water Hyacinth.
4	This is a small area of Common Reed on low-lying land; it would seldom be very wet.
5	This long and narrow low-lying area mainly supports scattered Common reed and a few other species, including the introduced weed Water Hyacinth.
6	This very wet area mainly supports Water Couch and the introduced weed Water Hyacinth. Water Primrose, Common Reed and a few River Oaks are also present. There are two large specimens of Broad-leaved Apple near the creek and one specimen of Blue Box to the far south.
7	This area is permanently wet and supports a fairly dense cover of Water Couch and a few other wetland species such as Common Rush. Water Primrose and a few River Oaks.
8	This small pond has muddy edges and a dense fringe of Common Rush. Water Primrose, Slender Knotweed, Water Couch and Azolla.
9	There is a dense stand of Cumbungi along the drainage line to the south of the road. The northern side is more entrenched and contains a permanent billabong with many wetland plants including small stands of Cumbungi, with Water Primrose, Water Couch and Common Rush.
10	This site is a shallow muddy pond with scattered clumps of Common Rush and tussock Sedge in a well grazed paddock.
11	This site contains degraded riparian forest composed of River Oaks and many introduced shrubs and vines. At this location, the river is a large pond with wetland plants along the edge, including River Club-rush, Marsh Club-rush and Cumbungi.
12	The old settling pond is nearly full of sediment and, although wet, there is little standing water. The area is being invaded by Willows and other weed trees. It also supports scattered River Oaks and dense Common Reeds.
13	This is a small low-lying area supporting Cumbungi, Water Couch and Water Hyacinth on the lower wet channel and Tussock Sedge on higher area.
14	This section of creek is permanently wet and supports various wetland species such as Willows, Cumbungi, Common Rush and the weed, Water Hyacinth.
15	This small area supports a stand of Cumbungi of varying density. The surrounding land is intensively farmed.
16	The ungrazed paddock supports two stands of cumbungi, but the rest of the area is dry and supports mainly pasture species, Blackberry thickets and stands of Sydney Green Wattle.
17	This broad low-lying area supports a cover of Tussock Sedge in a grazing paddock.
18	This drainage line mainly supports weeds, such as thickets of Blackberry and Willows; there are also a few patches of Cumbungi.
19	This drainage ditch along the southern side of Smith Road contains Cumbungi, Spike-rush, Common Rush, Tussock Sedge and a few specimens of the Paperbark, *Melaleuca linariifolia*.
20	This part of the river is similar to site 11. The degraded forest is a mixture of River Oak and weed species. There are various wetland species along the edge of the river, both native and introduced. Cumbungi is common in the shallows.
21	This creek is usually dry. The main feature of the area is the stand of large native trees, mainly Broad-leaved Apple and Forest Red Gum.

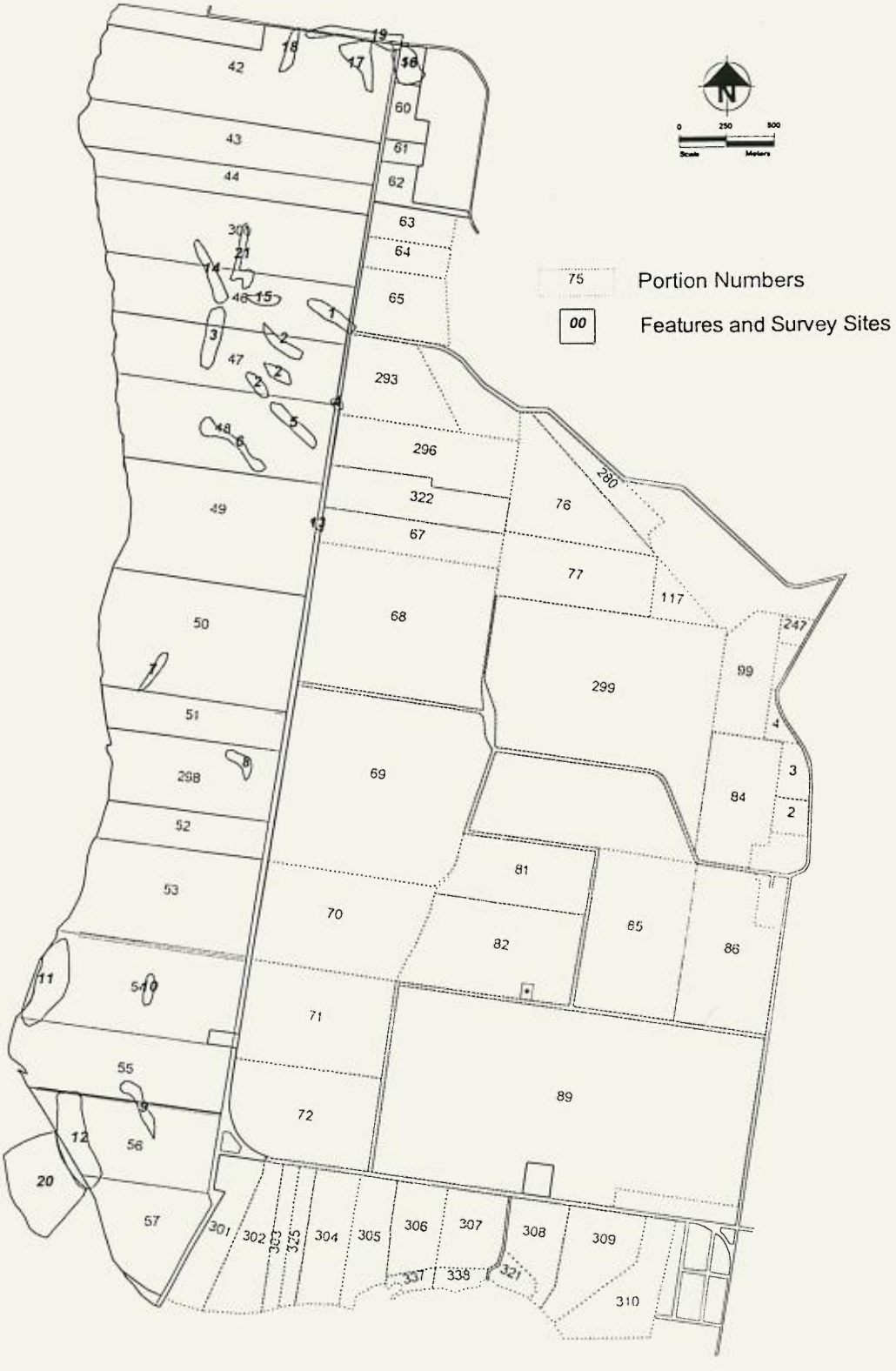


Figure 6.15 Wetlands and Habitats

Fauna Survey Results

Birds

Seventy-five (75) bird species were recorded in the DA4 area and a full species list is provided in the full report in **Attachment C**. Most species were recorded along the Nepean River corridor, although the small wetlands on the floodplain also provided important habitat for birds. The cleared farmland supports native and introduced species that favour the open character of these areas.

A census of the 67 wetland birds recorded in the Penrith district, 58 have been recorded at Penrith Lakes and 20 species were recorded during this survey of the DA4 area. The wetland avifauna was much less diverse and the populations were much smaller than on the large wetlands in the DA3 area studied by Kevin Mills & Associates (1995a). Except for the river, the wetlands in the DA4 area are small, most are ephemeral and some usually contain very little or no standing water.

Most of the native birds recorded in the DA4 area were found along the Nepean River corridor.

Frogs

A survey of frogs recorded seven species at the 21 survey sites in the DA4 area; although no frogs were found at 10 of the sites. Most of the frog species recorded in the DA3 area at Penrith Lakes were found in the DA4 area; all except one are common and widespread species. The Green Tree Fog *Litoria caerulea* has become uncommon to rare around Sydney, disappearing from many areas where it was once common. It was not found in 1995 at Penrith Lakes (Kevin Mills & Associates 1995a), although it had been recorded at seven of 36 survey sites in 1981 (Department of Environment and Planning, 1984). However, several frogs were observed near survey site 3 in the DA4 area.

Swampy sites likely to support the endangered green and Golden Bell Frog *Litoria aurea* were carefully investigated to determine whether the species was present, particularly the settlement pond in the southwestern corner of the DA4 area (Survey site 12). The species has been recorded at this site in 1981 (Department of Environment and Planning, 1984). At these locations, additional time was spent searching and listening for frogs, and playing recordings of calling males at night to elicit a response from resident frogs. Despite these efforts, the Green and Golden Bell Frog was not recorded in the area.

Other Species

The other vertebrate species recorded in the DA4 area are listed in the full study in **Attachment C**. The grey-headed Flying-fox *Pteropus poliocephalus* was the only native mammal recorded. Two introduced mammals were observed, the Feral Cat *Felis catus* and the brown Hare *Lepus capensis*. Residents reported the Fox *Vulpes vulpes* and the Black Rat *Rattus rattus*. Some of the native species found in the region are expected to occur in the DA4 area, but would be uncommon; these include the Short-beaked Echidna *Tachyglossue aculeatus*, the Common Brushtail Possum *Trichosurus vulpecula* and the Water Rat *Hydromys chrysogaster*, as well as some bat species that are most likely to occur along the Nepean River corridor. A small number of reptiles were recorded during the survey and listed in the species tables.

Threatened Species

Flora

The Threatened Species Conservation Act 1995 provides legislative protection for species considered to be threatened in NSW; these species are listed on the schedules attached to the Act. Species are listed as "extinct", "endangered" or "vulnerable". No threatened species were recorded in the DA4 area. The natural environment has been severely modified and it is unlikely that any threatened species are present on the farmland on the floodplain. The forest along the Nepean River contains some native plant species but has become severely degraded, mainly because much of the natural vegetation has been removed and weeds have invaded. A list of "vulnerable" species have been identified in the DA4 area. Most of the species occur along the Nepean River corridor and will not be affected by the development in DA4.

Fauna

The Threatened Species Conservation Act 1995 provides legislative protection for species considered to be threatened in NSW; these species are listed on the schedules attached to the Act. Species are listed as "extinct", "endangered", or "vulnerable". No threatened fauna species were recorded in the DA4 area. However, threatened species known to occur in the vicinity of the DA4 area, and which could reasonably be expected to occur in the area, have been identified in the species lists. Twenty threatened species were assessed because there are records of their presence in the Penrith district.

6.6.2 Environmental Management Procedures

Plan of Management for Flora and Fauna

The investigations have shown that the Nepean River corridor is the most important habitat in the DA4 area. Although the proposed development includes the construction of four floodways and the removal of some vegetation from the upper riverbank, the development will not impinge significantly on the corridor.

In response to the recommendation of the specialist study that the Corporation develop a strategy for the management of the Nepean River corridor, the Corporation is preparing a "Plan of Management for Flora and Fauna in the Penrith Lakes Scheme".

The principle aim of the Plan of Management is to create a diverse and sustainable ecosystem of such quality that it can truly be regarded as World's Best Practice with regard to quarry and mine rehabilitation. The Plan of Management is a "manual" or guiding document containing a set of aims, directions and desired outcomes for the management of the Penrith Lakes Scheme biological environment. It has the following objectives:

- To describe the biological characteristics of the Penrith Lakes Scheme;
- To set appropriate and achievable goals over a period of time for the management of flora and fauna;
- To identify and discuss potential management issues;
- To consider management options and to identify strategies;
- To set priorities for proposed actions;
- To establish guidelines to monitor the effectiveness of the management strategies.

The Plan of Management is based on three vital principles; total catchment management, the conservation of biological diversity and ecological sustainable development.

The Scheme provides an opportunity to create a range of habitats able to support rich and varied flora and fauna populations. However, the development of mature and sustainable ecosystems is a relatively slow process compared with the expected life of the quarry. When the land has been recontoured and the final landform achieved, the vegetation must pass through a succession of changes leading, ultimately to the development of a mature and stable ecosystem. For these reasons, the Corporation is proceeding towards laying the best possible foundation for long-term rehabilitation and to ensure that the process begins as soon as possible after the final contours have been established.

The Plan of Management will provide policies for enhancement of biodiversity, native habitats, uplands, wetlands, habitat corridors, management of threats, interim problems and existing biological assets, integration with the local environment, education and public use and water quality. The Plan should be completed by June 1998.

Green and Golden Bell Frog

Despite exhaustive investigations, the presence of the Green and Golden Bell Frog has not been found on the site. Nevertheless, in accordance with the recommendations of the specialist study, a further field survey will be undertaken to determine whether the frog is present in a proposed floodway.

Hadley Park

The treed creek north of "Hadley Park" that contains mainly *Angophora subvelutina*, will be retained as part of the curtilage around "Hadley Park". The vegetation along the creek is a good source of seed of several local tree species and will be useful in revegetating in the Scheme area.

6.6.3 Environmental Interactions and Impacts

Vegetation and Fauna Habitats

The Penrith Lakes Scheme and the adjacent Nepean River provide a large area of wetland habitats, most of them artificial, created following quarry operations. The wetlands support virtually all the waterbirds and frogs recorded or expected to occur in the western Sydney Region. The unquarried DA4 area contains much less wetland habitat than the DA3 area; there are few significant wetlands in this area.

The Nepean River is the most important wetland in the DA4 area; the others are small and mostly ephemeral, and provide only minor habitat for wetland fauna. The cleared farm paddocks are not good habitat for native fauna and are plentiful in the region. The riverine habitats will not be affected by development of the DA4 area, although four overflow structures will be built in the bank along the river, between the river and the DA4 excavations. These will result in the removal of some native trees in the vicinity of the levee banks, but not the river edges where most of the River Oaks *Casuarina cunninghamiana* are located. Because only a small amount of vegetation will be removed, this is considered to be a minor impact.

The development will have an important positive impact on native fauna because farmland will eventually be converted to wetland habitat, the intervening areas will be landscaped and native bushland will be restored in some locations.

Threatened Species

The Threatened Species Conservation Act 1995 (TSC Act) commenced operation on 1 January 1996 and applies to all plants and animals native to NSW, with the exception of humans, fish and marine vegetation. The TSC Act provides three categories of threatened species; endangered species, vulnerable species, and species presumed extinct. The Act also calls for the listing and protection of "endangered populations" of any plant or animal, and of "endangered ecological communities". Species identified as being threatened are listed on the schedules attached to the Act.

The TSC Act makes various amendments to the National Parks and Wildlife Act 1974 and the Environmental Planning and Assessment (EPA) Act 1979. The TSC Act provides that the criteria in Section 5A of the EPA Act must be considered in deciding whether there is likely to be a significant effect on threatened species, etc, and hence if a Species Impact Statement (SIS) is required. The following factors must be taken into account in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats.

(a) in the case of threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The probability of threatened species occurring in the DA4 area has been assessed. Of the twenty fauna species assessed, it was concluded that only four species have the potential to occur in the DA4 area; the Australian Bittern, the Greater Broad-nosed Bat, the Large-footed Myotis, and the Green and Golden Bell Frog. The first three species are unlikely to be affected by the development; they are highly mobile animals that would simply choose alternative habitat when the DA4 area is no longer available to them and, in the long term, the area will be enhanced for these species because more wetlands and native trees will be present.

The Green and Golden Bell Frog *Litoria aurea* was recorded near the CSR quarry in the southwestern corner of the DA4 area in 1981 and some DA4 sites appear to contain suitable habitat. If the species is present it could be affected by the development. However, the species was not detected during the survey despite a thorough search, and mosquitofish were found in most ponds, reducing the chance of the frog being in the area. Perhaps it is no longer present; the most suitable site is an old settling pond (Site 12). Field studies are on-going.

If any other threatened species occur in the DA4 area, their presence is likely to be a chance occurrence or a fleeting visit, for the area contains insufficient habitat to sustain viable local populations of these species.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No "endangered populations" as defined in Part 2 of Schedule 1 of the TSC Act have been declared in the Penrith area.

(c) in relation to the regional distribution of the habitat of a threatened species population or ecological community., whether a significant area of known habitat is to be modified or removed.

The DA4 area contains no habitat known to be used by a threatened species, although the old settling pond near the CSR quarry was habitat for the Green and Golden Bell Frog in 1981. It is not expected that there would be any significant areas of threatened species habitat in the DA4 area. Notwithstanding this comment, further investigations are proposed as outlined in **Section 6.6.2**.

(d) whether an area of known habitat is likely to become isolated from interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The development of the DA4 area would not result in the isolation of threatened species habitat because most of the area is farmland and the Nepean River habitat corridor will not be significantly affected.

(e) whether critical habitat will be affected.

No "critical habitat" has been declared under Part 3 of the TSC Act in the Penrith area.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Because of a lack of research, it is not known whether the species discussed in the report are adequately reserved in the region. The habitat of the species found in the sandstone environments are likely to be adequately reserved in the Blue Mountains National Park and associated reserves, while those found on the Cumberland Plain are likely to be inadequately reserved.

(g) whether the development or activity is a class of development or activity that is recognised as a threatening process.

No "key threatening processes" have yet been specified in Schedule 3 of the TSC Act.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution.

None of the species in the report is at the limit of its distribution in the region.

Conclusion

The Penrith Lakes Scheme and adjacent Nepean River provide a substantial area of wetland habitat and greatly enrich the biodiversity of the district. Based on the findings of the biological investigations it is concluded that quarrying in the DA4 area will not have a significant impact on flora and fauna, including threatened species, and the preparation of a Species Impact Statement is not required.

Generally it is considered that the development will be advantageous to native fauna. The featureless and, for native species, sterile farm paddocks, which are so inhospitable to most native fauna, will eventually be replaced by wetland habitat and some terrestrial native habitat will be restored to the landscape.

The process will provide an opportunity to greatly enhance the regional biodiversity. The Plan of Management currently under preparation is exploring avenues to integrate:

- the NSW Biodiversity Strategy
- The findings of the Western Sydney Urban Bushland Biodiversity Survey,
- The Department of Land and Water Conservation/Nepean-Hawkesbury Catchment Management Trust Riverbank Management Program,
- Council's preliminary work on corridors,

into clearly defined strategies to maximise flora and fauna opportunities created by the quarry process.

7.0 ENVIRONMENTAL INTERACTIONS AND IMPACTS ON THE CULTURAL ENVIRONMENT

This section contains a description of the existing cultural environment, proposed environmental management measures, and environmental interactions and impacts of the DA4 operations. Aspects addressed include visual environment, heritage sites, archaeological sites, agriculture, traffic, urban development, employment and energy use.

7.1 VISUAL ENVIRONMENT

7.1.1 Existing Environment

The existing visual environment of the DA4 area, and of the Scheme area as a whole, is the result of a combination of farming and quarrying activities on the floodplain, set against a backdrop of predominantly unaltered natural escarpment features.

A detailed visual assessment of the Scheme area was presented in the Regional Environmental Study. As described in the Study, the Blue Mountains escarpment, rising 200 metres or more from the general level of the Scheme area land, forms a strong profile to the west which is visible from anywhere within the Scheme area. To the northeast and east, the low ridge of the Castlereagh escarpment is also apparent, rising 30 to 50 metres above the general level of the land within the Scheme area. While the bush vegetation of the Blue Mountains escarpment is generally unbroken, it is possible to see a scatter of houses within the lighter vegetation of the Castlereagh escarpment.

The Scheme area consists generally of a flat alluvial terrace divided visually by vegetation associated with the creek beds that flow north and northwest through the Scheme and by the planting, structures and roads associated with agricultural activities. In the DA4 area the views are generally of open farmland, the Nepean River and the Blue Mountains escarpment in the west, north, and south and previous quarry/rehabilitation areas to the east.

To the east of Castlereagh Road, the existing environment is predominantly quarry activities. The SIRC area encapsulates the potential visual amenity through the quarry rehabilitating processes.

7.1.2 Environmental Management Procedures

The main quarry activities will be undertaken west of Castlereagh Road. The road and adjoining lands will remain in place until the last stages of the Scheme. This landform will effectively screen day-to-day operations from observers on the east of the Scheme.

7.1.3 Environmental Interactions and Impacts

There would be a difference between the visual impacts associated with the extraction and the rehabilitation phases of the DA4 program. The visual impacts of the extraction phase would be relatively short lived, being limited to extraction periods of one or two years in localised areas. Visual impacts of the rehabilitation

phase would change over time as the long-term landscaping and rehabilitation measures are implemented.

Impacts of Extraction Activities

Extraction and rehabilitation operations in the northern part of the DA4 area will be visible to residents located on the elevated portions of the Castlereagh Escarpment and Smith Street. As operations proceed away from these areas, visual impacts will be ameliorated by the distance between observers and the operations. At all times, the operations will be visible to the few residents on the Blue Mountains escarpment who have direct, but long distant views of the extractive operations. In particular, operations in the northern part of the Scheme will be visible from Hawkesbury Lookout. As extractive operations proceed in the southern parts of the DA4 area, operations will become visible to Emu Heights. Visual impacts, however, overall are short-term, as quarrying operations proceed quickly through the Scheme area.

In longer distance views of the area, quarry activities would appear as just one visual element in a panorama embracing a number of natural and man-made visual elements.

Castlereagh Road will not be extracted until the new alignment along the eastern part of the Scheme has been constructed. Once this occurs, visual impacts of the extractive operations will be minimised by the distance between the operations and observers on the new road and on the Castlereagh escarpment.

Impacts of Rehabilitation Activities

Detailed rehabilitation plans prepared by the Corporation are based on principles and guidelines documented in the Landscape Manual (1987) and plans submitted at two yearly intervals.

In general, landscaping principles associated with the development of the Scheme are to maintain the integrity and consistency of the floodplain. This implies that landforms and landscaping works in rehabilitated areas be directed toward re-creating a fluvial structure which could be expected to be found in such a riverine system. This dictates landform profile, tree selection and the like. Quality viewing features such as the Nepean River gorge, Blue Mountains and Castlereagh escarpments are considered in determining landscape plans for rehabilitation works.

The resultant landforms surrounding the Nepean and Hadley Park heritage precinct will be designed to recreate the historical landscape of alluvial terraces traditionally used for farming and cropping activities.

In the proposed urban areas it will be several years between the time the land is constructed and when it is marketed for urban development. Interim and final land uses have been considered in the preparation of landscape plans. Tree planting would be undertaken at the completion of rehabilitation works, such planting being compatible with both interim and final land uses. Foreshore areas will be planted in advance of urban development work.

The visual quality of the area will be enhanced by the rehabilitation works for both views from within the Scheme and views to the Scheme.

7.2 ARCHAEOLOGICAL SITES

This section summarises the results of detailed investigations of the DA4 area undertaken by Dr James Kohen (1997a). The full report is provided in **Attachment D**. The investigations were designed to identify known archaeological sites, to assess the significance of these sites, identify areas with high archaeological and Aboriginal cultural potential which could be conserved because of local or regional significance, and to make recommendations regarding future management of archaeological sites and investigations.

In accordance with the policy of the National Parks and Wildlife Service, the location of the sites has been protected.

7.2.1 Existing Environment

Archaeological investigations in the Nepean River area have been carried out since the 1930s. The Nepean River and the adjoining floodplain acted as a focus for prehistoric Aboriginal communities, and the area abounds with sites very much disturbed by 200 years of agricultural activities.. The large area involved and the disturbance of the surface and near-surface soil during the gravel extraction process lends itself to an intensive study of the distribution and nature of archaeological sites.

The Scheme area and adjacent lands were extensively surveyed during preparation of the Regional Environmental Study. All sites that were identified were recorded and registered with the National Parks and Wildlife Service. A total of 31 sites and isolated finds were identified within or immediately adjacent to the Scheme area, and subsequent surveys, test excavations and inspections have revealed additional sites.

Extensive archaeological investigations in the western Cumberland Plain all demonstrate that sites occur throughout the area, and are particularly likely to occur adjacent to rivers and creeks (Kohen, 1986a). The distribution of the raw materials associated with the manufacture of stone tools suggest that chert and basalt were carried, or traded east from the river gravels, and that silcrete was traded or carried from sources near South Creek and eastern Creek west towards the Nepean River floodplain.

It has been concluded that all artefacts located with the Scheme are younger than 40,000 years old, and the vast majority are less than 4000 years old. Most of the sites are likely to belong to the most recent lithic cultural tradition, commonly referred to as the Australian Small Tool Tradition, and locally as the Bondaian phase. These recent stone industries are characterised by the production of small blades and points, the use of a bipolar reduction technique resulting in bipolar cores, and the use of edge-ground hatchet heads. The nature of the assemblages identified during a 1997 study at Cranebrook Creek and the Palaeochannel (Kohen 1997b), strongly supports Hiscock's model of primary modification at sites close to the source of gravels and subsequent lithic reduction at other specialised sites (Hiscock, 1993).

The sub-surface testing identified bioturbation as the main reason artefacts are found at depths of up to 2m within the overburden deposits. The geomorphic and archaeological evidence suggests that all of the overburden units were deposited by alluvial activity, and that no artefacts occur in situ at depth. Artefacts were originally deposited on the surface, and moved down into the overburden due to bioturbation, ploughing, and tree and stump removal (Kohen 1997b).

The NPWS register records 11 sites from the 1981 survey in the DA4 area. Additional surveys were conducted in the DA4 area in 1997 to identify the original sites recorded in the register and to identify further areas with high archaeological potential. A representative of the Darug Tribal Aboriginal Corporation participated in the survey to not only observe but to provide input on Aboriginal cultural heritage value of the sites. The Daruk Local Aboriginal Land Council (later renamed the Deerubin Local Aboriginal Land Council) were invited but declined to participate in any archaeological assessment in the Penrith Lakes development.

The survey identified most of the original sites and additional locations. A full description of these is provided in the specialist report in **Attachment D**.

The surveys confirmed the findings of the earlier 1981 report that there are four zones with the greatest archaeological potential. Three of these zones occur with the DA4 area. These include the eastern bank of the Nepean River, the area immediately south of Smith Street, and the banks of Cranebrook Creek. In addition, there are a number of different geomorphic units within the DA 4 area supporting archaeological material.

Aboriginal Consultation

Consultation was carried out with the Darug Tribal Aboriginal Corporation (DTAC). The Darug are the traditional owners of the Sydney region, and their territory extended from the coast to Katoomba and from the Hawkesbury River to Appin in the south. During 1996 and 1997, DTAC have been involved in monitoring and archaeological studies undertaken at Penrith Lakes, and have participated in discussions concerning the methodology employed to conserve and protect Aboriginal sites.

The DTAC expressed the strong view that the Smith Street complex should be protected, as it was in a visually important position. This area had particular significance to the contemporary Darug people because of conflicts between the Darug and Europeans in the early nineteenth century. One of the known massacres of the Darug people took place at Yellow Rock west of the Smith Street complex.

The conservation of the river banks was also seen to be important as the Darug traditionally used many resources in and adjacent to the river. A flat area perhaps adjacent to the Smith Street complex was suggested for inclusion as part of a conservation zone because of its significance as part of the cultural landscape in the area. The DTAC also thought the Smith Street complex was an excellent choice for an Aboriginal centre.

The practice of Aboriginal monitoring during surface stripping was seen to be an important part of the process to identify and protect significant cultural remains. The DTAC were strongly of the view that Aboriginal people should continue to be employed by the Corporation to monitor the quarrying activities during the development of the DA4 area in the same way that they had been involved in the DA3 area.

Archaeological evidence forms an important component in the process of cultural identity for Darug people, and an appropriate facility for educational purposes, incorporating the archaeological remains from the Penrith Lakes Area, could act as a focus for Aboriginal people in the region (Kohen 1988d).

7.2.2 Environmental Management Procedures

The archaeological consultant made the following recommendations based on archaeological, geomorphic and Aboriginal cultural heritage information. The recommendations are shown in italic followed by the measures to be undertaken by the Corporation in response to these recommendations.

1. *Part of the eastern bank of the Nepean River of the Nepean River should be set aside as an archaeological conservation zone, extending east of the river.*

The Nepean River bank zones will be given special consideration. A major issue is the long-term stability of the banks. At this stage it is not intended to disturb the nominated sections of the bank, but detailed engineering studies may require some re-grading of the bank's profile for stability. Depending on the scope of the works, the integrity of the conservation zone should remain.

2. *The region south of Smith Street contains several major archaeological sites, as well as being close to significant archaeological and historically important areas for the local Darug people. This area should be set aside as a conservation zone, and has the highest priority.*

This area occurs on an elevated sandstone outcrop and will not be quarried. The entire complex will form a major conservation zone. The opportunities provided by this conservation zone have been tentatively explored with the UWS Nepean Aboriginal Centre. A concept has evolved of developing the area into an Aboriginal Research and Education Centre, which will create Aboriginal employment opportunities. Such a Centre would be ideally located because of its strong linkages to the other significant areas in proximity to the Scheme. Rehabilitation of the northern lake could be directed towards creating assets for the Centre, particularly in the selection of indigenous flora and fauna.

3. *A proportion of Cranebrook Creek and its tributaries should be set aside as a conservation zone. This could be done in association with other European conservation areas planned for Hadley Park and Nepean Park.*

This recommendation will be adopted and a conservation area will be created to preserve archaeological, flora/fauna, and heritage items. The area occurs within the heritage precinct developed around Hadley and Nepean Parks.

4. *Aboriginal monitoring during surface stripping should continue as a routine part of the development.*

This recommendation will be adopted during the DA4 quarrying operations.

5. *Where possible, known Aboriginal sites should be protected. This is particularly important in the case of the Smith Street complex. Consent to destroy must be sought from the National Parks and Wildlife Service if any sites are to be impacted by the development in the DA4 area.*

The creation of the conservation zones, shown on **Figure 2.4**, will ensure that sites of known Archaeological potential and importance are protected. Isolated sites will be lost during the extractive operations and a consent to destroy will be sought in accordance with the requirements of the National Parks and Wildlife Service prior to their destruction.

6. *The establishment of an Aboriginal Cultural centre should be considered and supported, and an appropriate location would seem to be on or near the Smith Street site complex.*

This recommendation is supported and discussed under recommendation 2.

7.2.3 Environmental Interactions and Impacts

The proposed conservation zones will ensure that most of the significant archaeological sites in the DA4 area will be preserved. Some isolated sites will be lost during the quarrying operations. A Consent to Destroy Application will be made to the National Parks and Wildlife Service before quarrying of these areas.

The National Parks and Wildlife Service has expressed the view that samples of the different geomorphic units with potentially different archaeological histories, should be preserved. Preservation of the three major zones will conserve samples of most of the geomorphic zones. Only one unit would (Unit G) (see **Figure 3.1**) would not be represented, but an opportunity exists to include a small segment of this unit by linking the Nepean River conservation zone with the Smith Street conservation zone.

7.3 EUROPEAN HERITAGE

7.3.1 Existing Environment

A comprehensive review of European Heritage sites and items of the Scheme are and surrounding lands was carried out during preparation of the Regional Environmental Study. A specialist report was completed by F. Bently and J.M. Birmingham in 1981 and was subsequently issued and exhibited as a "working Paper" for the Regional Environmental Study. The 1981 report identified 75 heritage items or sites, within or immediately adjacent to the Scheme area, including existing buildings, ruins, sites or former buildings, roads, river fords and landscape features.

As a result of these investigations SREP 11 - Penrith Lakes Scheme, listed the following structural items for retention in Schedule 3 (Heritage Items).

- Hadley Park
- Nepean Park
- McCathys Cemetery
- Upper Castlereagh Methodist Church and Hall
- Upper Castlereagh School and Residence
- Methodist Church

The Scheme design provides for retention of these items and their integration into the final landform and future site use. Other items will be retained either fully or in part. Some unscheduled items occurring in the Scheme area have been or will be removed as the quarrying operations and Scheme rehabilitation are completed. Under an existing arrangement between the Corporation and the Nepean District Historical Archaeological Group (NDHAG), the NDHAG have previously completed reports on a number of sites or items removed during the development of the Scheme.

This section presents a summary of recent detailed investigations undertaken in the DA4 area by Lavelle and Bickford (1997), Consultant Heritage Consultants. The detailed report is provided as **Attachment E**. The investigations were carried out to refine the existing understanding of the heritage significance of a selection of items identified in the Regional Environmental Study through investigation of each item's historical context, history and fabric. The study was designed to analyse documentary and physical evidence to determine the nature, extent and degree of significance of the remaining heritage items, and make recommendations about the management of these items in accordance with their significance.

Items already scheduled for retention in DA4 or for which separate assessments have been prepared were not included in the re-evaluation. A separate archaeological and heritage assessment report has been prepared on "Minnaville" (RES 15) by Lavelle (1996) in association with the NDHAG and is also included in **Attachment E**.

A total of 34 Inventory Sheets/database forms have been prepared for items occurring in the DA4 area (excluding Minnaville which was subject to the separate study). These included the original sites identified in the 1981 survey and two additional sites. These included 95 Castlereagh Road/43 Smith Street at the northern end of the Scheme area, and 143 Castlereagh Road. All sites were examined in detail by the consultants and information documented in the report.

During the field survey, brief statements of significance for each item were also drafted. This information appears on the individual inventory sheets. A number of categories or types of significance may be applied in attempting to determine the heritage value of an individual item. The range of heritage values assessed in the investigation included the categories of historical, social, aesthetic, technical/research, and the comparative values of rarity and representativeness in accordance with the NSW Heritage Manual.

Heritage Advisory Group

To assist in its deliberations on European Heritage items in the DA4 area, the Corporation established a Heritage Advisory Group. This group consisted of representatives of the Corporation, the Heritage Office, Penrith City Council, University of Western Sydney, the NDHAG, the Nepean District Historical Society, Friends of the Nepean, the Corporation's consultants, and a descendent of the McCarthy family.

The purpose of the group was to provide community input for consideration by the Corporation, recognising that the planning process will seek their comments on detailed proposals after the application has been lodged.

From a Scheme design sense, the following issues were raised for assessment:

- the possibility of retaining Minnaville,
- the possibility of restoring the Hadley Park property,
- the possibility of retaining the northern part of Castlereagh Road, and
- the possibility of retaining Landers Inn.

Heritage issues related to each of these sites have been fully addressed in **Section 2.8.2**. In regard to Scheme design, these possibilities were included in the design assessment process, to be considered along with other design variables. The location of each of the above sites is shown on **Figure 7.1** along with other RES items. In addition, to the above, the Group also recommended several other matters to be addressed:

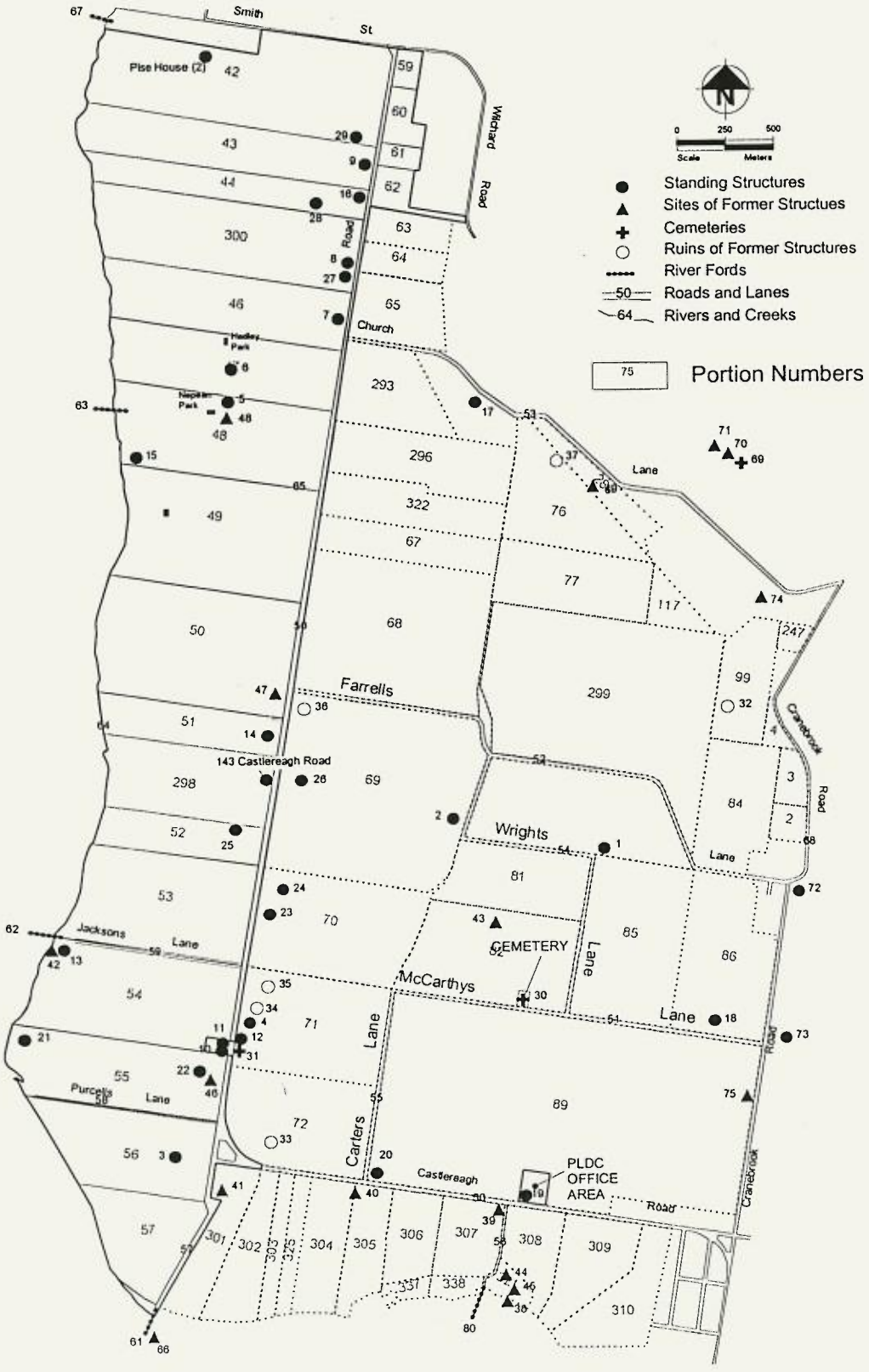


Figure 7.1 European Heritage Sites

- The preparation of the history of Castlereagh,
- The preparation of a Collections and Interpretations Policy,
- The preparation of an Oral History of the area, and
- The introduction of new technologies into the recording process.

Work has commenced on all these issues and are expected to be fully completed by early 1998.

7.3.2 Environmental Management Procedures

The recommendations of the specialist report are summarised below. The recommendations are shown in italic followed by the measures to be undertaken by the Corporation in response to these recommendations.

1. *Individual items assessed as being of Local value are not individually of such significance that they should impede the intended quarrying operations. Previous reporting by NDHAG is considered to provide an appropriate standard of documentation and should be continued prior to the removal of individual items;*

Recommendation to be adopted.

2. *RES Item N° 9: Landers Inn Complex has been assessed as being of Regional significance. Retention and conservation of this complex is recommended;*

Retention of this item has major implications for earthwork balances and landform integrity (see discussion below). The item is not planned to be retained. In view of the competing needs for fill volumes it was decided that the most practical solution was to maintain the current Structure Plan in this section of the Scheme.

3. *RES Item N° 50: Castlereagh Road has been assessed as being of Regional significance. Parts of the road to be retained are identified and a further section (associated with the Lander's Inn complex) is recommended for retention;*

Retention of this item has major implications for earthwork balances and landform integrity (see discussion below). The item is not planned to be retained. In view of the competing needs for fill volumes it was decided that the most practical solution was to maintain the current Structure Plan in this section of the Scheme.

4. *A Mass Concrete house (95 Castlereagh Road/43 Smith Street) has been assessed as being of Regional significance. Previously thought to be of concrete pise construction, it has been identified as mass concrete. Investigation into the retention of this building not identified in the RES is recommended;*

This item will be retained and restored. A conservation/management plan will be prepared for this item and all other Corporation items to be retained.

5. *RES Item N° 21: Penrith Quarry complex has been assessed as being of Regional significance. This item is less that 50 years old. It is recommended that a professional recording report (including history and comparison with*

other sites) be prepared prior to demolition and the history of the site be included in an Oral History Study and a History of Castlereagh Study;

The Penrith Quarry complex will be recorded in a professional report, the oral history and the history of Castlereagh prior to removal.

6. *Conservation management plans be prepared for all sites to be retained are recommended;*

Recommendation to be adopted.

7. *Building maintenance plans for sites currently tenanted is recommended;*

Emergency repairs will continue to be undertaken in accordance with normal tenant/landlord arrangements.

8. *Cataloguing and storage of artefacts collected are recommended;*

Recommendation to be adopted.

9. *An assessment of the significance of the Castlereagh area by a contextual study is recommended;*

Recommendation to be adopted.

10. *A history of Castlereagh study for the early colonial period - 1788-1840 is recommended;*

Recommendation to be adopted.

11. *An Oral history program of local current former residents is recommended;*

Recommendation to be adopted.

12. *Preparation for Scheme interpretation is recommended;*

Recommendation to be adopted.

13. *It is recommended that other potential archaeological sites such as RES N° 49: Fraser's House and RES N° 74: Rev. Fulton's Parsonage or those identified by other studies be identified, assessed and then appropriate policies/management strategies be prepared;*

Recommendation to be adopted.

14. *Excavation permits are recommended to be sought from the Heritage Office prior to removal of "relics" older than 50 years;*

Recommendation to be adopted.

The report also made several recommendations for some items not owned by the Corporation or in the DA4 area.

7.3.3 Environmental Interactions and Impacts

The proposals presented above provide for the retention of the scheduled items and some additional items identified during the more recent studies. The issues raised by the Heritage group provided opportunities for the Corporation to undertake further work in regard to heritage.

The retention of the Mass Concrete house (95 Castlereagh Road/43Smith Street) has been considered with the aim of creating a centre of research and education into Aboriginal Heritage described in **Section 7.2**.

Some items are not proposed to be retained and further details are provided below.

Minnaville

The structure described as Minnaville is located adjacent to the Nepean River. The current SREP 11 does not provide for its retention and the Corporation has undertaken a detailed heritage assessment of the item and the report included in **Attachment E**.

As shown on **Figure 2.3**, Minnaville is located on one of the flood weirs to be constructed as part of the Scheme's flood protection system. These weirs are essential features to ensure the long-term viability of the Scheme (University of NSW Water Research Laboratory - June 1992).

If Minnaville is to be retained, then the only possible alternative is to relocate the weir. The general dimensions of this particular weir are crest width 3 metres at RL 20m AHD, length 300 metres with downstream scour protection (See **Table 5.3**). If the weir is to be relocated then the embankment separating Main Lake 'A' and Main Lake 'B' must be moved from where it joins the Nepean River bank. Moving it north is not possible as the landforms associated with the retained 'Nepean Park' would isolate Main Lake 'B' from the flood protection system.

It would be possible to push the embankment further south to put the weir site clear of the Minnaville structure. The centre line of the embankment would need to move approximately 400 metres south to ensure adequate clearance from Minnaville and provide for the integration of retained landforms into constructed landforms.

Associated flood studies undertaken to ensure the integrity of the flood protection system under different design options indicate that the option to retain Minnaville would require adjustment to the flood weirs for the flood protection system to perform satisfactorily.

An issue that should also be considered in respect of Minnaville is the recreational utility of Main Lake 'A'. The dimensions of this lake in the original Scheme design was based on providing a club sailing course. These courses are triangular with equal legs of 1.25 to 1.5 kilometres. The course must be able to be rotated through 60° to accommodate prevailing wind conditions. The design to accommodate the retention of Minnaville cannot support club sailing on Main Lake 'A' or any other lake.

An additional consideration is the visual amenity provided by the lakes to the proposed urban area. While this issue is very subjective, the Minnaville design would provide a visual amenity of less quality than the original design.

The Corporation decided not to proceed with the possible retention of Minnaville because of the following reasons:

- optimised use of the resource is not achieved,
- extra rehabilitation costs will be incurred through adjustment of the flood weirs,
- recreational opportunities associated with Main Lake 'A' will be compromised, and
- the urban area's visual amenity will be reduced.

Restoration of Hadley Park Property

Conservation plans have been prepared for Hadley Park, and the Corporation will restore the building. The Heritage Advisory Group considered the heritage context of Hadley Park. It was felt that the current design associated with the Nepean Park/Hadley Park heritage precinct did not retain the full context of these significant structures. A possible opportunity is to restore the lands associated with these structures to original natural surface levels, with rehabilitation works directed toward the creation of early settlement farmlands.

The current design provides for rehabilitation of both properties consistent with the overall Scheme. It was not intended to restore lands associated with these structures.

The properties could be considered as the front section, between the structure and Castlereagh Road and the rear section, between the structure and the Nepean River. The front section of the properties would take in excess of 6 million m^3 of overburden to return the properties to natural surface levels.

Given the earthworks balances required this is not a feasible option and was not progressed through the various design phases. This issue is discussed in **Section 2.8.2.**

The rear sections of the properties provide different opportunities, as parts of the properties would be rehabilitated. A volume check of the additional overburden required to restore the property indicated that about 0.5 million m^3 would be required over and above the volumes already provided. This volume is within the bounds of possibility, given the calculated balances.

An issue which should be considered is the allocation of the 0.5 million m^3 to restore the property or whether it could be used beneficially elsewhere. Candidate sites would be to provide greater recreational utility around the foreshore area or increasing the urban development area.

The Corporation decided to provide for the restoration of the rear portion of the Hadley Park property because it:

- optimised use of the resource is achieved,
- restoration of the rear section of the property will provide better heritage outcomes by having a significant section of the original property restored, and
- the restored section will provide additional heritage opportunities than would be available under the previous design.

The Northern Section of Castlereagh Road and Landers Inn

The Heritage Advisory Group considered the possible retention of the northern part of Castlereagh Road and Landers Inn as an opportunity that may require assessment during the design process. The current Structure Plan does not provide for the retention of either item, although a 2.5 kilometre section of Castlereagh Road will be retained in the southern section of the Scheme.

The difficulty with the possible retention of these items relates to overburden volumes required to create a reasonable form of rehabilitation. As can be noted on **Figure 2.2** the eastern bank of the Wildlife Lake has been moved further east to free up overburden for use in other areas.

Retention of these areas will require a substantial amount of overburden possibly in the order of 1.0 million m^3. The assessment saw the trade off between allocating overburden volumes for these works or the restoration of the Hadley Park property.

The Corporation decided not to provide for the retention of the northern section of Castlereagh Road and Landers Inn because:

- optimised use of the resource is not achieved, and
- allocation of overburden for this work would prevent the restoration of the rear section of the Hadley Park property.

7.4 AGRICULTURE

7.4.1 Existing Environment

Agricultural activities within the DA4 area comprise dairying, horse grazing, spelling and agistment, turf farming, citrus orchards, vegetable and fodder crop growing, and the manufacture of horticultural products. Some cattle grazing is conducted north of Church Lane and east of Castlereagh Road. All freehold land is owned by the Corporation, and these activities are conducted under a lease arrangement with the tenants. These temporary activities have proved to be a rational use of the land, as well as being appropriate to the available managerial resources, and to the maintenance of the attractiveness of the area at a fairly low cost.

The relatively fertile river flats, availability of irrigation water, proximity to market, and suitability of the terrain for mechanised farming make parts of the area particularly well suited to turf farming and vegetable growing.

7.4.2 Environmental Interactions and Impacts

The proposed development would result in the loss of an area presently used for relatively intense agricultural activities. Cessation of these agricultural activities is not expected to have a significant impact either on total production from the area or on supplies to the metropolitan area, as this production can be easily replaced by intensified production in other areas.

Although the end use of the DA4 area would not be for agriculture, it is possible that there could be some agriculturally related uses, such as grass hay production or grazing, in the interim on rehabilitation land. However, it is unlikely that rehabilitated

land could be used for more intensive agriculture uses because of the need to establish and conserve landforms.

If quarrying were not a prospect for the DA4 area, it is likely that the agricultural activities in the area would continue to decline in importance, although the rate of change would be different. In the absence of Corporation ownership of the land, it is likely that dairying and grazing would decline at a faster rate, and that there would be a greater proportion of the area developed to other land uses.

In summary, the DA4 area is of minor importance in terms of agricultural production on a State basis, and all production could be replaced economically by intensifying production elsewhere.

7.5 TRAFFIC

7.5.1 Existing Environment

Castlereagh Road, Andrews Road and Cranebrook Road provide access to the Scheme. There are three major elements contributing to the existing transport situation in the Scheme area:

- the general movement of cars and trucks to, through, and around the area;
- the movement of raw feed from quarries to crushing plants; and
- the movement of crushed gravel and concrete from the crushing and concrete plants to destinations outside the Scheme area.

The third of these elements, the movement of finished products from crushing and concrete plants, is not considered in this application, as the crushing plants are not included in this development application. However, the production of sand and gravel will remain at current levels therefore traffic output of existing crushing plants would not alter significantly.

Most of the Scheme area is served only by road, with no bus or rail services being available for either passengers or goods. A bus service is available along Cranebrook Road. South of the river, there is a spur track to the Boral crushing plant, although none of the finished product from this plant is transported by rail.

General Vehicular Movement

Access to the DA4 area is via Castlereagh Road, a state arterial road, providing access from both the south and north. Cranebrook Road is located along the eastern boundary of the Scheme.

Estimated average daily traffic volumes of these roads are:

• Castlereagh Road at Gordon Street (Penrith Council 1989):	6,900
• Castlereagh Road at Devlins Lane (RTA 1993)	4,270
• Cranebrook Road at Andrews Road (Penrith Council 1991)	10,500
• Cranebrook Road at Londonderry Road (RTA 1993)	4,570

Today's traffic volumes along Castlereagh Road would be about the same level or marginally higher than the 1987 figures. The Gordon Street figures would include quarry transport traffic from the CSR plant. A 1987 traffic survey of Cranebrook Road at Andrews Road indicated average daily traffic volumes of 8,170. The 1993 figure represent an increase of about 30% and would be associated with the urban development of the Mt. Pleasant/North Cranebrook areas. Today's traffic volumes on Cranebrook Road would be higher as the residential area was not completed by 1993.

A number of lesser roads provide cross-connections through or to the DA4 area. These include Jacksons and Purcells Lanes which are dead-end lanes between Castlereagh Road and the Nepean River and Smith Street which forms the northern boundary of the DA4 area. Smith Street is also a dead-end road between Castlereagh Road and the river and serves a number of residences at the western end of the street. These streets carry negligible daily traffic. Jacksons Lane currently provides public access to the Nepean River.

Church Lane provides a connection between Cranebrook Road and Castlereagh Road in the northern part of the Scheme and is important for local requirements. The volume of traffic is in the order of 200 vehicles per day.

Transport of Raw Feed

All raw feed is transported from the quarry faces to the crushing plants by off-road haulage (**Figure 4.6**). Vehicular and pedestrian access to the quarry areas, haul roads, crushing plants and areas undergoing rehabilitation is strictly controlled, with no unauthorised personnel or vehicles being permitted in these areas.

7.5.2 Environmental Management Procedures

This development application provides for the removal and relocation of Castlereagh Road, consistent with the development of the Large Main Lake Scheme selected through the RES/REP process described in **Section 2.3**. The REP/RES assessed three alternative locations, with the preferred route following Cranebrook Road from Andrews Road to the Village, moving around the east of the Village and then following the base of the Castlereagh escarpment and joining the existing Castlereagh Road alignment at the very north of the Scheme.

In its preliminary urban planning described in **Section 2.8.2**, the Corporation identified an opportunity to integrate the new Castlereagh Road alignment within the urban development. This route follows generally the same route as the preferred route identified in the RES/REP process, except that it lies to the west of Cranebrook Village. This would avoid the necessity to acquire private lands outside the Scheme for road construction.

The relocation of Castlereagh Road traffic onto the Cranebrook Road alignment would increase the average annual traffic volumes on Cranebrook Road to around the 17,000 to 19,000 vehicles. The level of service provided by the existing roadworks would be approaching capacity. The additional contribution associated with the urban development would increase traffic volumes beyond the capacity of the existing Cranebrook Road.

The staging of DA4 development is shown of **Figure 4.5**. The alignment of the existing Castlereagh Road is planned to be extracted in about 2008/2009. It will be at this time that the new route would need to be completed and available for use. The

new route cannot be fully serviced until all lands along the route scheduled for extraction have been extracted and the landforms rehabilitated.

7.5.3 Environmental Interactions and Impacts

Cranebrook Road would be near capacity with the additional traffic from the relocation of Castlereagh Road. The additional traffic from the urban development would certainly require the upgrading of Cranebrook Road. The Corporation, as a DA2 consent requirement, has prepared preliminary designs for a four lane divided carriage road to just north of Cranebrook Village. The existing carriageway is not sufficient to accommodate the four lanes. Using Scheme lands adjoining the west boundary of Cranebrook Road can provide additional land requirements. Just north of Cranebrook, the road would divide with two lanes adjoining the existing Cranebrook Road, and two lanes following the base of Castlereagh escarpment to join the existing Castlereagh Road in the north near Smith Street.

A decision on which route to use around Cranebrook Village would be best made when detailed urban planning is undertaken when factors such as noise, amenity, safety and access can be better addressed. This planning is expected to be completed by the end of 1998.

The timing of works will very much depend upon when the urban development program commences and what stage the quarry development is at. Timing and scope of works will be addressed in detailed urban planning and negotiated with Penrith City Council and the Roads & Traffic Authority.

An avenue currently being investigated by the Corporation is the possible upgrading of Church Lane to accommodate early diversion of Castlereagh Road traffic. This option would need to be fully discussed with landowners along Church Lane, Council and the RTA.

While the development of the Scheme will remove the existing public access to the river via Jackson's Lane in the short term, the final lake Scheme will provide wider public access to the river and additional water based recreational facilities.

7.6 URBAN DEVELOPMENT

7.6.1 Existing Environment

The areas subject to extraction and rehabilitation under the DA4 application are located between 5km and 7km northwest of the central area of Penrith. The area to be quarried is principally rural land occupied only by scattered residences associated with agricultural activities. Nearest residences not associated with the development include residences in Wilchard Road on the elevated Castlereagh escarpment to the northwest, isolated residences in Smith Street on elevated land to the north and the isolated residences of Camenzuli and "Nepean Park" in the central portion of the area. **Sections 6.4, 6.5** and **7.1** have examined noise dust and visual impacts associated with the DA4 development at these residences.

The operations in DA4 proceed away from Cranebrook Village and no impact from noise or dust in the Village will occur from the DA4 development. Areas within the vicinity of the village will be rehabilitated to provide additional urban areas to complement the existing village development.

7.6.2 Future Urban Development

SREP N°. 11 Structure Plan shows an area on the eastern side of the Scheme as "Future Urban Area". This proposed urban development is an integral part of the Scheme. It provides the mechanism for the Shareholder companies to recoup the additional rehabilitation expenditures incurred in developing the Large Main Lake Scheme above those that would have been associated with the Wetland Scheme (Refer to **Section 2.3**). It also provides the funding mechanism for the future managers of the Scheme.

This DA4 application does not address urban planning issues. These will be addressed in detailed planning studies that will be undertaken as part of the process to re-zone the area to permit urban land uses. This process will involve a community consultation program. It is expected that this process will commence in the near future for completion by the end of 1998.

7.7 EMPLOYMENT AND ECONOMIC IMPACTS

Operations in the Penrith Lakes Scheme currently provide direct employment for 82 people as listed in **Table 7.1**. The numbers and distribution given in this table are not expected to change as a result of DA4 activities.

TABLE 7.1
EXISTING DIRECT EMPLOYMENT IN EXTRACTION AND REHABILITATION
PENRITH LAKES SCHEME

Category	Pioneer	Boral	CSR	Contract	PLDC	Total
Pit Operators	1	1	1	2	-	5
Workshop staff (pit related)	0	0	0	9	-	9
Raw feed haulage	3	5	4	3	-	15
Rehab./maintenance	-	-	-	31		31
Staff	1	1	1	6	13	22
Total	**5**	**7**	**5**	**51**	**13**	**82**

The quarry, rehabilitation, crushing plant operations and transport operations by the Corporation, its shareholders and long-term contractors provide employment for more than 450 people. Three hundred and fifty of these are from the Penrith City local government area, with the remaining 100 from the Greater Western Sydney area. This local industry is a significant regional employment asset.

The University of Western Sydney assessed the local economic implications of the Scheme. They calculated that the industry annually has:

Direct expenditure in Penrith LGA of: $25.8 million

Flow-on activities in Penrith LGA of: $12.4 million.

The $38.2 million per annum provides for significant local employment in sectors that provide goods and services to the quarry industry, and flow on activities. This is a significant contribution to the local economy.

Comparable figures for Greater Western Sydney region, including Penrith, were $68.2 million direct and $46.1 million as flow on, giving a total of $114.3 million per annum.

The Scheme is a significant entity in economic and employment terms.

7.8 ENERGY STATEMENT

During the DA4 period, it is proposed to continue using the existing methods of extraction and rehabilitation as described in **Section 4.0.** All equipment use diesel fuel. The fleet of equipment described in **Section 4.5** and other equipment uses in operations and maintenance works would consume on an annual basis the following approximate quantities:

Raw Feed Winning, Loading and Haulage	2,400,000 litres
Stripping and Rehabilitation	2,100,000 litres
Haul road maintenance	300,000 litres
Miscellaneous-slashing/minor works/dewatering	200,000 litres
Total	5,000,000 litres

Actual annual consumption of diesel will vary depending on raw feed extraction levels, haul distances and mine sequencing.

7.9 SERVICES

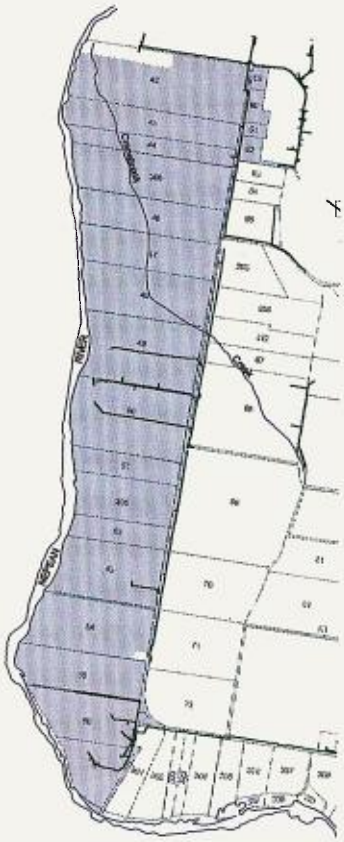
As indicated in the Regional Environmental Study, the Corporation is required to pay all costs associated with the relocation of any services affected by the Scheme.

Services within the DA4 area are shown on **Figure 7.2**.

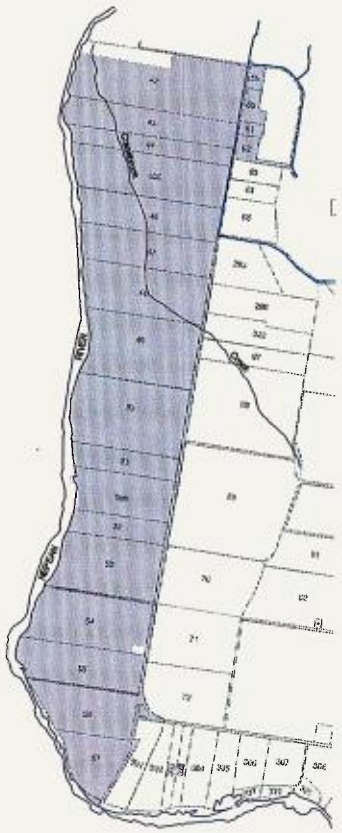
Relocation of Integral Energy's service lines along the north-south section of Castlereagh Road will occur around the year 2008 or 2009. Underground and aerial telephone services along Castlereagh Road would be relocated in the same period. Telephone services in Church Lane will be relocated in the short-term to ensure that residences are not disadvantaged by the early stages of quarrying operations in the DA4 area north of Church Lane and east of Castlereagh Road. Liaison would be maintained as required with Integral Energy and Telstra.

Water mains in the affected part of Church Lane and Castlereagh Road will be located as soon as possible to permit quarrying in the early stages of the DA4 program. There are no sewers that would be affected by the DA4 operation.

Power



Telephone



Water Mains

Figure 7.2 Services

REFERENCES

Bently, F. and Birmingham, J. Penrith Lakes Scheme *Regional Environmental Study: History of European Settlement, Working Paper, Department of Environment and Planning, 1983.*

Department of Planning, 1979. *Environmental Planning & Assessment Act 1979.*

Department of Environment and Planning 1984. *Regional Environmental Study - Penrith Lakes Scheme.*

Department of Environment and Planning 1984 *Sydney Regional Environmental Plan N°. 11 - Penrith Lakes Scheme.*

Department of Environmental and Planning 1986. *Draft Regional Environmental Plan - Penrith Lakes Scheme*

Department of Environment and Planning 1986. *Sydney Regional Environmental Plan N°. 9 - Extraction Industry and Planning Report (1986)*

Department of Urban Affairs and Planning 1995 *Sydney Regional Environmental Plan N°. 9 (2) - Extractive Industry*

Department of Environment and Planning, 1988. Penrith Lakes Scheme: *Recreation/Management Study.*

Dr James L. Kohen, 1986a. *Prehistoric Settlement in the western Cumberland Plain: resources, environment and technology.* Unpublished Ph.D. thesis, Macquarie University.

Dr James L. Kohen, 1988d. *The importance of archaeology to Aboriginal communities on the Cumberland Plain: an archaeologists view.* In Wright, B., D. moody and L. Petchkovsky (Eds.) Contemporary Issues in Aboriginal Studies: 2. Proceedings of the Second National Conference on Aboriginal Studies. Nepean College of advanced Education. October 1998, 123-134. Firebird Press, Sydney.

Dr James L. Kohen 1997a. *Archaeological Investigations in the DA4 Area, Penrith Lakes Scheme.*

Dr James L. Kohen 1997b. *The monitoring and sieving of sub-surface deposits at Penrith Lakes, January-March 1997; final report.* Unpublished report lodged with the NPWS.

ERM Mitchell McCotter Pty Ltd 1997 *Penrith Lakes Sand and Gravel Quarry - DA4 Assessment of Air Emissions. Report N°. 96221rp2.*

Graham Edds & Associates, 1996. *"Hadley Park". Conservation/Management Plan.*

Hiscock, P. 1993. *Bondian technology in the Hunter Valley, New South Wales.* Archaeology in Oceania 28(2): 65-76.

Kevin Mills & Associates Pty Limited. 1995a. *Penrith Lakes Scheme, Wetlands Study, DA3 Area, Cranebrook.* Prepared for the Penrith Lakes Development Corporation Ltd.

Kevin Mills & Associates Pty Limited, 1996. *Flora and fauna Study, DA4 Investigation Area, Penrith Lakes Scheme, Cranebrook. Penrith Lakes Development Corporation, Castlereagh, NSW.*

Lavelle, Siobhan, and Bickford, Anne, *1997 DA4 Management Study. Heritage Assessment. Penrith Lakes Scheme Area, Castlereagh, NSW.*

Lavelle, Siobhan, and NDHAG, 1996. *Archaeological and Heritage Assessment, RES Site 15, "Minnaville". Penrith Lakes Scheme Area.*

Oakes, G, Lishmund, S and Paterson, I. 1996. *The Supply of Construction Sand to the Sydney Market.* Geological Survey of NSW. (GS 1996/205).

NSW Soil Conservation Service, *1986 Penrith Lakes Scheme-Land Rehabilitation Manual.*

Noel Arnold & Associates. 1997. *Boundary Airborne Silica Monitoring. Penrith Lakes Development Corporation. Penrith Quarry Site.*

Penrith Lakes Development Corporation Ltd 1987. *Landscape Manual.*

Penrith Lakes Development Corporation Ltd, 1994. *Penrith Lakes Scheme. Development Application 3 (DA3) Extraction and Rehabilitation Programme. Statement of Environmental Effects.*

Penrith Lakes Development Corporation 1997 - *Two Year Report July 1995 - June 1997. September 1997.*

Penrith Lakes Development Corporation, 1997. *Planning Report Supporting Amendment (N° 4) to SREP N° 11 Structure Plan.*

Penrith Lakes Development Corporation and Kevin Mills & Associates Pty Ltd (in progress*). Plan of Management. Flora and Fauna . Penrith Lakes Scheme.*

University of Western Sydney, 1997. *Economic Modelling of the Penrith Lakes Development.*

Unisearch, 1992. *Penrith Lakes Scheme: Flood Protection Physical Model Studies. University of NSW Water Research Laboratory.* Technical Report No92/03.

Unisearch, 1997. *Amendments to the Penrith Lakes Scheme.*

Valerie Smith & Associates,1995. *The Geomorphology and Resources of the Penrith Lakes Scheme Area.* Prepared for the Penrith Lakes Development Corporation.

Wilkinson Murray Pty Ltd 1999. *PLDC Operations Noise. DA4 Noise Assessment Report N° 96263.*