EIS 508 Appendices

AB019170

Proposed sand & soil extraction : Nepean River & environs,

Menangle NSW : environmental impact statement

ENVIRONMENTAL IMPACT STATEMENT

PROPOSED SAND & SOIL EXTRACTION NEPEAN RIVER & ENVIRONS MENANGLE NSW

Prepared for MENANGLE SAND AND SOIL PTY LTD

APPENDICES

NOVEMBER 1987

L87/0016

planning workshop

PROPOSED SAND & SOIL EXTRACTION
NEPEAN RIVER & ENVIRONS
MENANGLE NSW

EIS APPENDIX

Prepared for
MENANGLE SAND AND SOIL PTY LTD

By
PLANNING WORKSHOP
346 Kent Street Sydney NSW

November 1987
Job No: 87094

planning workshop

TABLE OF CONTENTS

APPENDIX I

Director's Specifications

New South Wales Government

Department of Environment and Planning

Remington Centre
175 Liverpool Street, Sydney 2000
Box 3927 G.P.O. Sydney 2001
DX. 15 Sydney

Telephone: (02) 266 7111 Ext. 7490
Telex: DEP NSW 176826
Fax No.: 266 7599

Contact: M. Vincent

Our reference: 85/2865

Your reference: 87094:NI/IH

Planning Workshop,
P.O. Box C183,
Clarence Street,
SYDNEY. 2001 00.

04 NOV 1987

19 OCT 1987

Dear Sir,

RE: MENANGLE SAND AND SOIL PTY. LTD. SAND AND LOAM EXTRACTION, MENANGLE, N.S.W.

Thank you for your letter of 15 October, 1987, indicating that you are consulting with the Director with regard to the preparation of an environmental impact statement (EIS) for the above development.

2. As development consent is required for the proposal and it is a designated development within the meaning of Schedule 3 of the Environmental Planning and Assessment Regulation, 1980, as amended, an EIS must accompany the development application to the Campbelltown City Council and the Wollondilly Shire Council. The EIS shall be prepared in accordance with clause 34 of the Regulation and shall bear a certificate required by clause 26(1)(b) of the Regulation (see Attachment No.1).

3. Attachment No.2 sets out the range of issues for consideration in the EIS relevant to this proposal and we suggest they be fully addressed.

4. The proposed development is subject to a direction under S.101 of the Environmental Planning and Assessment Act and consequently the Minister for Planning and Environment would determine the development application.

5. In preparing your EIS you should approach Campbelltown and Wollondilly Council and take into account any comments the councils consider may apply to their determination of the proposal.

6. Under S.101(5) of the amended Act, the consent authority, the applicant, and any person who made a submission under S.87(1) in relation to the development application shall be afforded the opportunity of a hearing and shall be entitled to appear and be heard by a Commission of Inquiry if so required. There will be no right of appeal to the Land and Environment Court, and the Minister's determination is final.

7. Should you have any queries on this matter please contact Murray Vincent of this Department on 266 7490.

Yours faithfully,

B. Adams
Manager, Environmental Assessments Branch,
As Delegate for the Director

DEPARTMENT OF ENVIRONMENT AND PLANNING
ATTACHMENT No.1

STATUTORY REQUIREMENTS FOR ENVIRONMENTAL IMPACT STATEMENTS.

In accordance with Part lV of the Environmental Planning and Assessment Act,1979, an environmental impact statement (EIS) must meet the following requirements:

Pursuant to clause 34 of the Environmental Planning and Assessment Regulation,1980, as amended, the contents of an EIS shall include the following matters:

(a) full description of the designated development proposed by the development application;
(b) a statement of the objectives of the proposed designated development;
(c) a full description of the existing environment likely to be affected by the proposed designated development, if carried out;
(d) identification and analysis of the likely environmental interactions between the proposed designated development and the environment;
(e) analysis of the likely environmental impacts or consequences of carrying out the proposed designated development (including implications for use and conservation of energy);
(f) justification of the proposed designated development in terms of environmental, economic and social considerations,
(g) measures to be taken in conjunction with the proposed designated development to protect the environment and an assessment of the likely effectiveness of those measures;
(g1) details of energy requirements of the proposed development and measures to be taken to conserve energy;
(h) any feasible alternatives to the carrying out of the proposed designated development and reasons for choosing the latter; and
(i) consequences of not carrying out the proposed development.

The EIS must also take into account any matters required by the Director of Environment and Planning pursuant to clause 35 of the Regulation, which may be included in the attached letter.

The EIS must bear a certificate as required by clause 26(1)(b) of the Regulation.

DEPARMENT OF ENVIRONMENT AND PLANNING
ATTACHMENT No.2

ADVICE ON THE PREPARATION OF AN ENVIRONMENTAL IMPACT STATEMENT (EIS) FOR SAND AND SOIL EXTRACTION FROM THE NEPEAN RIVER AND ADJOINING AREAS NEAR MENANGLE.

Extractive industries have prompted considerable public controversy in the past since, among other things, they affect visual amenity, generate heavy vehicle movements, raise dust and cause disturbance through noise. This is the prime reason for designation of extractive industries under the Environmental Planning and Assessment Act, 1979.

Information provided should be clear, succinct and objective and where appropriate be supported by maps, plans, diagrams or other descriptive detail. The purpose of the EIS is to enable members of the public, the consent authority (usually the Council) and the Department of Environment and Planning to properly understand the environmental consequences of the proposed development.

1. Description of the proposal.

The description of the proposal should provide general background information on the location and extent of the works proposed, an indication of adjacent developments, and details of the site, land tenure, zonings and relevant forward planning proposals and any other land use constraints.

The EIS should address the compatibility of the proposal with the Elderslie Sand and Soil Deposits Land Management Study, Sydney's Extractive Industries Regional Environmental Study, Three Cities Structure Plan and with the provisions of the Local Environmental Plans for existing and proposed development.

This section should provide specific information on the nature, intent and form of the development. It should, as far as possible, include such details as the processes involved, disposal of wastes, landscaping and site rehabilitation. Scaled drawings should be included in the EIS. A description should also be provided of associated operations such as the transport of materials and use of the end product if likely to have environmental implications.

Particular details that are relevant include:
. Brief justification for proposal within the Sydney Region.
. Brief description of characteristics and economic significance of the resource.
. Possible availability of alternative resources (eg. Elderslie Deposits).
. Quantity of materials to be extracted.
. Methods of extraction/plans of operations.
. Noise (levels and controls).
. Type of machinery and equipment to be used.

. Expected life of the operation.
. Number of persons to be employed.
. Hours of operation.
. Details of necessary stockpiling.
. Access arrangements - truck routes, truck numbers etc.
. Site drainage and erosion controls.
. Proposals for rehabilitation and landscaping to provide for final land-use.

2. Description of the Environment.

Provide details of the environment in the vicinity of the development site and also of aspects of the environment likely to be affected by any facet of the proposal. In this regard, physical, natural, social, historical, aesthetic, archaeological and economic aspects of the environment should be described to the extent necessary for assessment of the environmental impact of the proposed development. This should include mapping of items of natural, remnant, ornamental and horticultural value and establish their significance in the local, regional and state context.

3. Analysis of Environmental Impacts.

Environmental impacts usually associated with extractive industries are listed below. Where relevant to the specific proposal, these should be addressed in the EIS, taking into account the adequacy of safeguards proposed to minimise them:

. The flow of the Nepean river or other watercourses.
. The effect of the extraction on the sediment transport rate in the river.
. The bed and bank stability of the Nepean river during and after completion of operations.
. Any possible siltation, sedimentation or downstream effects of the operation.
. Any likely cumulative effects of the proposed operation when considered together with other operations in the Nepean river.
. Details of floods and any likely effects of the operation on flood liability of surrounding lands.
. The possible effects of flooding on the operation.
. Effects on fauna and flora including historic plantings and natural vegetation.
. The agricultural viability of the land holding and surrounding properties.
. Likely noise/vibration disturbance caused by the operations, including transport operations, on roads and Nepean river.
. Other impact of truck movements, including access around railways and onto highways.
. Dust nuisance likely to be caused.
. Effects on water quality of Nepean river.
. Disposal of waste material.
. Effects on the visual environment of the Nepean river.
. Any likely affectation of sites of Aboriginal archaeological or European heritage value if located in the vicinity of operations.
. Establish the benefit of flood mitigation on the Nepean river.
. Effects on the historic landscape of Camden Park and Estate including impacts on major private and (proposed) public

vistas and on major historic ornamental, horticultural and scientific plantings.

. Impact on river navigation from cables, etc and recreational values of the Nepean river (see Hawkesbury/Nepean Valley Study, DEP - 1983).

In addition, any potential for hazard or risks to public safety and any proposals to monitor and reduce environmental impacts should be included (e.g. recreational water activities).

4. Contact with relevant Government Authorities.

In preparing the EIS, the authorities listed below should be consulted and their comments taken into account in preparing the EIS.

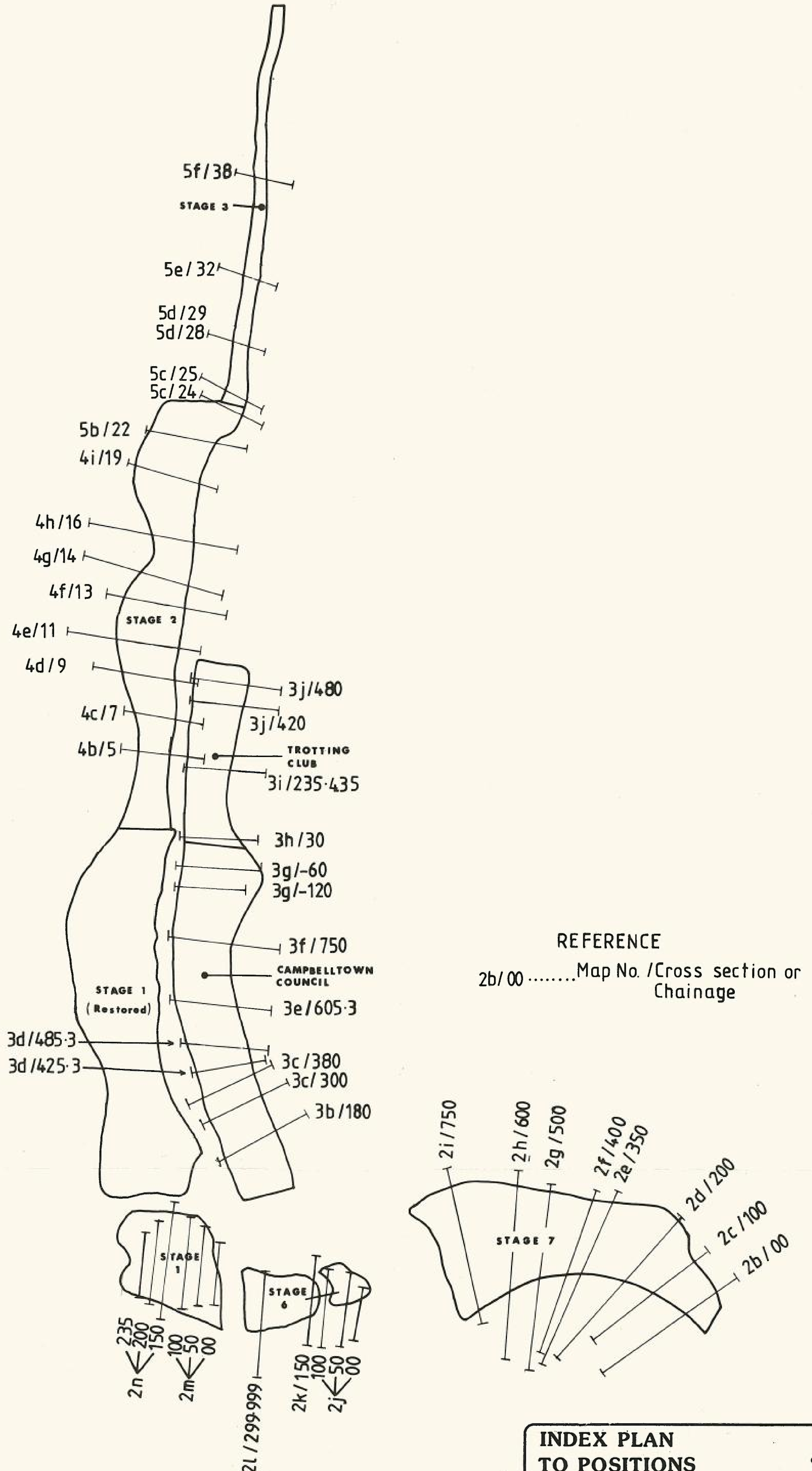
. The State Pollution Control Commission in regard to air, water and noise impacts and relevant pollution control legislation requirements.
. The Soil Conservation Service regarding appropriate erosion control and rehabilitation procedures.
. The Department of Agriculture as the lessee of the property and in regard to the likely effect on prime agricultural land and scientific research and their proposal to establish a museum which may be affected by the proposal.
. The Heritage Council of NSW if the proposal is likely to affect any place or building having heritage significance for the State.
. The National Parks and Wildlife Service in regard to natural areas or if aboriginal places or relics are likely to be affected.
. Water Resources Commission in regard to rights to use, the flow and control of the Nepean river water and the provisions of the Rivers and Foreshores Act, 1948.
. National Herbarium, Royal Botanic Gardens, Sydney in respect of natural and ornamental plant species and verification of floral surveys.
. Australian Heritage Commission as Camden Park and Estate is on the register of the National Estate.
. Local Councils in relation to future use of the area and river and for consent as landowners where appropriate.

You are invited to refer to the report by Mr. G.N. Bauer, Forestry Commission, on the vegetation in areas affected by the proposed developments.

You are also invited to discuss heritage conservation management proposals being developed for the Estate by contacting the Heritage Branch of this Department.

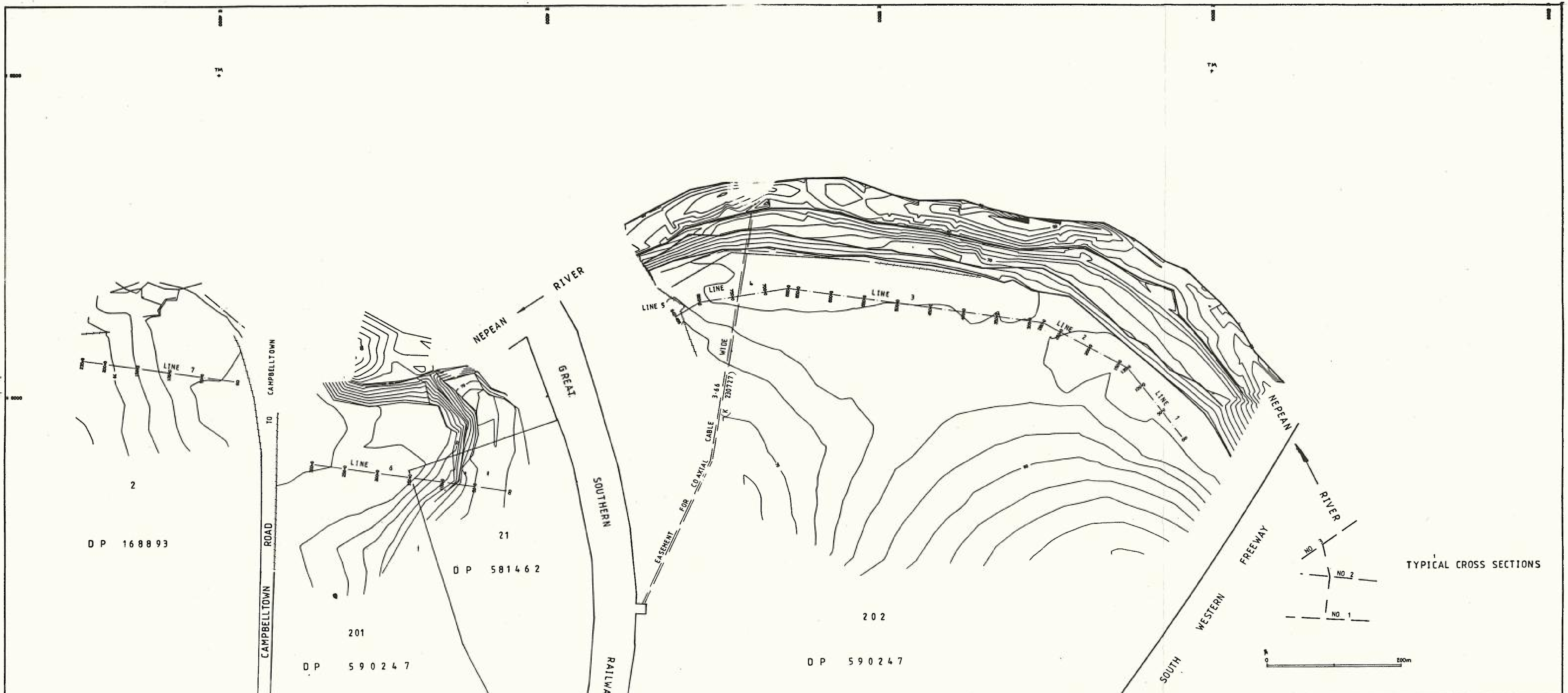
APPENDIX II

Cross-sections of Extraction Area



INDEX PLAN TO POSITIONS OF CROSS SECTIONS

1



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

.3 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

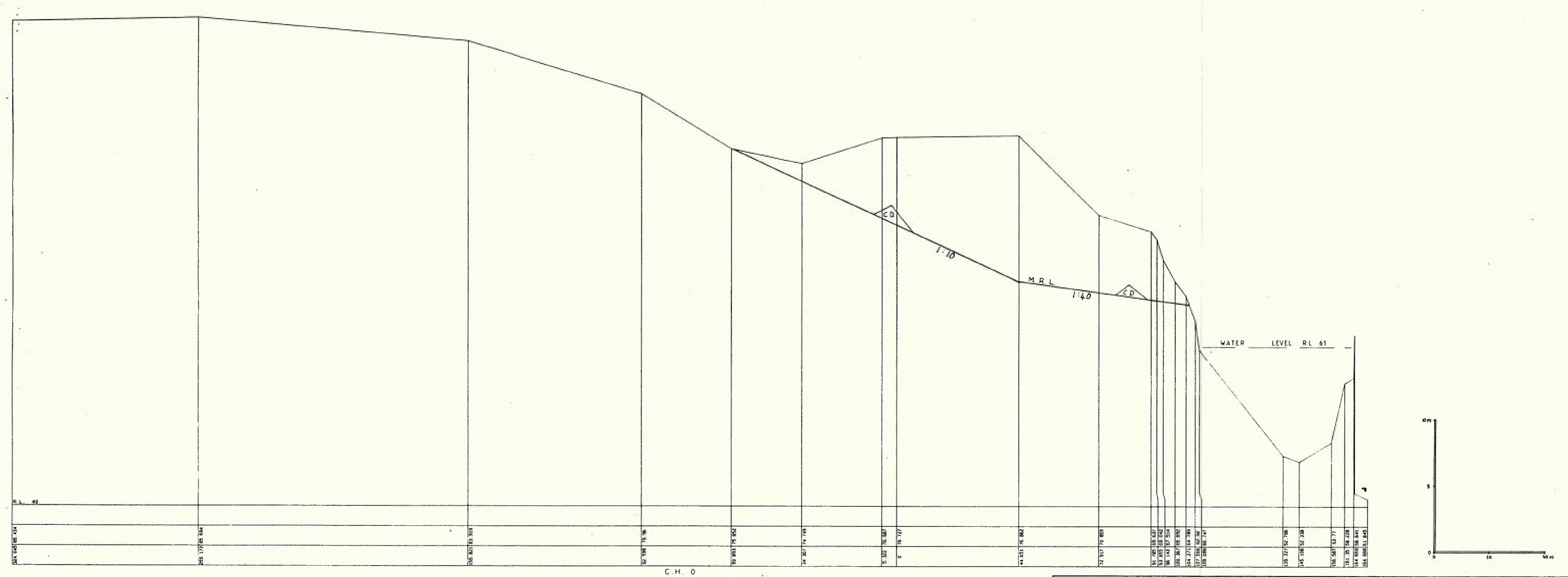
41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

PLAN SHOWING CONTOURS AND POSITION OF CONTROL LINES FOR CROSS-SECTIONS AT NEPEAN RIVER MENANGLE N.S.W.

SHIRE: WOLLONDILLY
PARISH: CAMDEN
LOCALITY: MENANGLE
COUNTY: CAMDEN

2a

REDUCTION RATIO 1 : 2000
DATUM A.H.D.
REF: 87/199



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X. 5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

CROSS SECTIONS: - LINE 1
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN

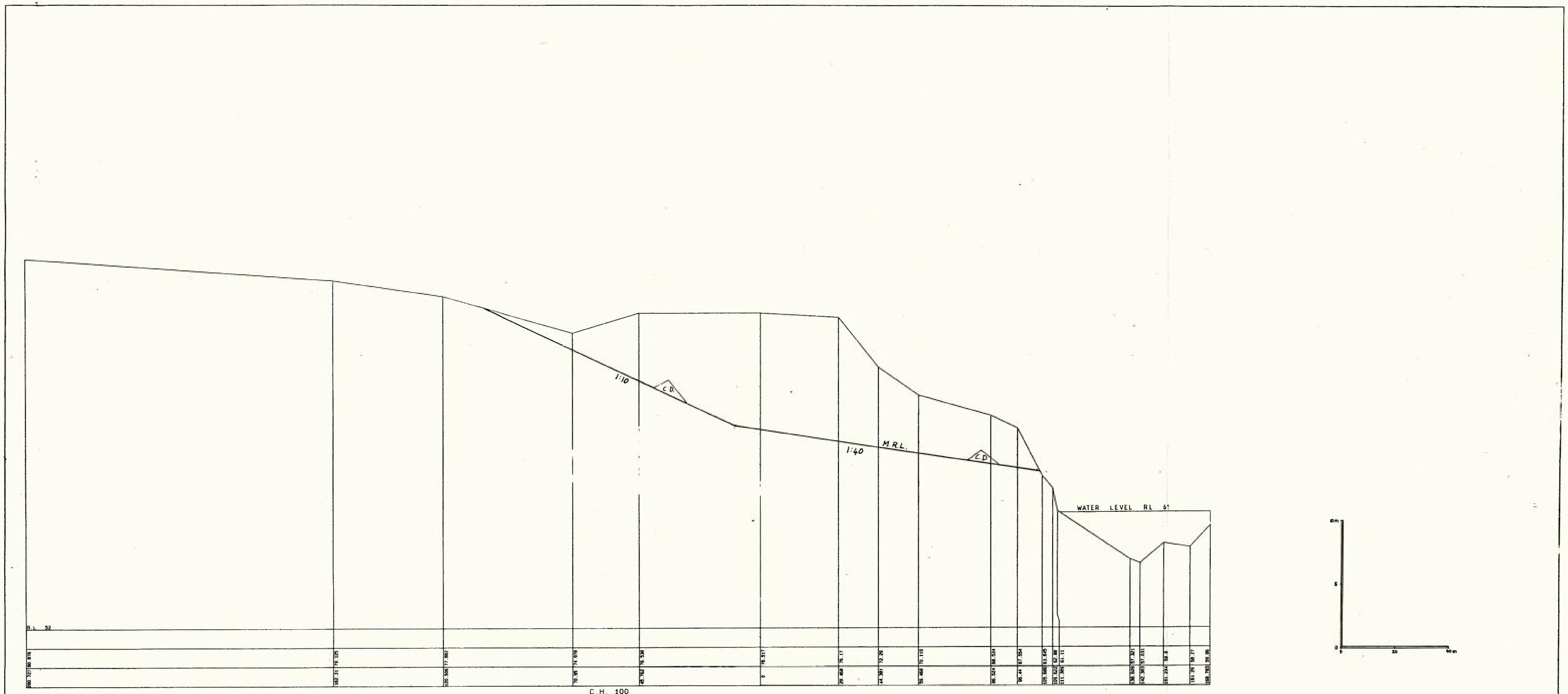
LOCALITY: MENANGLE
COUNTY: CAMDEN

2b

REDUCTION RATIO
1: 500H 1: 100V

DATUM
A.H.D.

REF: 87/197



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

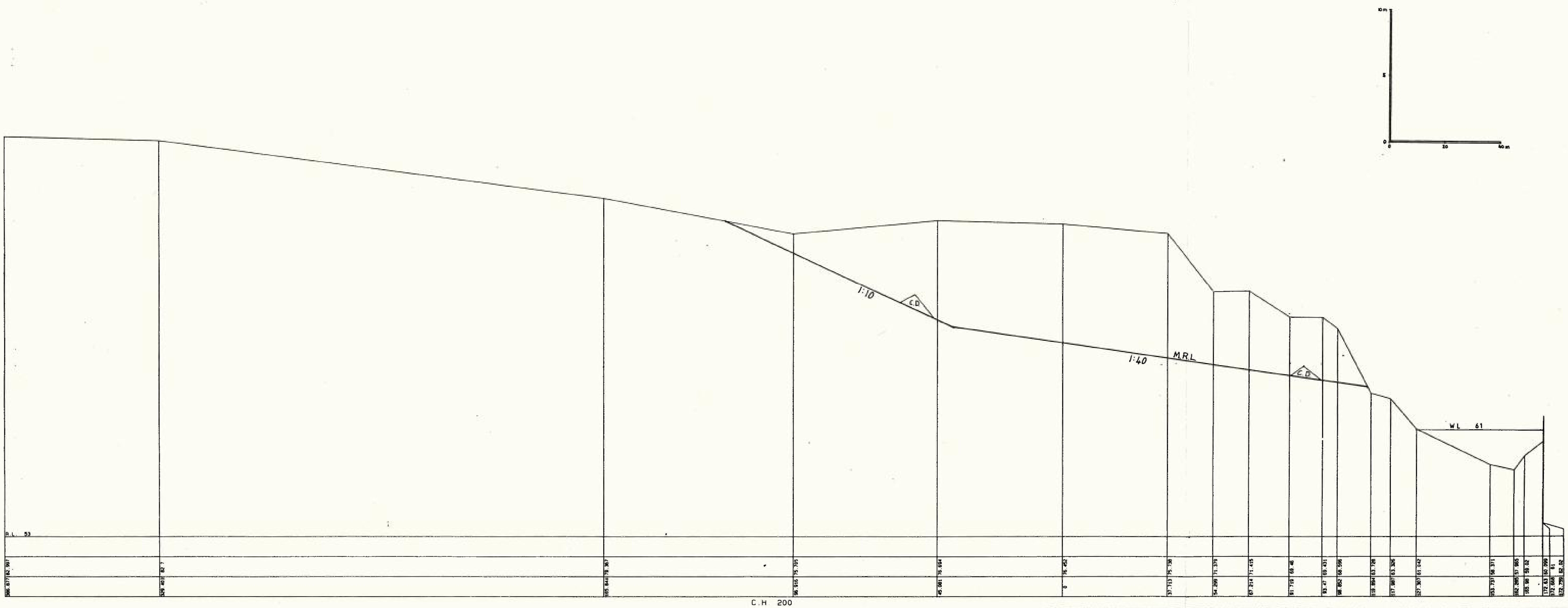
41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

CROSS SECTIONS: - LINE 1
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN
LOCALITY: MENANGLE
COUNTY: CAMDEN

2c

REDUCTION RATIO
1: 500H 1: 100V
DATUM
A.H.D.
REF: 87/197



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph(046) 255055 D.X.5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

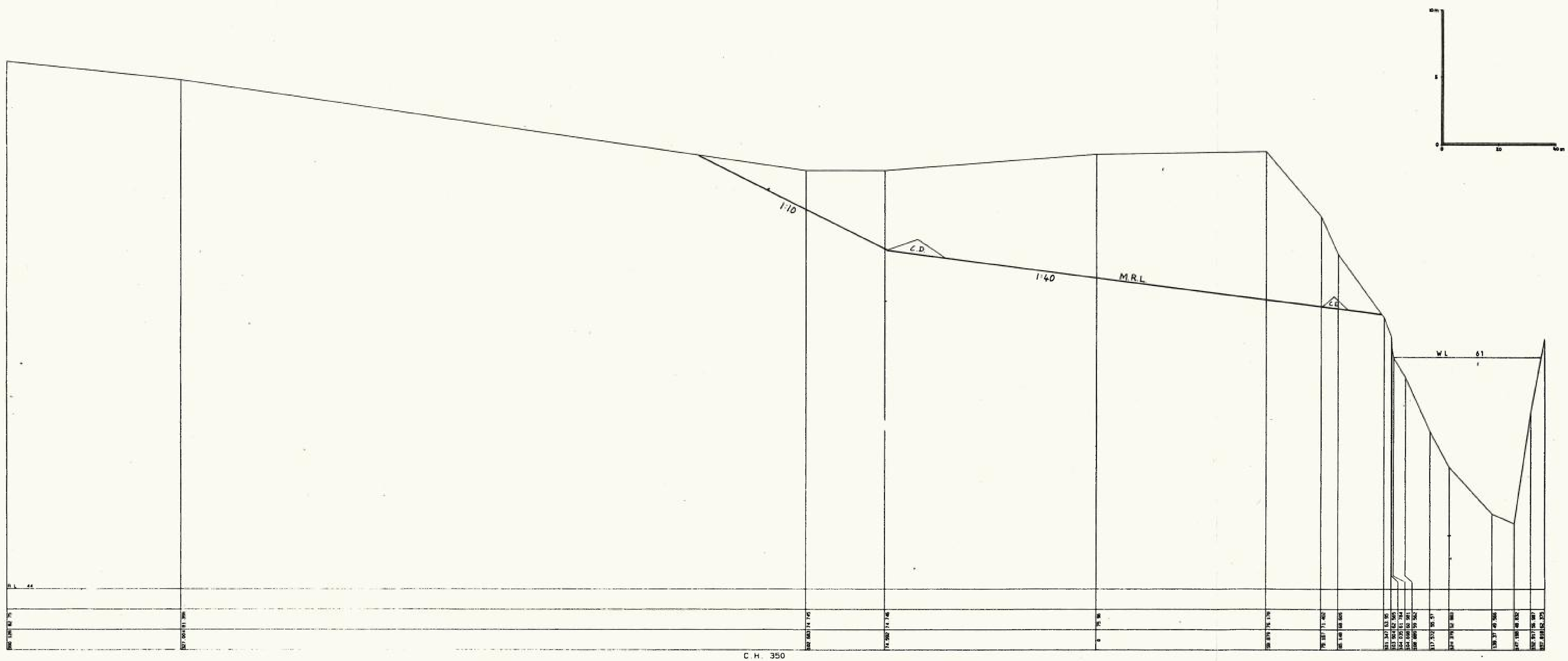
CROSS SECTIONS: - LINE 2
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN

LOCALITY: MENANGLE
COUNTY: CAMDEN

2d

REDUCTION RATIO
1: 500H 1: 100V
DATUM
A.H.D.
REF: 87/197



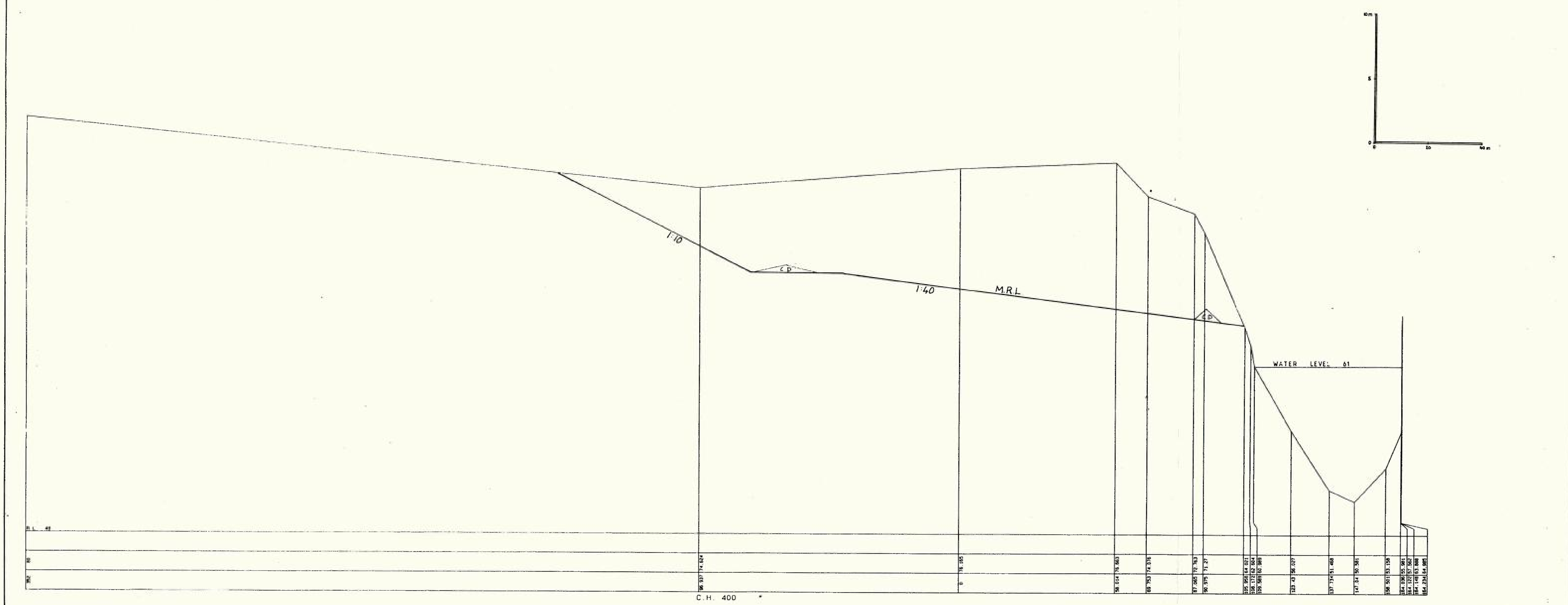
JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS	CROSS SECTIONS: - LINE 3 WITHIN LOT 202 IN D.P. 590247
13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	418 BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006
SHIRE: WOLLONDILLY PARISH: CAMDEN	LOCALITY: MENANGLE COUNTY: CAMDEN

2e

REDUCTION RATIO 1:500H 1:100V

DATUM A.H.D.

REF: 87/197



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

CROSS SECTIONS: - LINE 3
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN

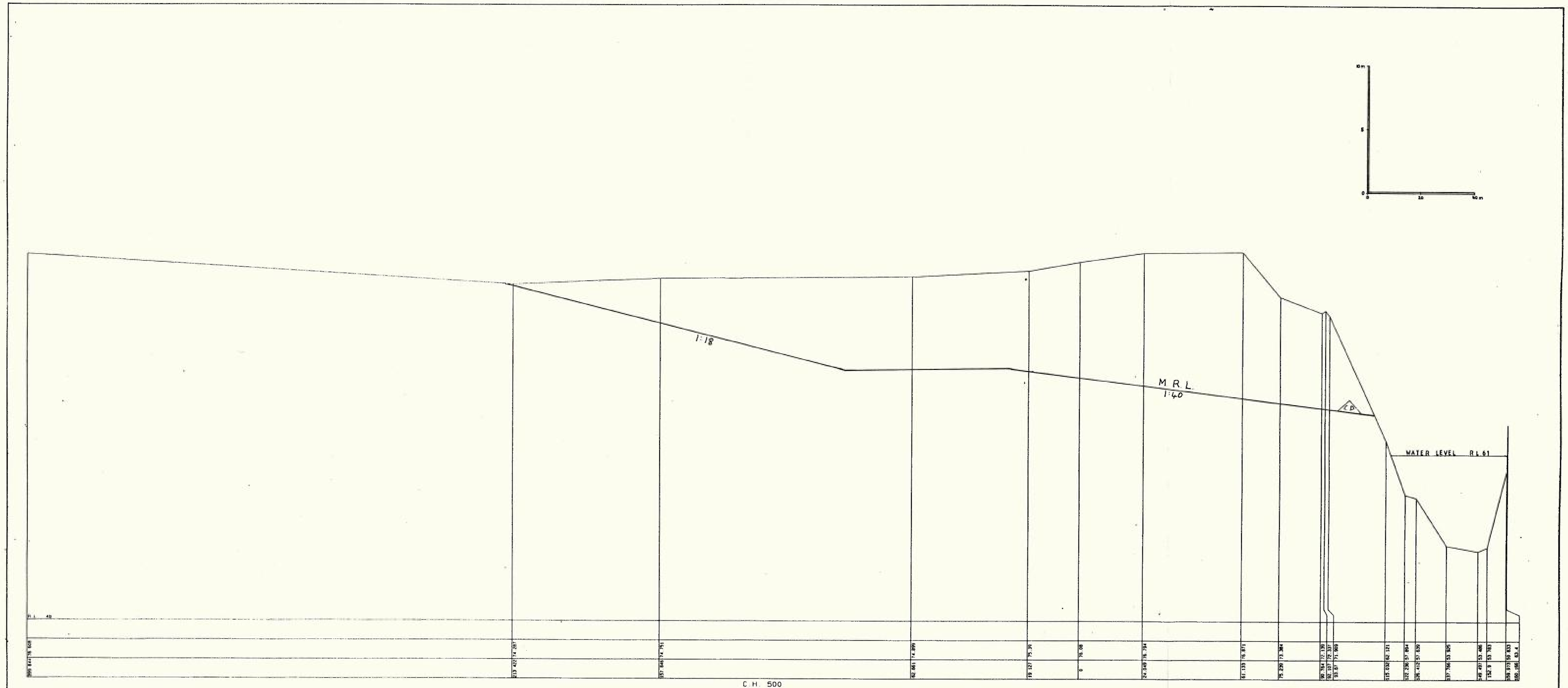
LOCALITY: MENANGLE
COUNTY: CAMDEN

2f

REDUCTION RATIO
1:500H 1:100V

DATUM
A.H.D.

REF: 87/197



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

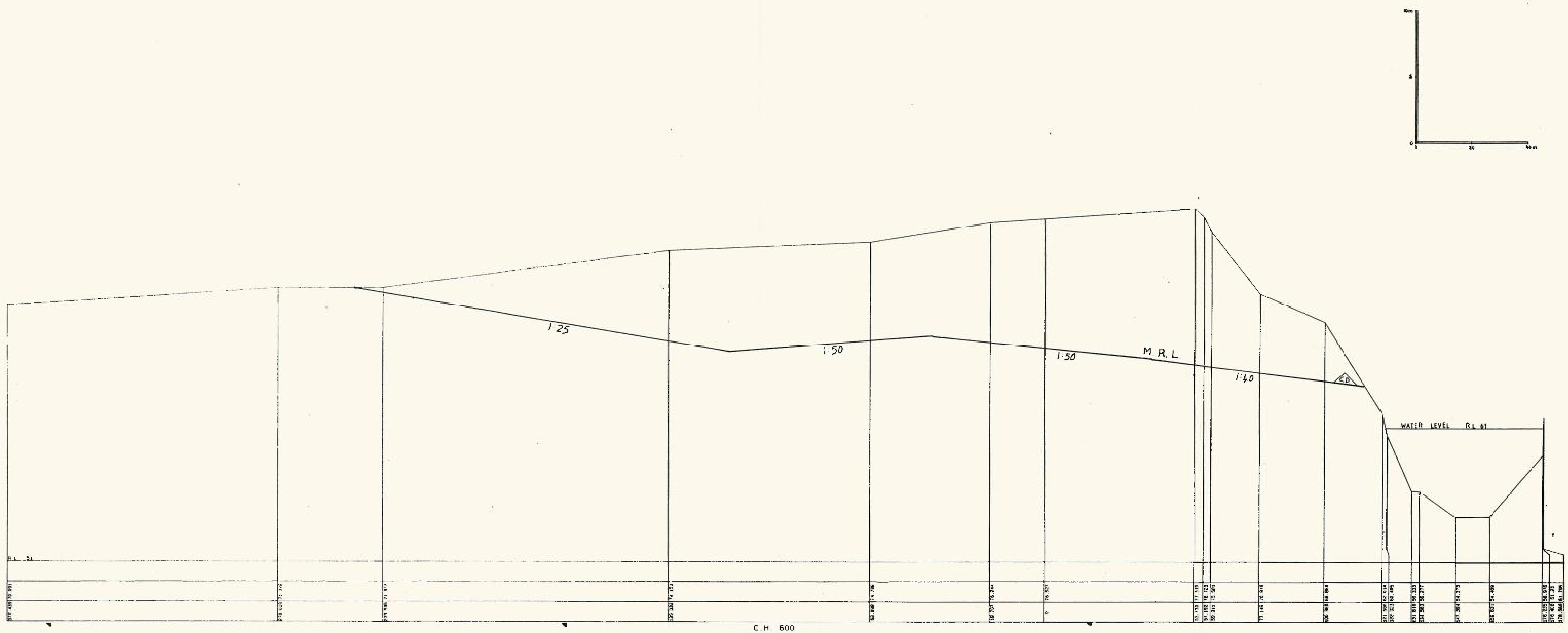
CROSS SECTIONS: - LINE 3
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN

LOCALITY: MENANGLE
COUNTY: CAMDEN

2g

RE: 1: 500m
DATUM A.H.D.
REF: 87/197



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

CROSS SECTIONS: - LINE 3
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN

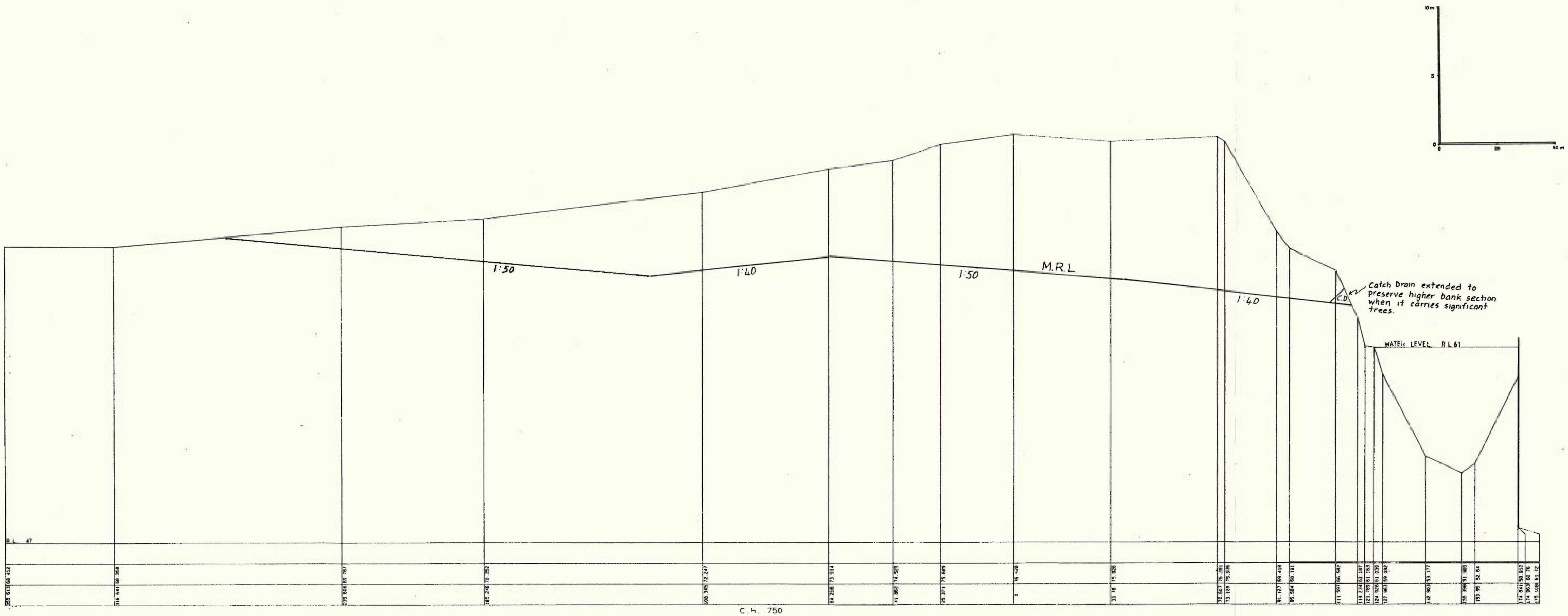
LOCALITY: MENANGLE
COUNTY: CAMDEN

2h

REDUCTION RATIO
1: 500H 1: 100V

DATUM
A.H.D.

REF: 87/197



JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X. 5112

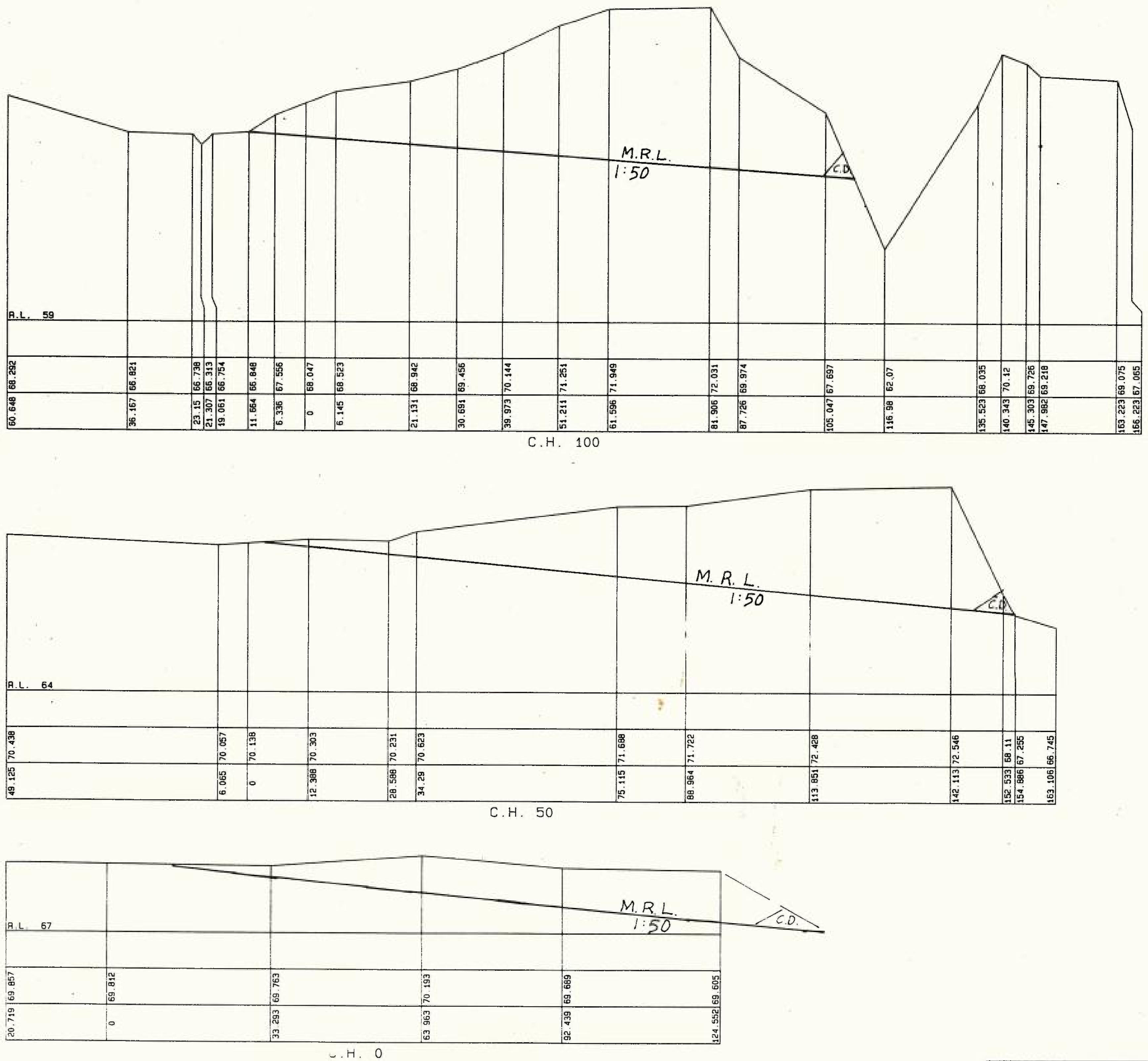
41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

CROSS SECTIONS: - LINE 4
WITHIN LOT 202 IN D.P. 590247

SHIRE: WOLLONDILLY
PARISH: CAMDEN
LOCALITY: MENANGLE
COUNTY: CAMDEN

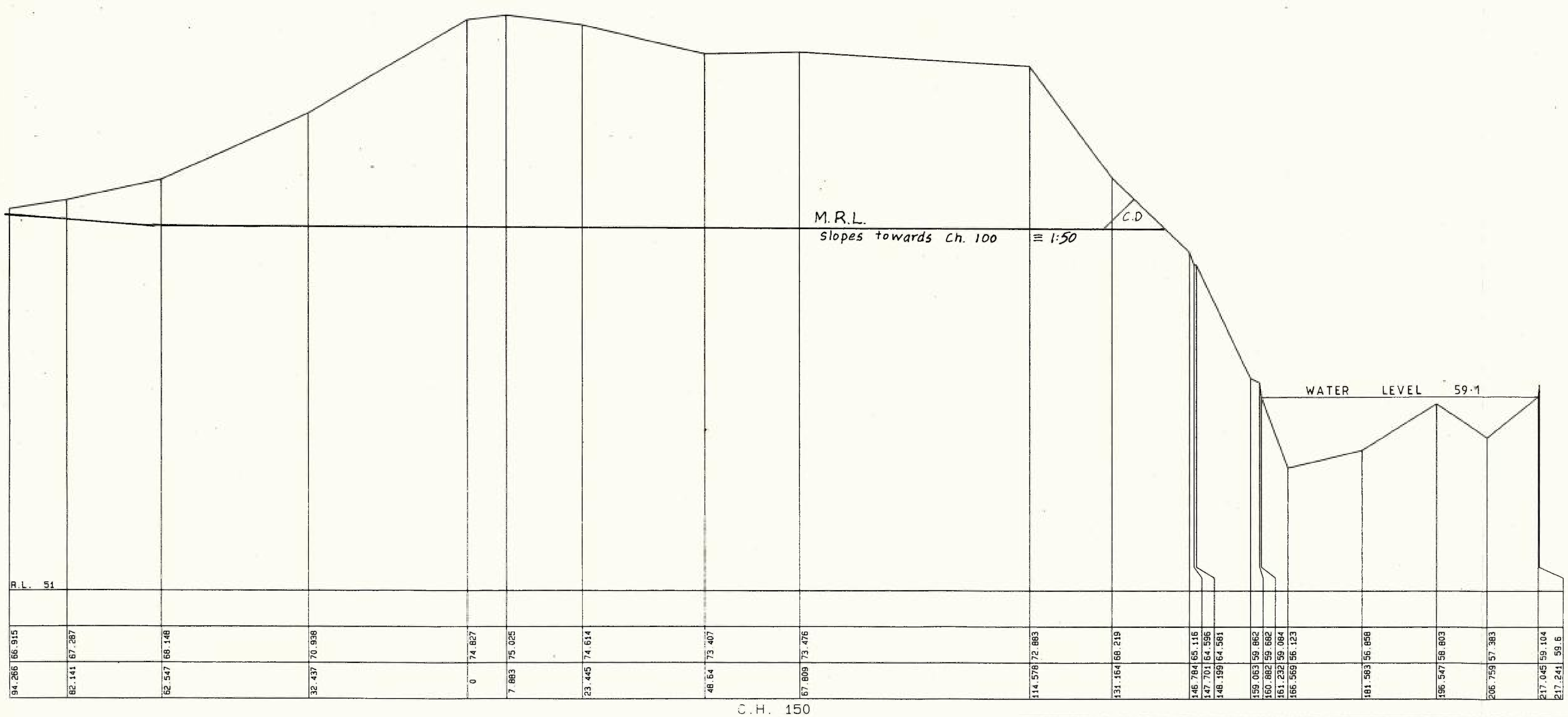
2i

REDUCTI... ID
1:500H 1:100V
DATUM
A.H.D.
REF: 87/197



SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS 13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112 41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	CROSS- SECTIONS :- LINE 6 NEPEAN RIVER MENANGLE SHIRE: WOLLONDILLY LOCALITY: MENANGLE PARISH: CAMDEN COUNTY: CAMDEN	2j REDUCT ATIO 1 : 50(.1 1: 100 V DATUM A.H.D. REF: 87/197



SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

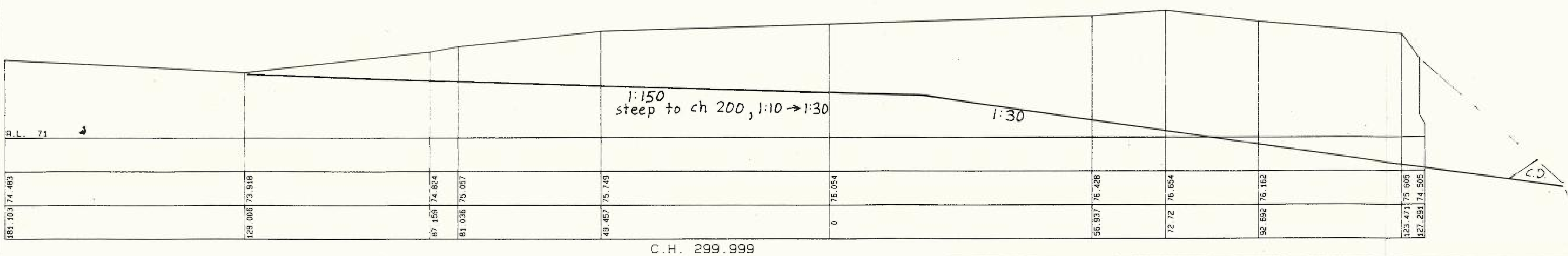
13 BLAXLAND ROAD	41B BELMORE STREET
CAMPBELLTOWN N.S.W. 2560	DUNDAS N.S.W. 2117
P.O. BOX 25 CAMPBELLTOWN	P.O. BOX 372 PARRAMATTA 2150
Ph (046) 255055 D.X.5112	Ph (02) 6832006

CROSS- SECTIONS :- LINE 6
NEPEAN RIVER MENANGLE

SHIRE: WOLLONDILLY LOCALITY: MENANGLE
PARISH: CAMDEN COUNTY: CAMDEN

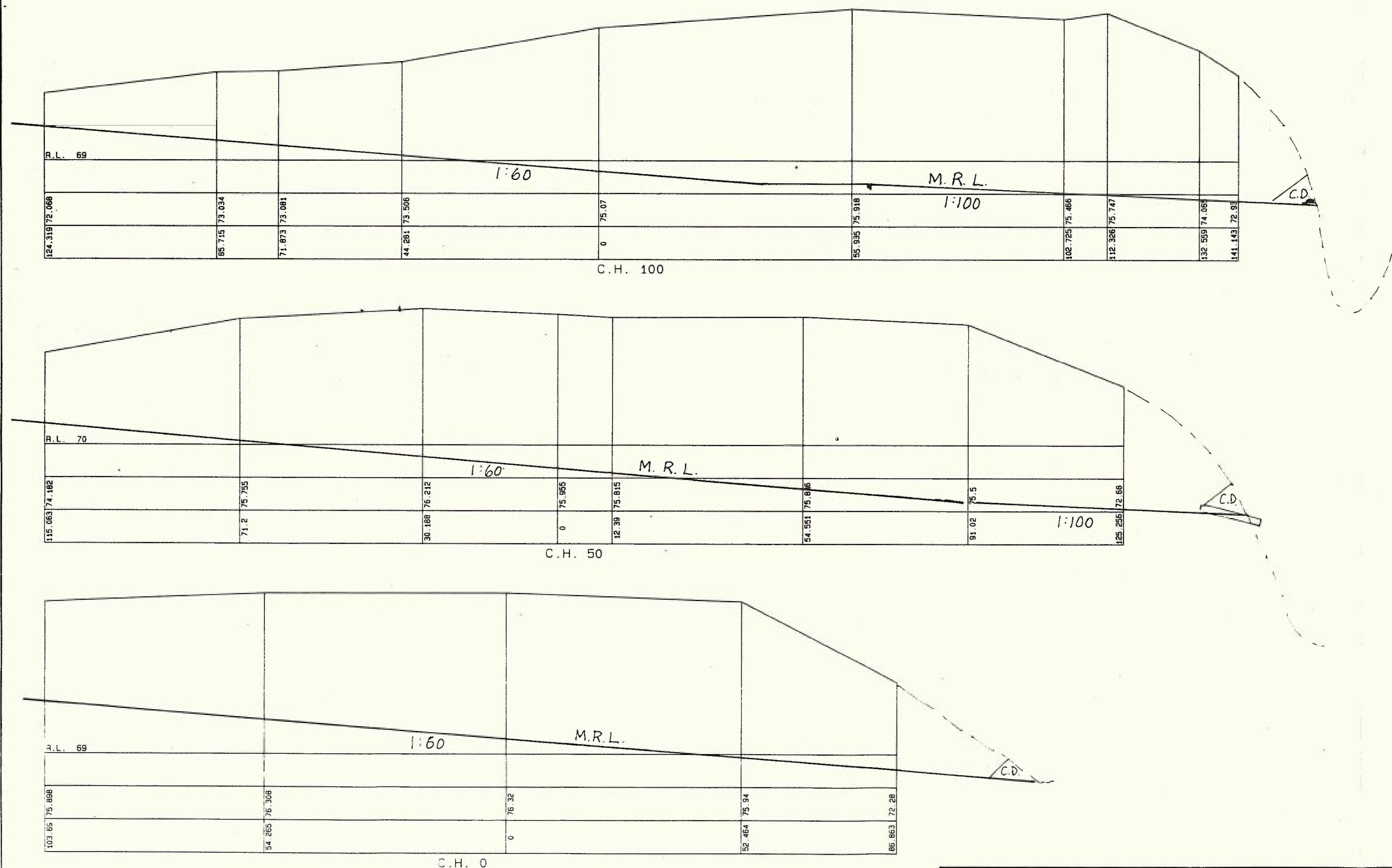
2k

REDUCTION RATIO
1 : 500 H 1: 100 V
DATUM -
A.H.D.
REF: 87/197



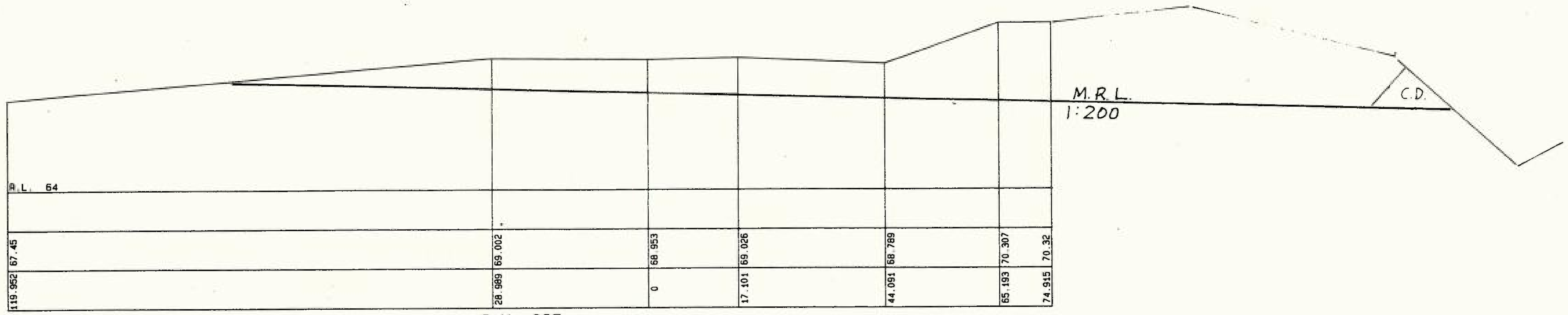
SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS 13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112 41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	CROSS- SECTIONS :- LINE 6 NEPEAN RIVER MENANGLE SHIRE: WOLLONDILLY. LOCALITY: MENANGLE PARISH: CAMDEN COUNTY: CAMDEN	**21** REDUCTION RATIO 1 : 500 H 1: 100 V DATUM A.H.D. REF: 87/197

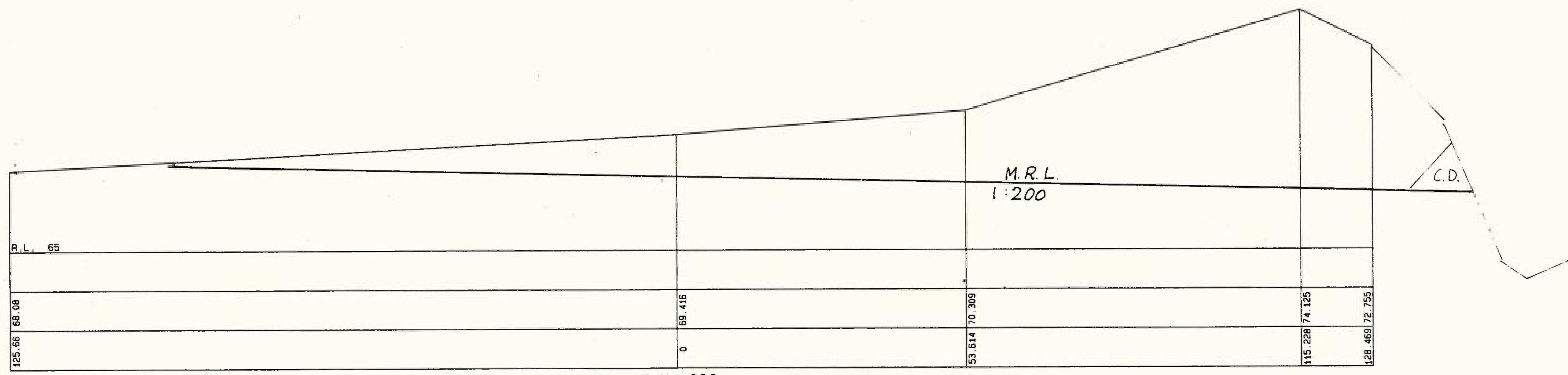


SCALE 1:1000 H / 1:200 V

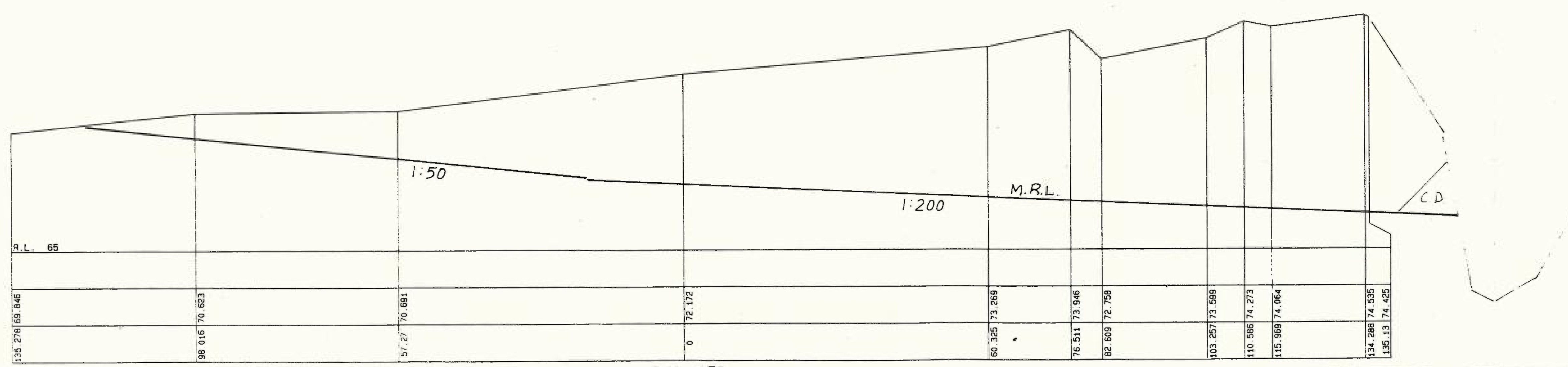
JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS		CROSS- SECTIONS :- LINE 7 NEPEAN RIVER MENANGLE	2m
13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	SHIRE: WOLLONDILLY LOCALITY: MENANGLE PARISH: CAMDEN COUNTY: CAMDEN	REDUCTION RATIO 1 : 500 H 1: 100 V DATUM A.H.D. REF: 87/197



C.H. 235



C.H. 200

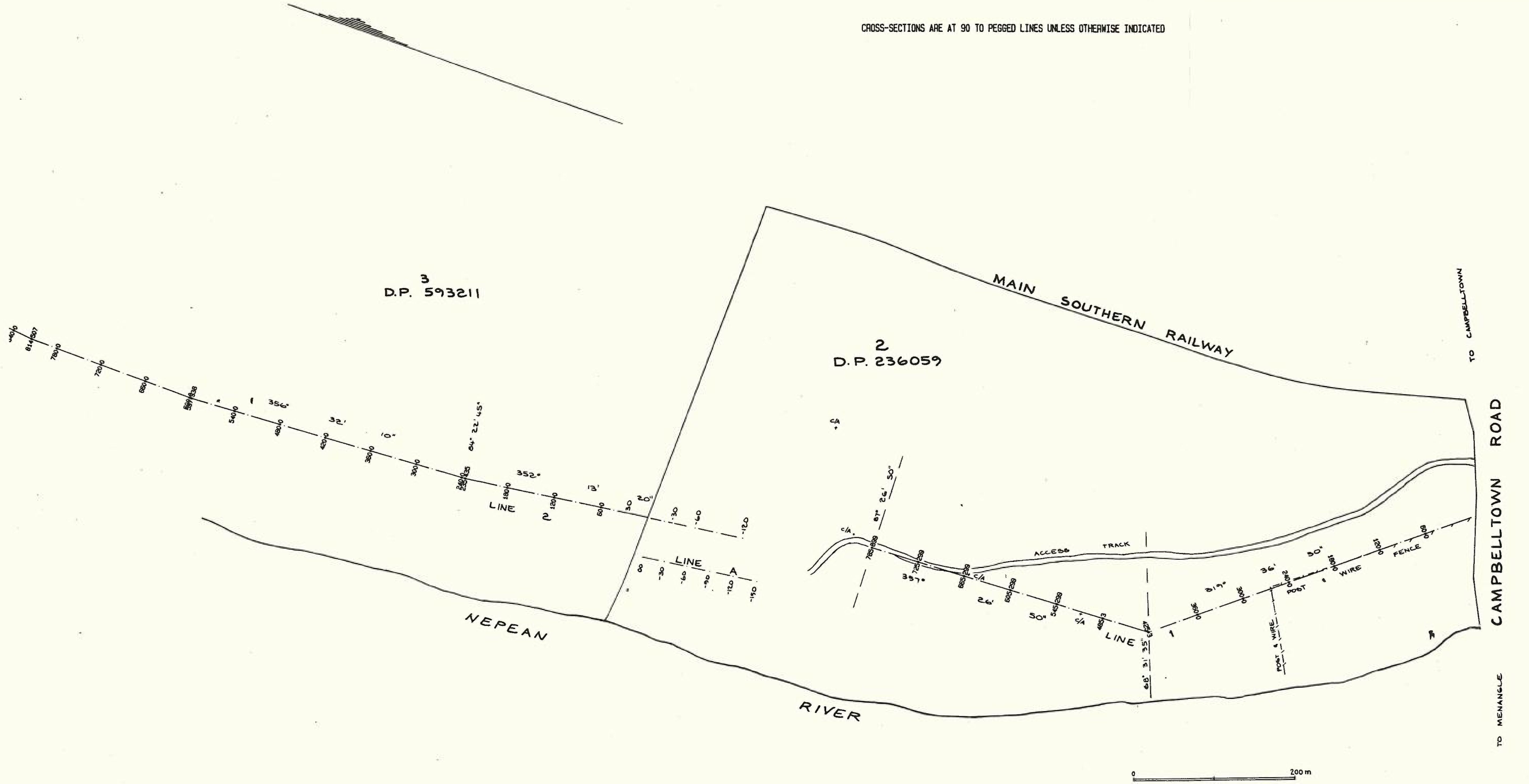


C.H. 150

SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS 13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112 418 BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	CROSS- SECTIONS :- LINE 7 NEPEAN RIVER MENANGLE SHIRE: WOLLONDILLY LOCALITY: MENANGLE PARISH: CAMDEN COUNTY: CAMDEN	2n REDUCTION RATIO 1 : 500 H 1: 100 V DATUM A.H.D. REF: 87/197

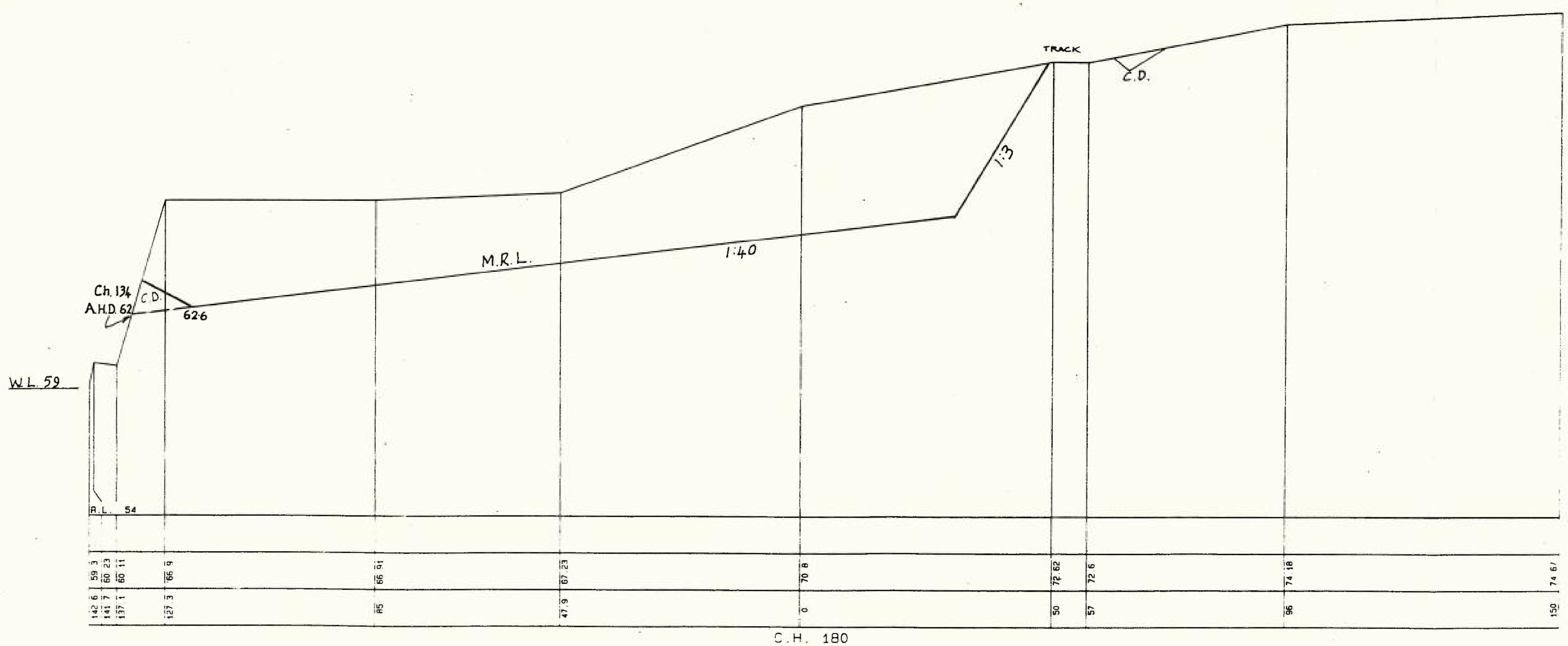
CROSS-SECTIONS ARE AT 90 TO PEGGED LINES UNLESS OTHERWISE INDICATED



ORIGIN OF LEVELS D.M.R. MARK 27215 R.L. 77.6 A.H.D.

3/9/87

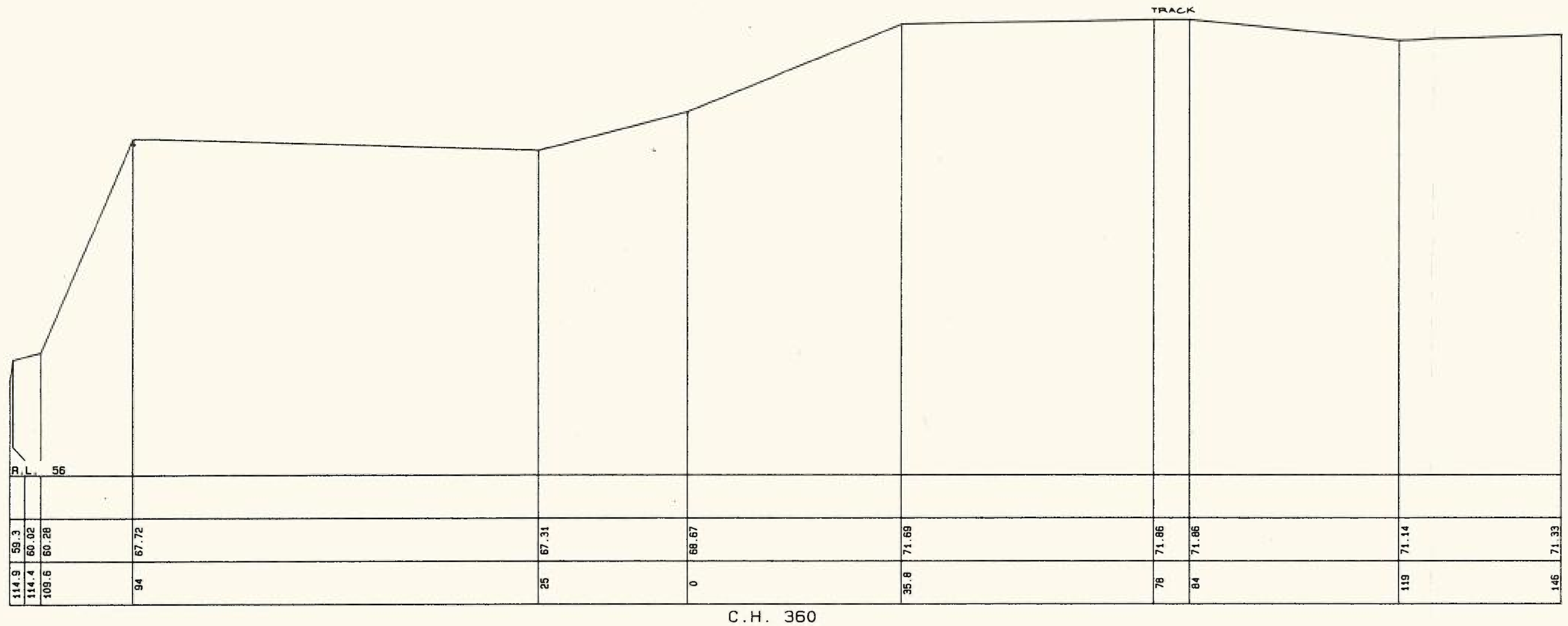
JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS		PLAN SHOWING POSITION OF CROSS-SECTIONS WITHIN LOT 2 IN D.P.236059 AND LOT 3 IN D.P.593211 NEPEAN RIVER MENANGLE		3a
13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	CITY: CAMPBELLTOWN PARISH: MENANGLE	LOCALITY: MENANGLE COUNTY: CUMBERLAND	REDUCTION RATIO 1 : 2500 DATUM A.H.D. REF: 87/258

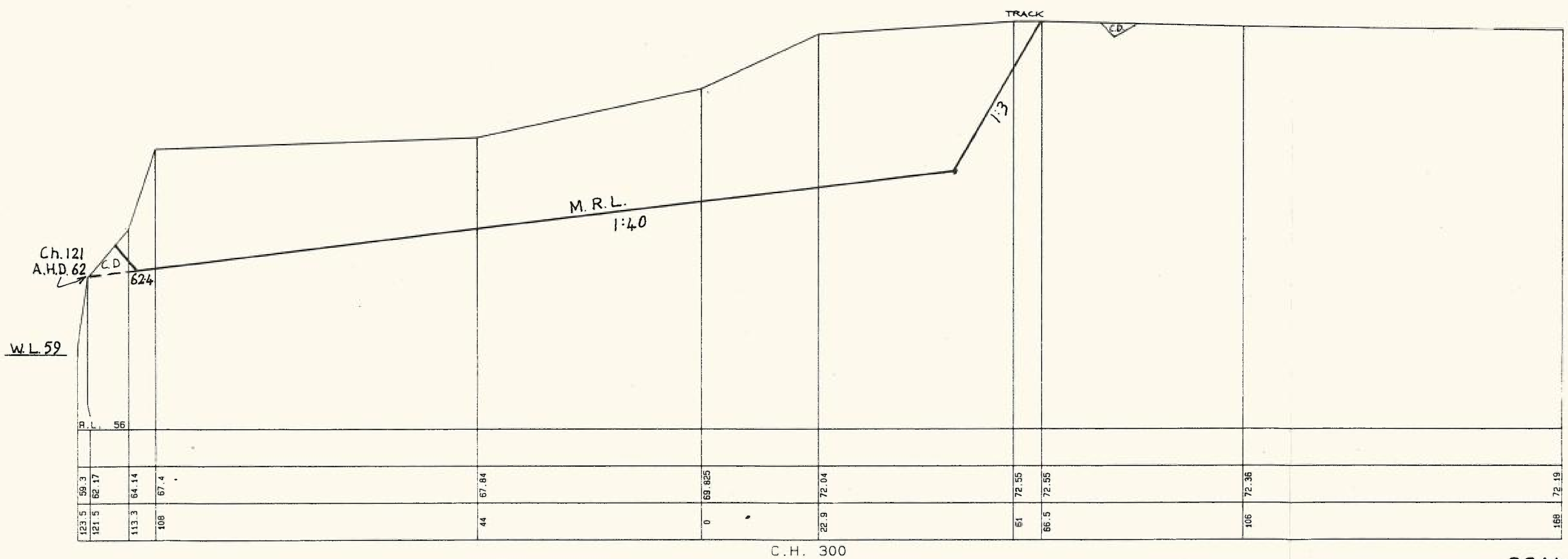


SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS 13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112 418 BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	PLAN OF CROSS-SECTIONS LINE 1 WITHIN LOT 2 IN D.P.236059 NEPEAN RIVER MENANGLE MUN/SHIRE/CITY: CAMPBELLTOWN LOCALITY: MENANGLE PARISH: MENANGLE COUNTY: CUMBERLAND	3b REDUCTION RATIO 1: 500H 1: 100V DATUM A.H.D. REF: 87/258

3/5/87





SCALE 1:1000 H / 1 : 200 V

JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

418 BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

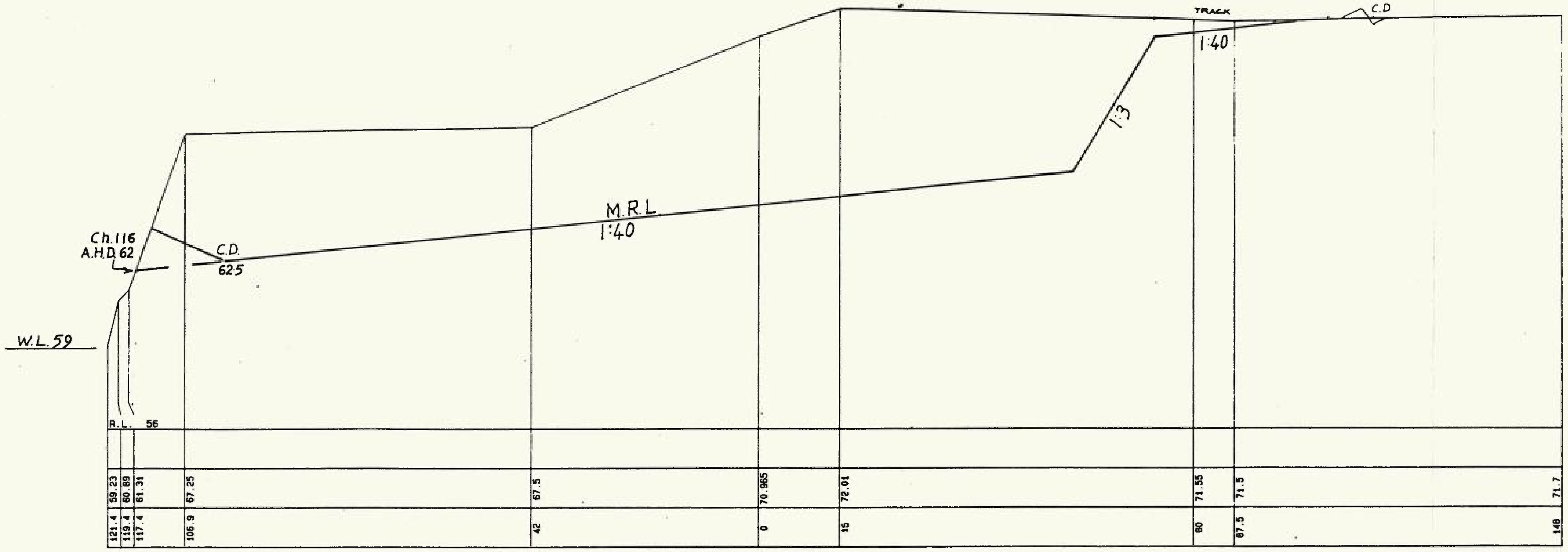
PLAN OF CROSS-SECTIONS LINE 1
WITHIN LOT 2 IN D.P.236059
NEPEAN RIVER MENANGLE

MUN/SHIRE/CITY: CAMPBELLTOWN
LOCALITY: MENANGLE
PARISH: MENANGLE
COUNTY: CUMBERLAND

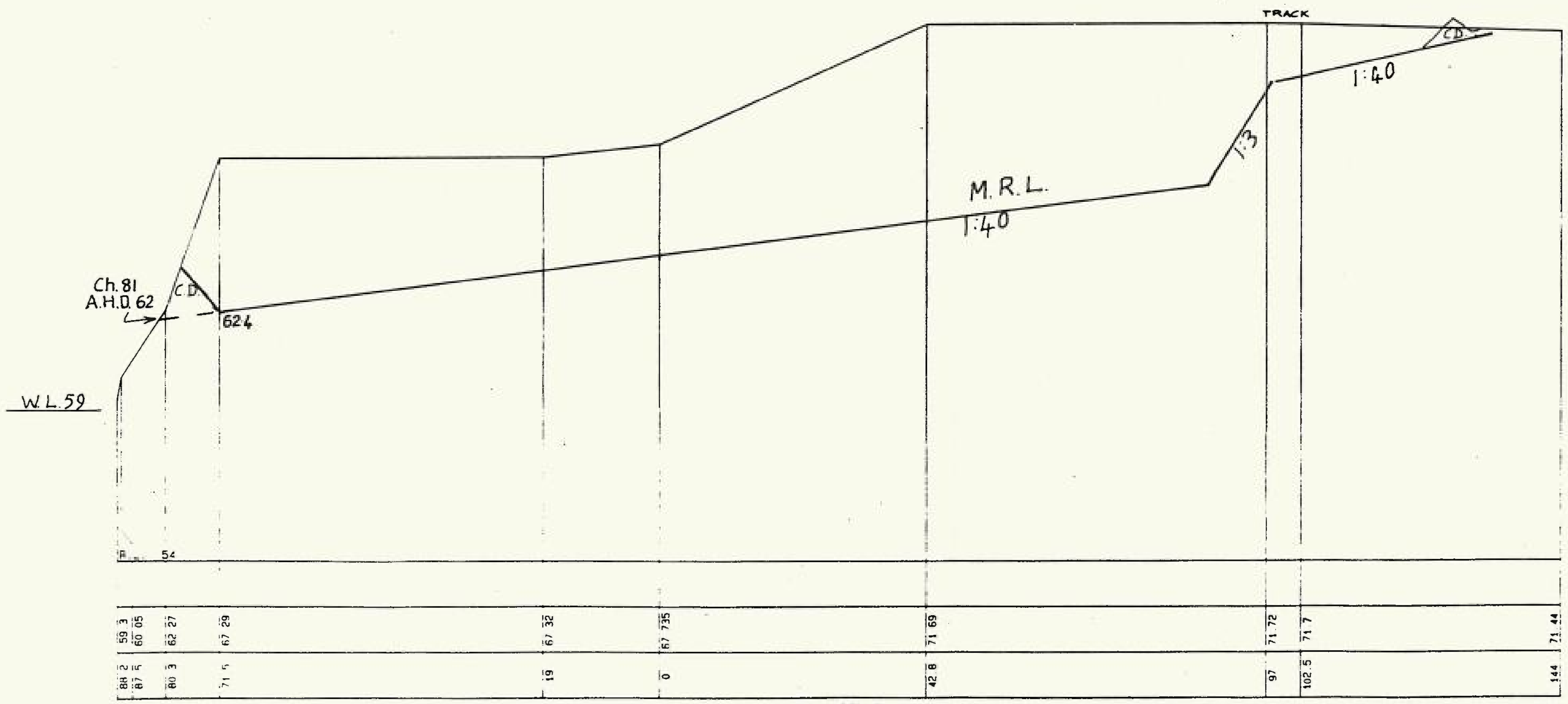
3c

REDUCTION RATIO
1 : 500H 1: 100V
DATUM
A.H.D.
REF: 87/258

3/9/87



C.H. 485.3

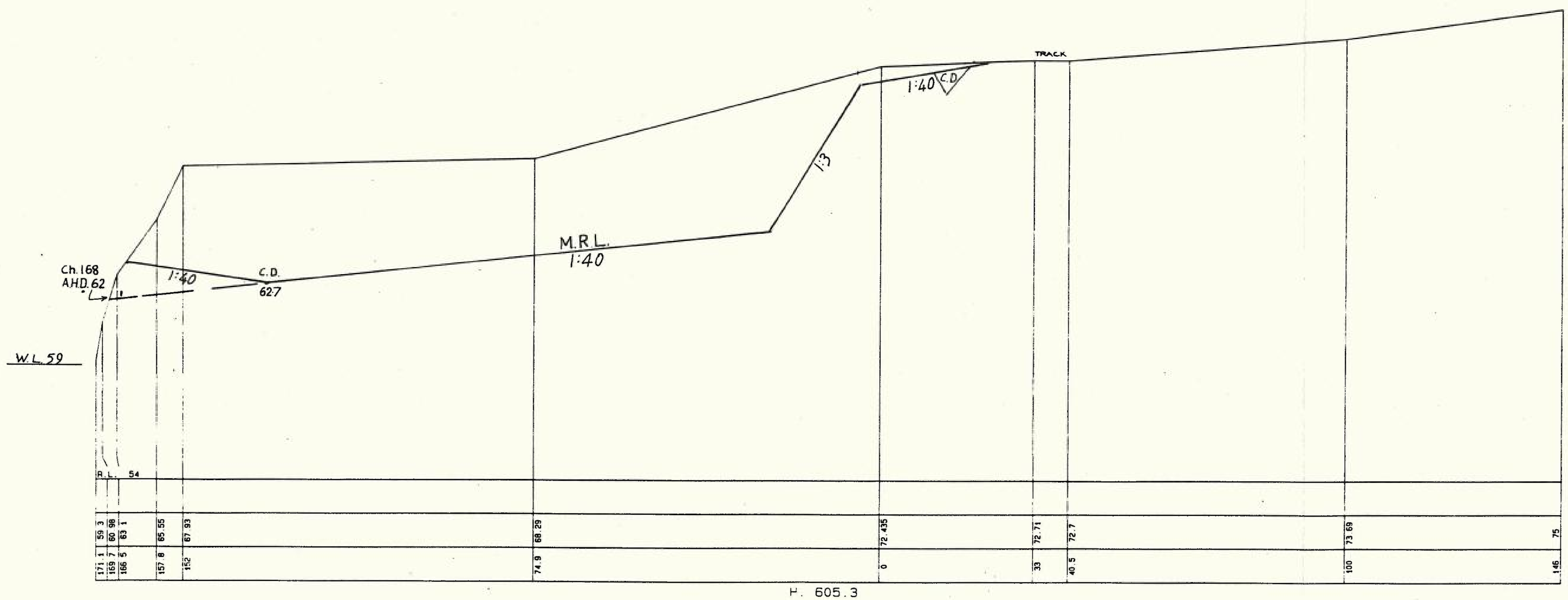


C.H. 425.3

SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS	CROSS-SECTIONS LINE 1 WITHIN LOT 2 IN D.P.236059 NEPEAN RIVER MENANGLE	3d
13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	CITY: CAMPBELLTOWN PARISH: MENANGLE	REDUCTION RATIO 1 : 500H 1:100V
41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	LOCALITY: MENANGLE COUNTY: CUMBERLAND	DATUM A.H.D. REF. 87/258

3/9/87



SCALE 1:1000 H / 1:200 V

3/9/87

JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

CROSS-SECTIONS LINE 1
WITHIN LOT 2 IN D.P.236059
NEPEAN RIVER MENANGLE

CITY: CAMPBELLTOWN
PARISH: MENANGLE

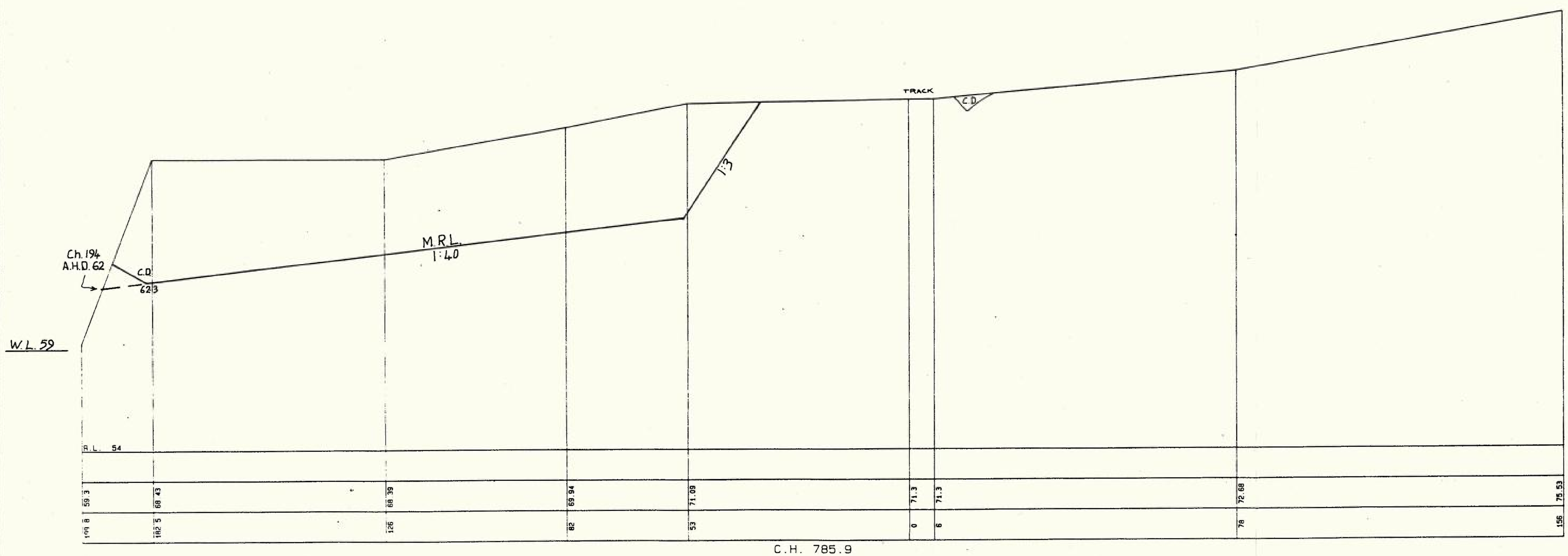
LOCALITY: MENANGLE
COUNTY: CUMBERLAND

3e

REDUCTION RATIO
1 : 500H 1: 100V

DATUM,
A.H.D.

REF: 87/258

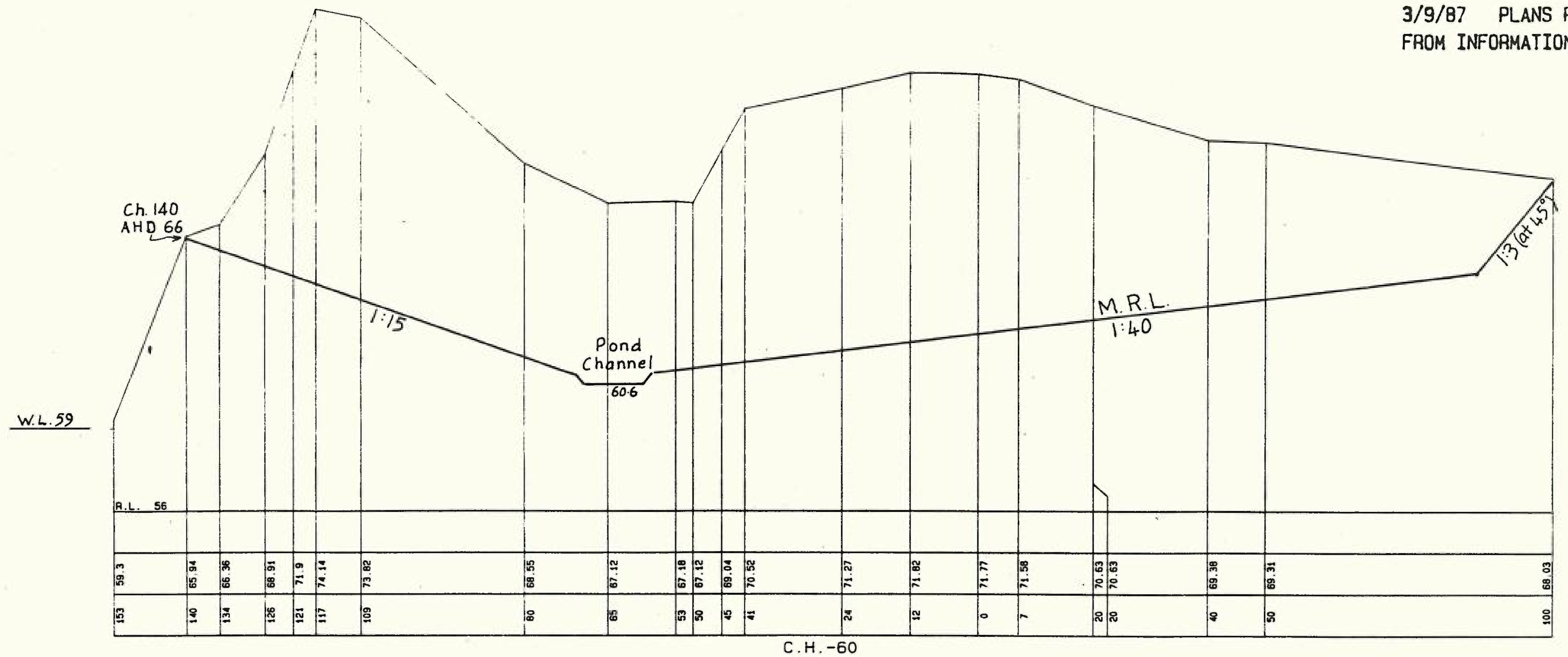


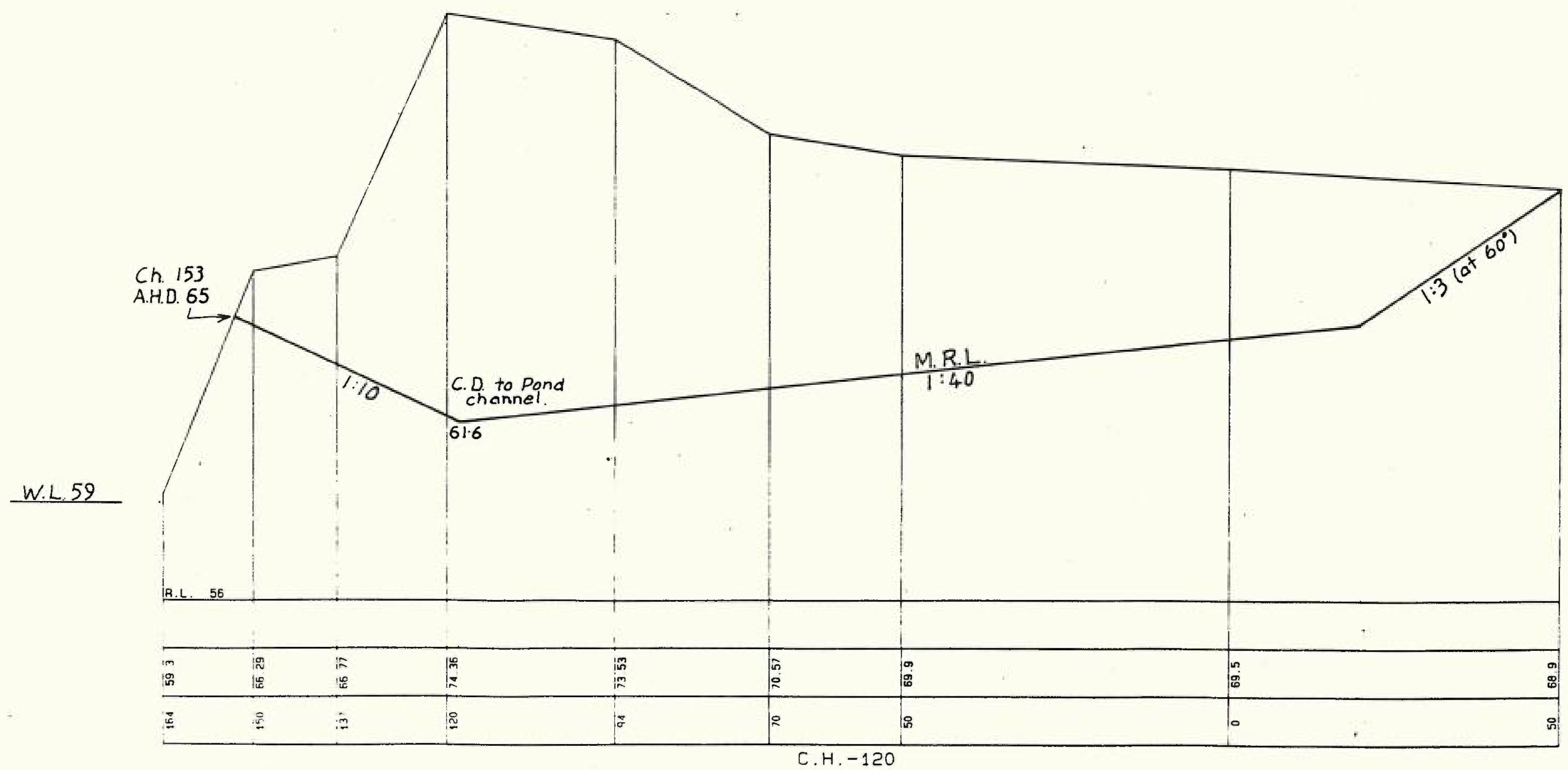
SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS	CROSS-SECTIONS LINE 1 WITHIN LOT 2 IN D.P.236059 NEPEAN RIVER MENANGLE	3f
13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	CITY: CAMPBELLTOWN PARISH: MENANGLE	REDUCTION RATIO 1 : 500H 1: 100V
41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	LOCALITY: MENANGLE COUNTY: CUMBERLAND	DATUM: A.H.D.
		REF: 87/258

3/9/87

3/9/87 PLANS REDRAWN AT SCALES INDICATED
FROM INFORMATION ON OUR PLANS REF 87/75

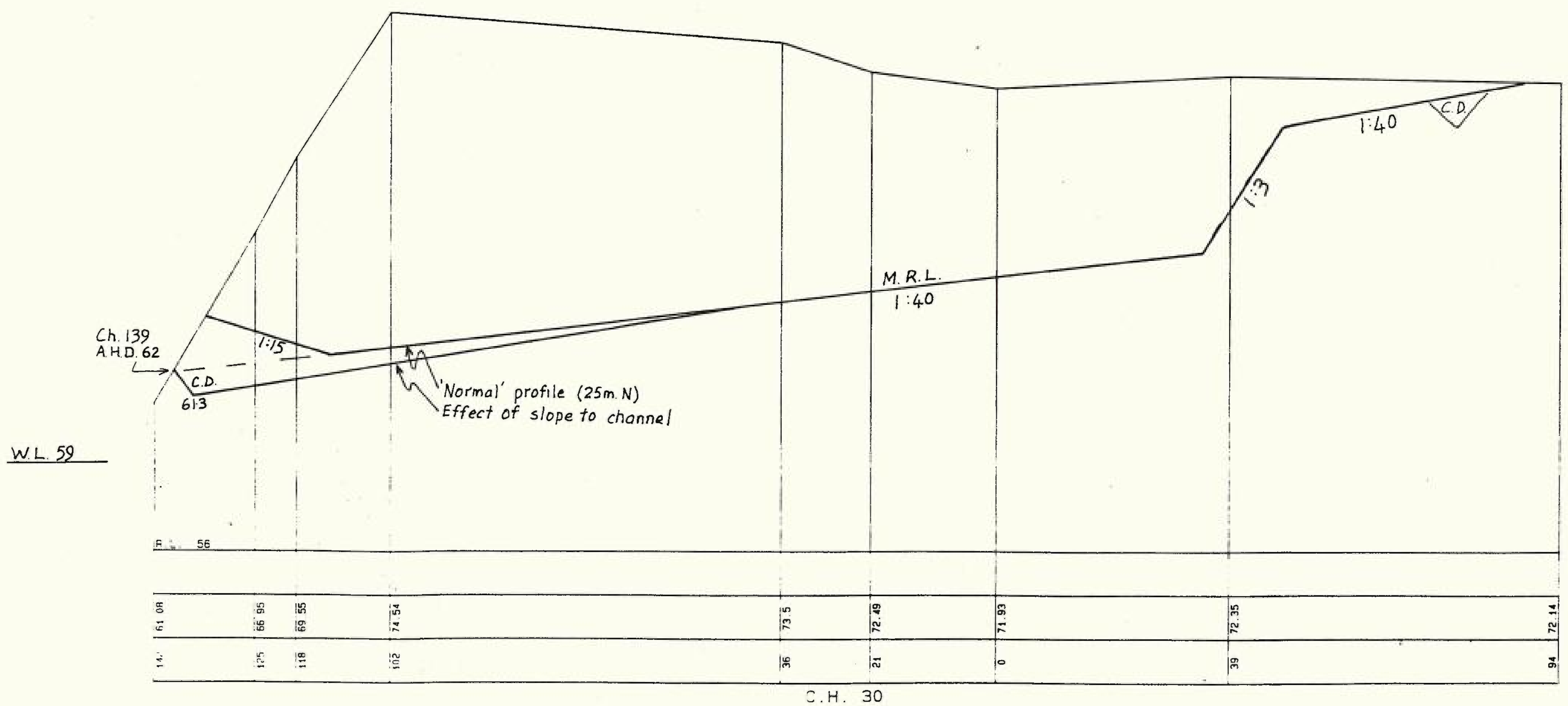




SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS 13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	CROSS- SECTIONS LINE 2 WITHIN LOT 3 IN D.P. 593211 NEPEAN RIVER MENANGLE CITY: CAMPBELLTOWN LOCALITY: MENANGLE PARISH: MENANGLE COUNTY: CUMBERLAND	**3g** REDUCT RATIO 1 : 500 H 1: 100 V DATUM A.H.D. REF: 87/258

3/9/87 PLANS REDRAWN AT SCALES INDICATED
FROM INFORMATION ON OUR PLANS REF 87/75



SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD.
REGISTERED SURVEYORS

13 BLAXLAND ROAD
CAMPBELLTOWN N.S.W. 2560
P.O. BOX 25 CAMPBELLTOWN
Ph (046) 255055 D.X.5112

41B BELMORE STREET
DUNDAS N.S.W. 2117
P.O. BOX 372 PARRAMATTA 2150
Ph (02) 6832006

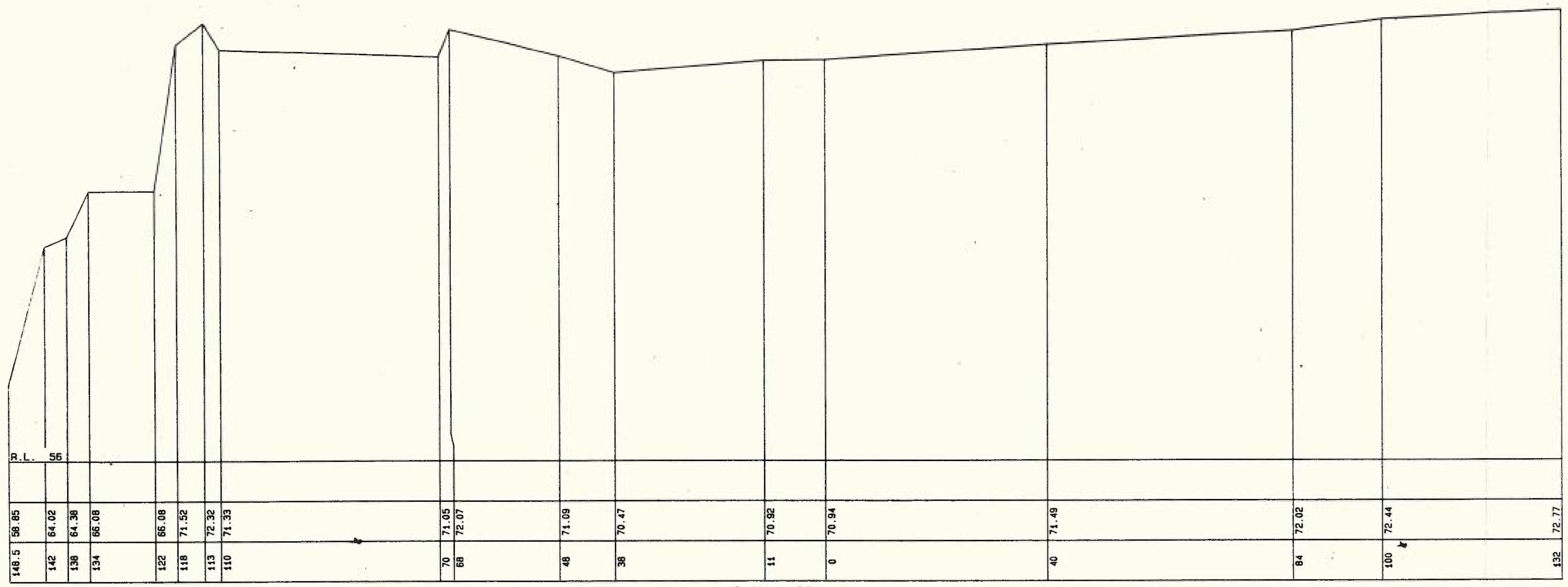
CROSS- SECTIONS LINE 2
WITHIN LOT 3 IN D.P. 593211
NEPEAN RIVER MENANGLE

CITY: CAMPBELLTOWN
LOCALITY: MENANGLE
PARISH: MENANGLE
COUNTY: CUMBERLAND

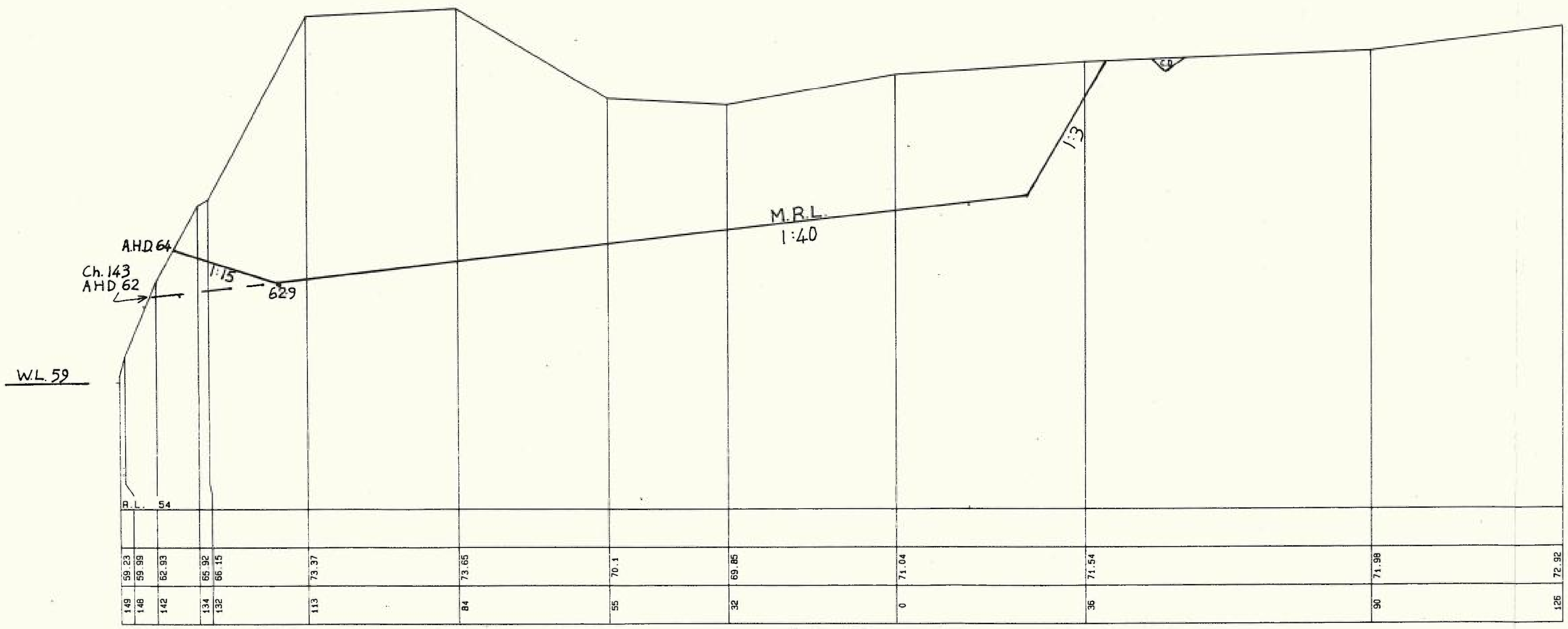
3h

REDUC. RATIO 1 : 500 H 1: 100 V
DATUM A.H.D.
REF: 87/258

3/9/87 PLANS REDRAWN AT SCALES INDICATED FROM INFORMATION ON OUR PLANS REF 87/75



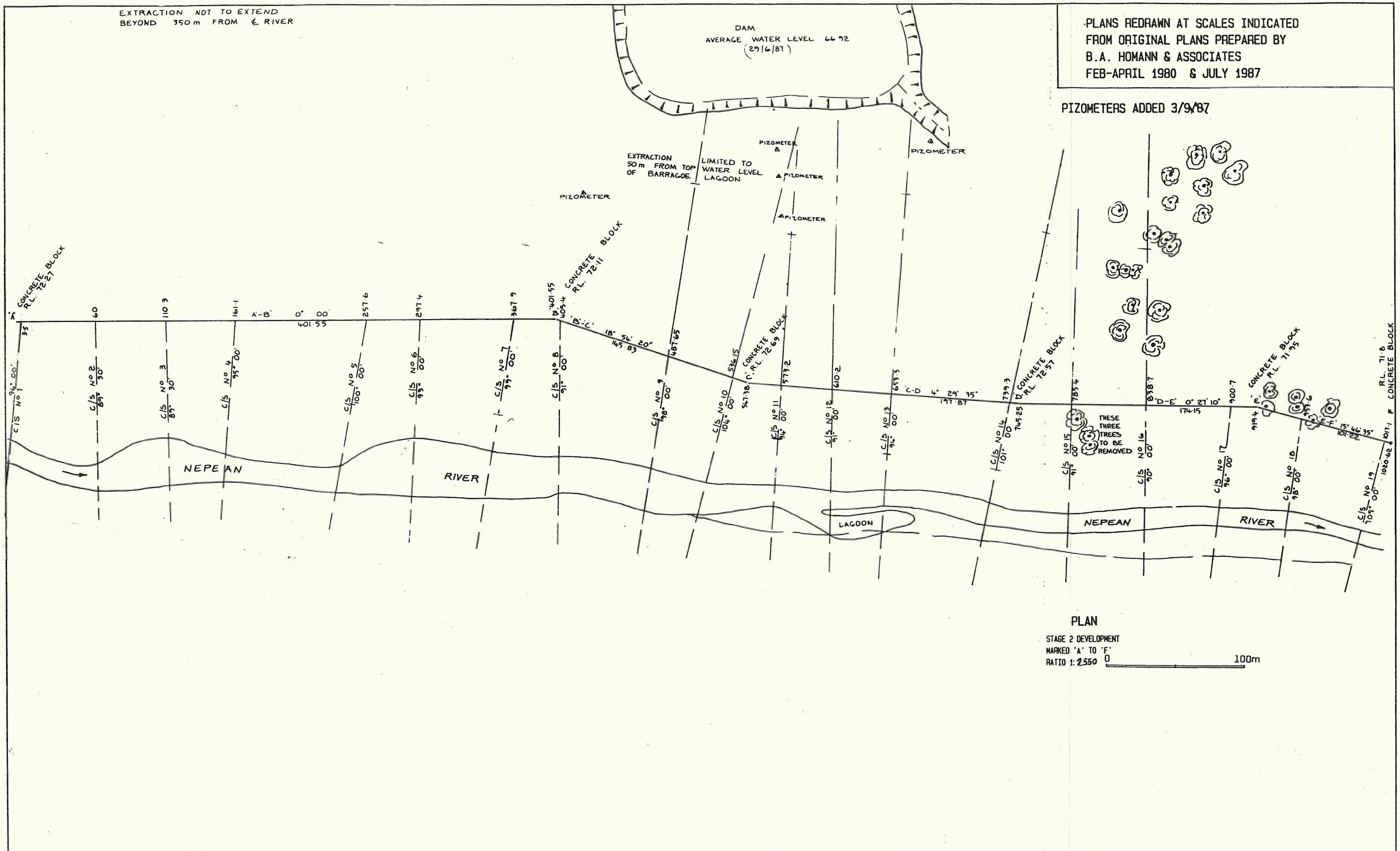
C.H. 480



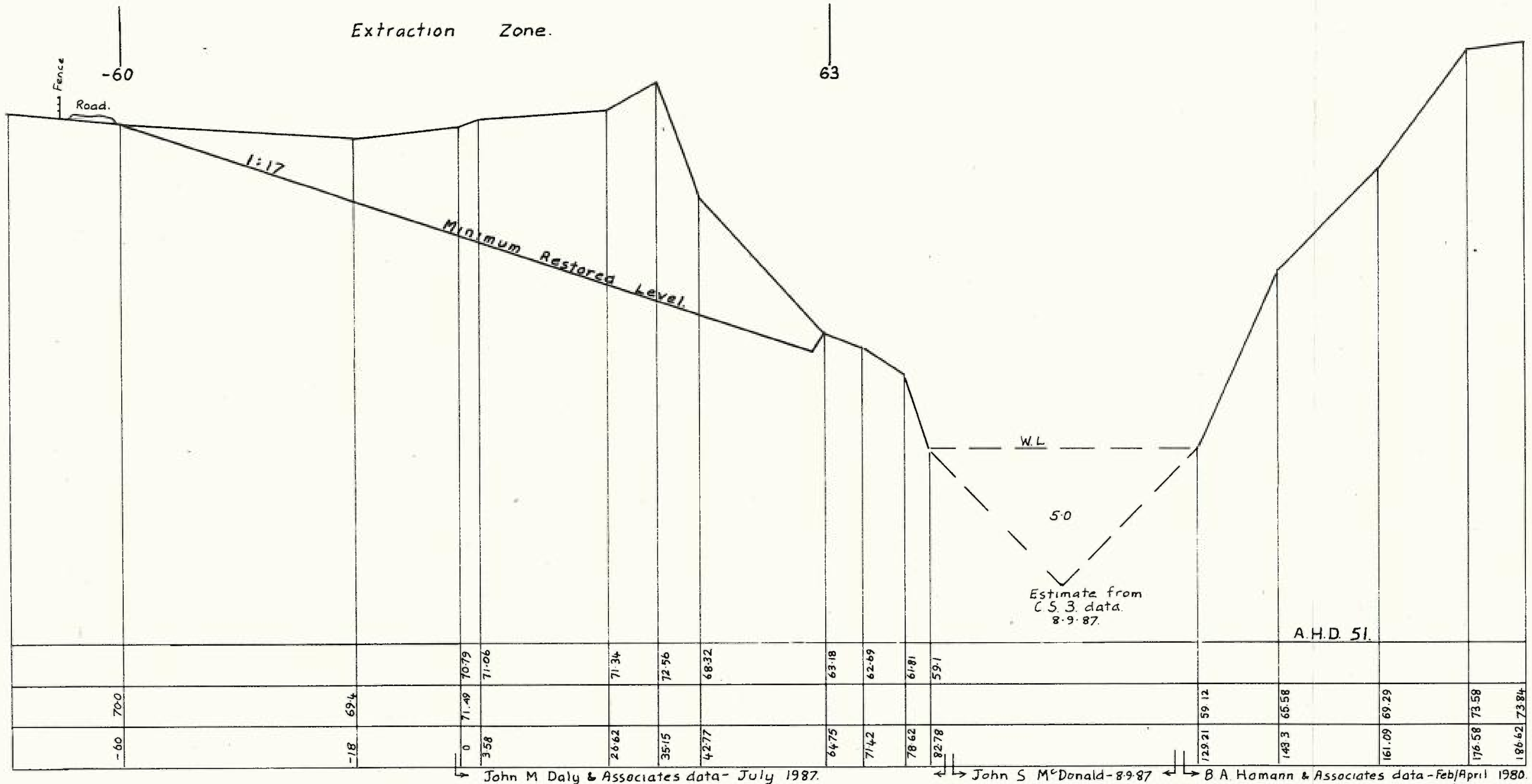
C.H. 420

SCALE 1:1000 H / 1:200 V

JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS 13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112 418 BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	CROSS- SECTIONS LINE 2 WITHIN LOT 3 IN D.P. 593211 NEPEAN RIVER MENANGLE CITY: CAMPBELLTOWN LOCALITY: MENANGLE PARISH: MENANGLE COUNTY: CUMBERLAND	3j REDUCTION RATIO 1 : ... 1:100 V DATUM A.H.D. REF: 87/258



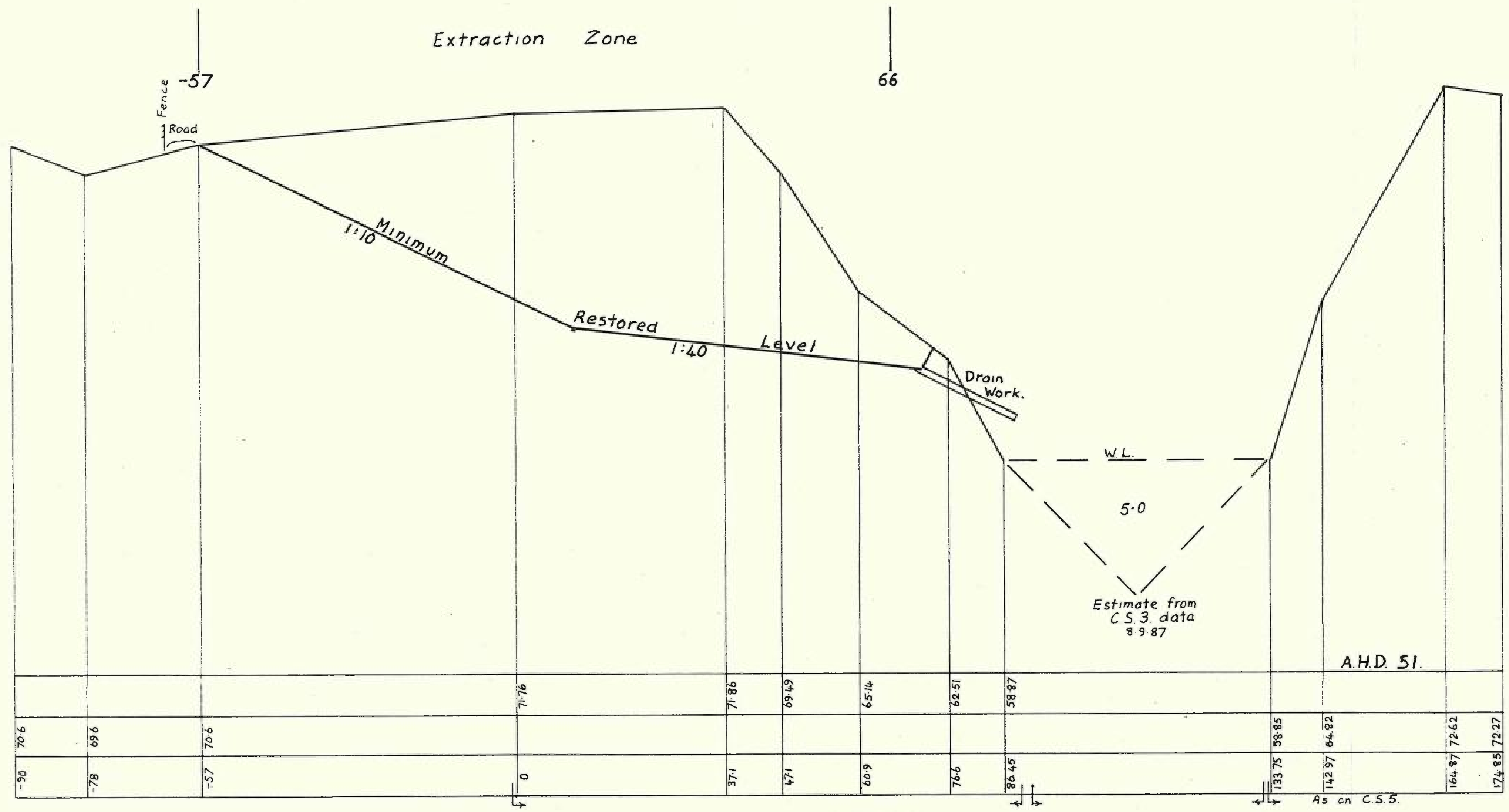
JOHN M. DALY & ASSOCIATES PTY. LTD. REGISTERED SURVEYORS	PLAN OF STAGE 2 DEVELOPMENT - NEPEAN RIVER MENANGLE	4a
13 BLAXLAND ROAD CAMPBELLTOWN N.S.W. 2560 P.O. BOX 25 CAMPBELLTOWN Ph (046) 255055 D.X.5112	~~MUN~~/SHIRE/~~CITY~~: WOLLONDILLY PARISH: CAMDEN	REDUCTION RATIO AS SHOWN
41B BELMORE STREET DUNDAS N.S.W. 2117 P.O. BOX 372 PARRAMATTA 2150 Ph (02) 6832006	LOCALITY: MENANGLE COUNTY: CAMDEN	DATUM A.H.D. REF: 87/245



C H. 257.6

C.S. 5.

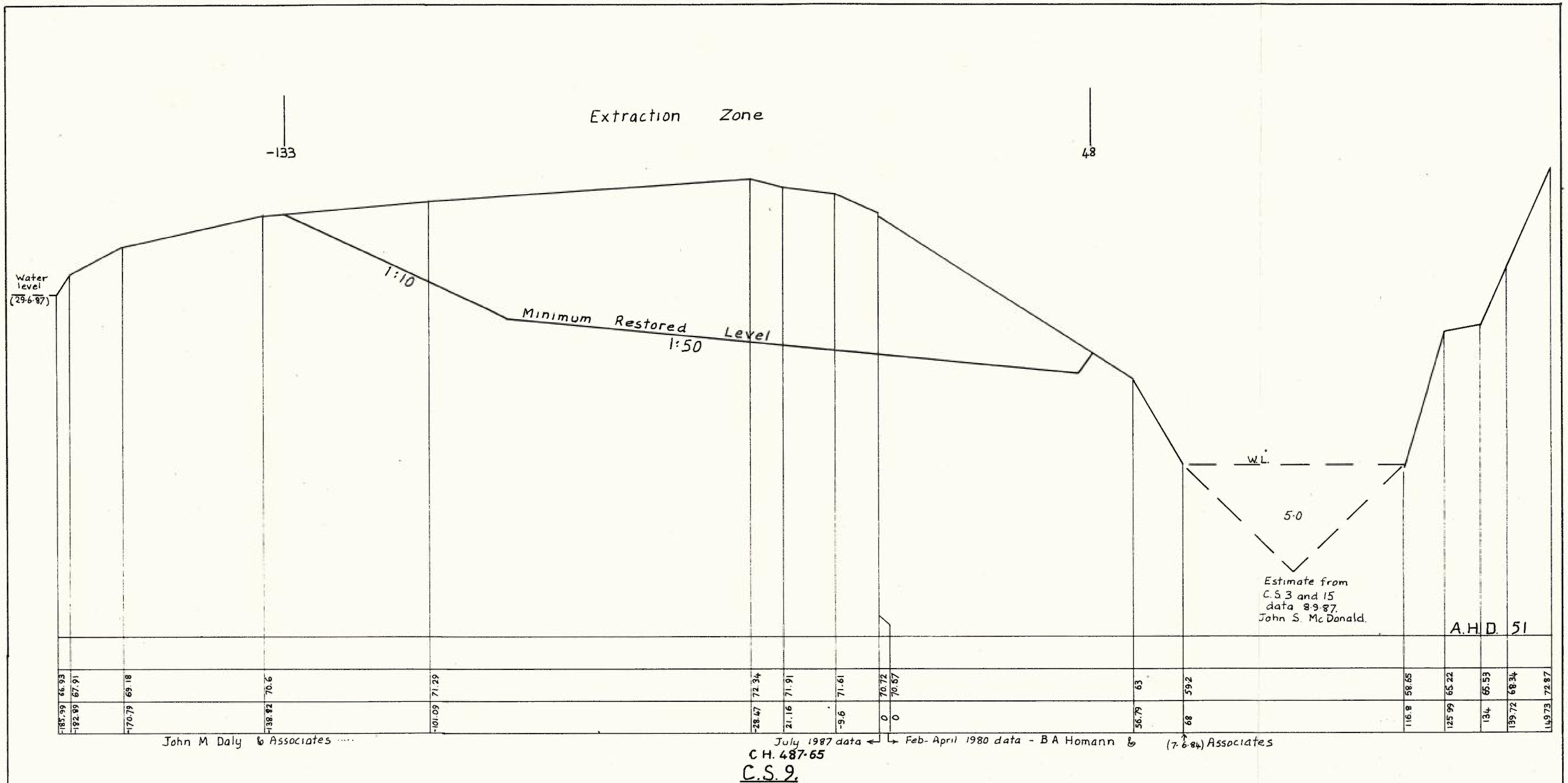
SCALE 1:1000H / 1:200V



C H. 367.9

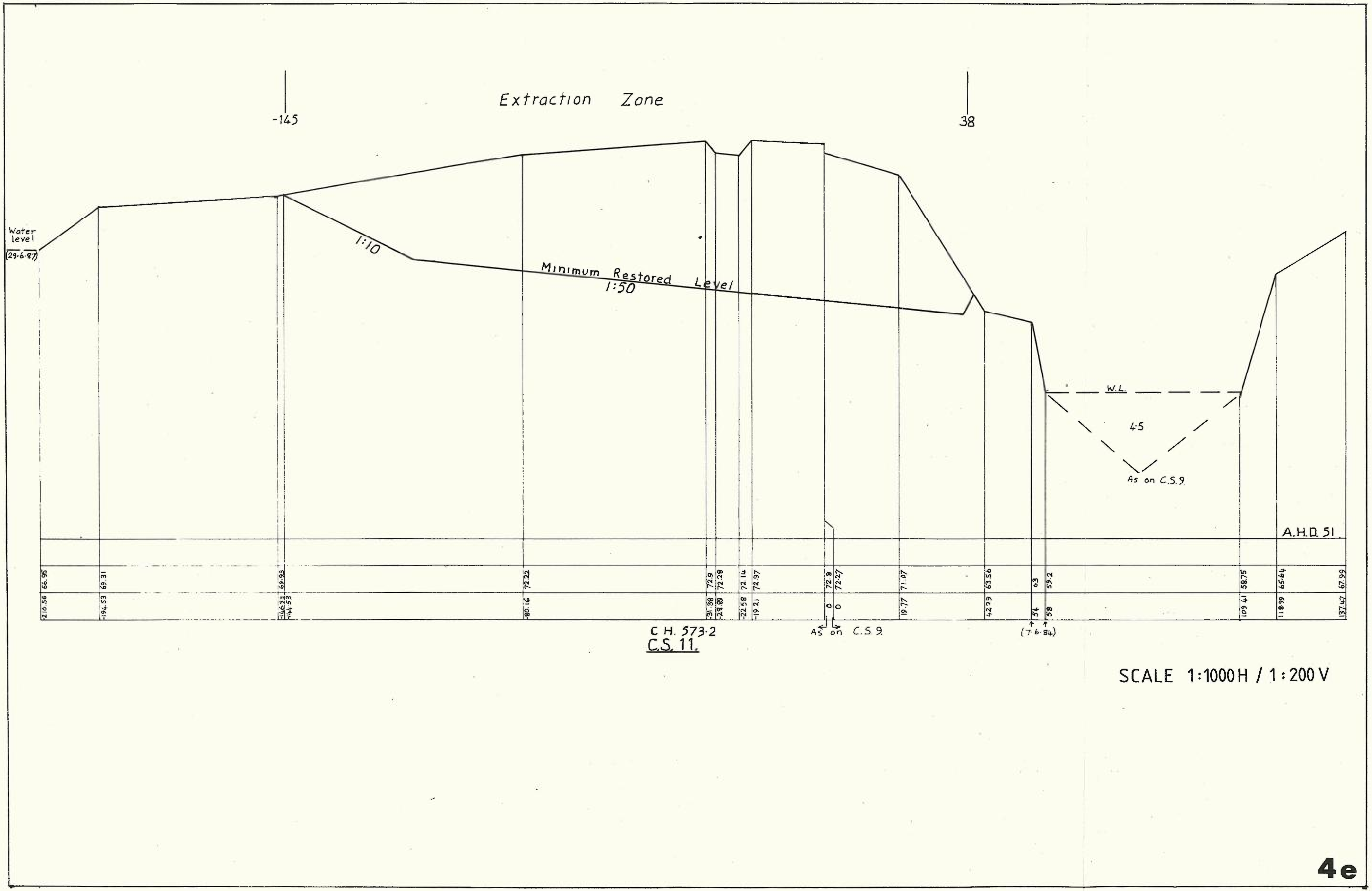
C.S.7.

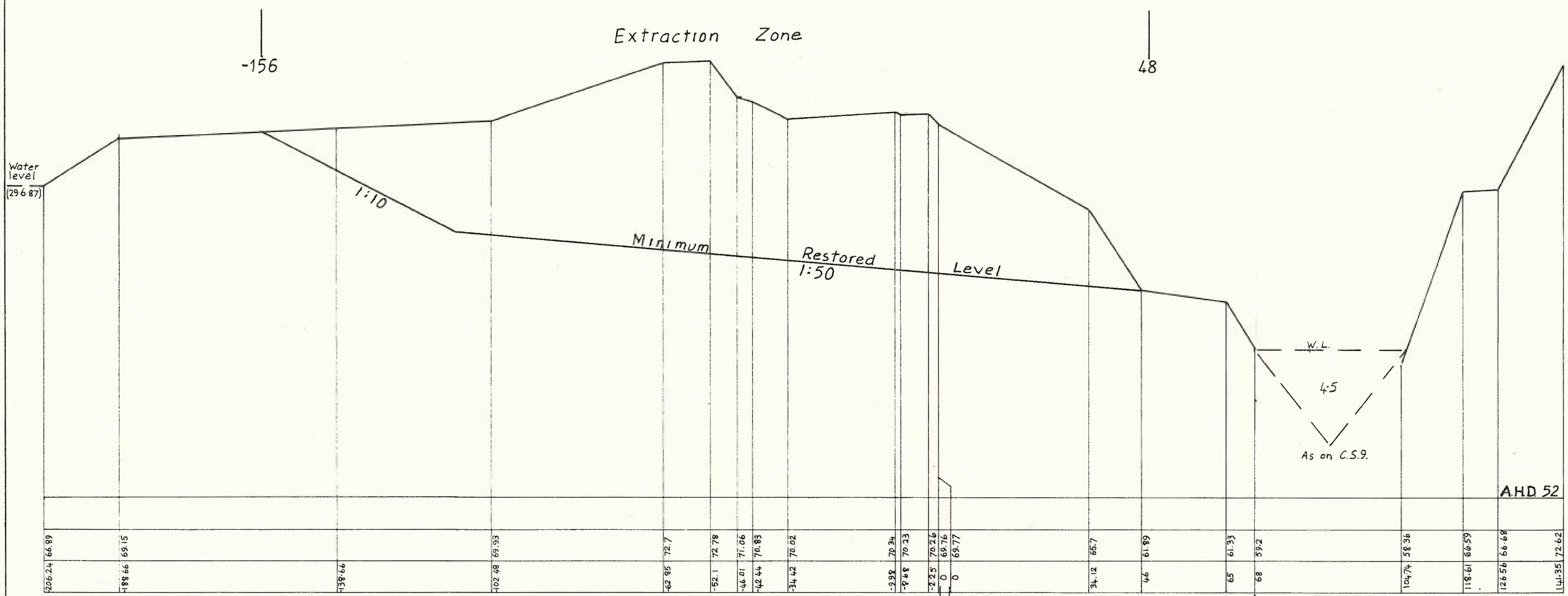
SCALE 1:1000 H / 1 : 200 V



SCALE 1:1000 H / 1:200 V

4d

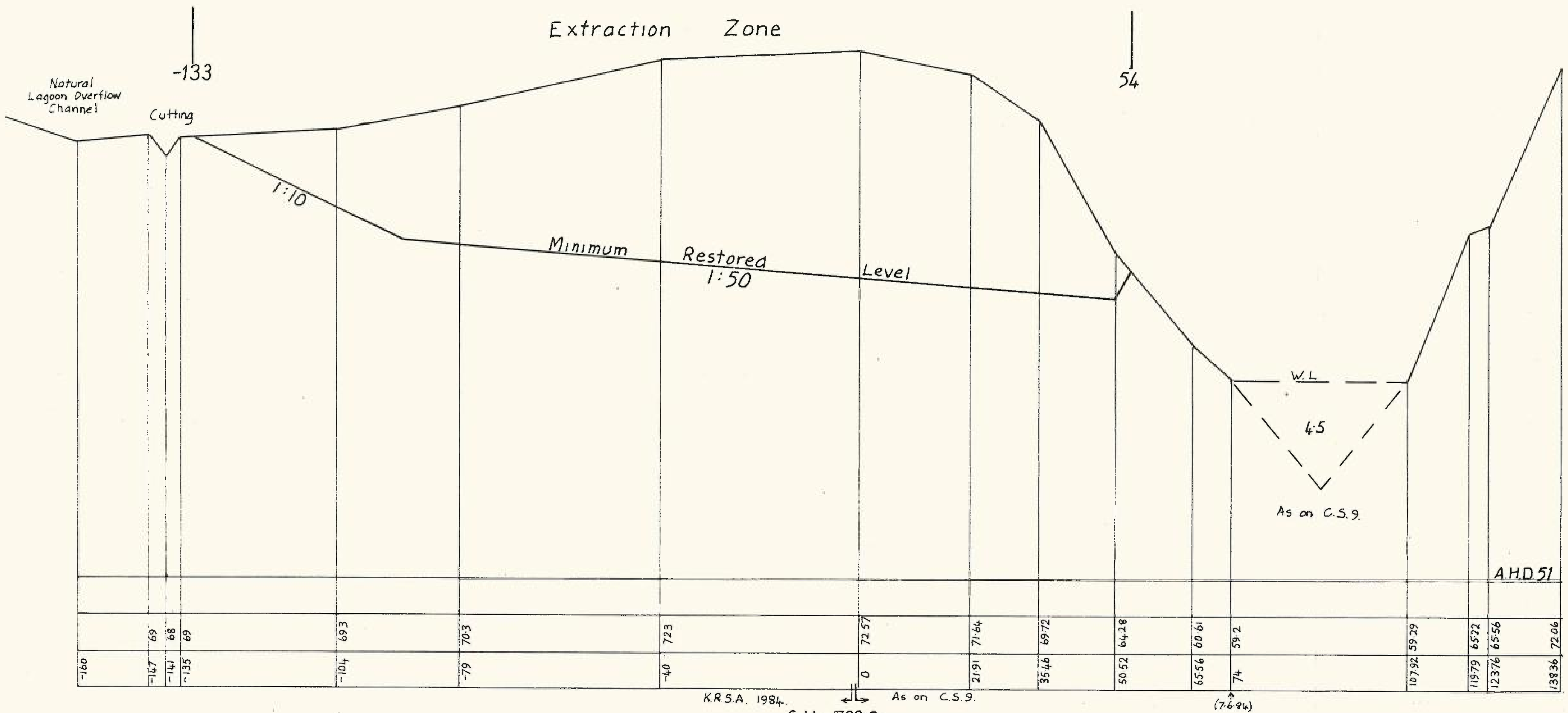

Extraction Zone
-145
38
Water level (29.6.87)
1:10
Minimum Restored Level
1:50
W.L.
4.5
As on C.S.9.
A.H.D. 51
C H. 573.2
C.S. 11.
As on C.S.9.
(7.6.84)
SCALE 1:1000H / 1:200V



C H 653.3

C.S. 13.

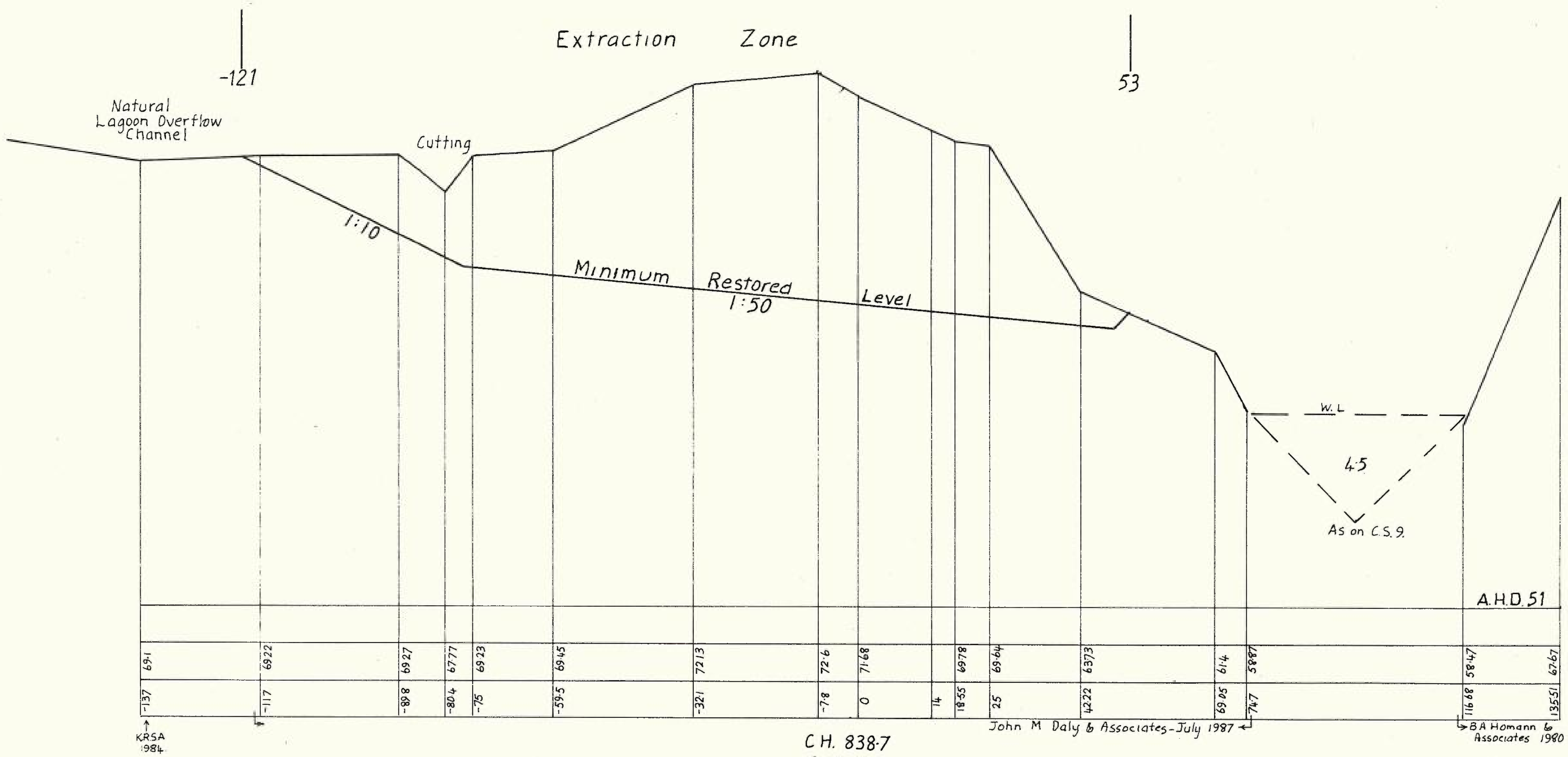
SCALE 1:1000 H / 1:200 V



C.H. 739.3

C.S. 14.

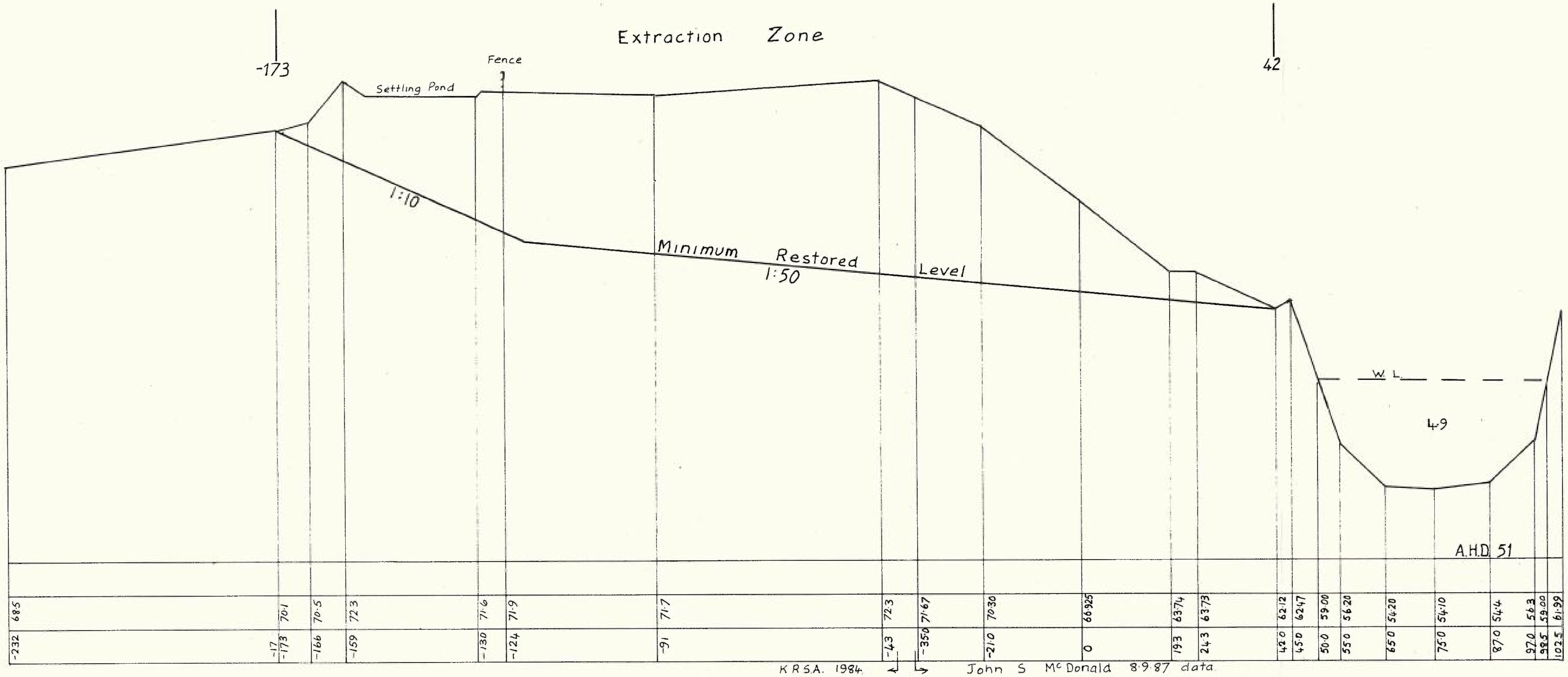
SCALE 1:1000H / 1:200V



CH. 838·7
C.S. 16.

SCALE 1:1000 H / 1:200 V

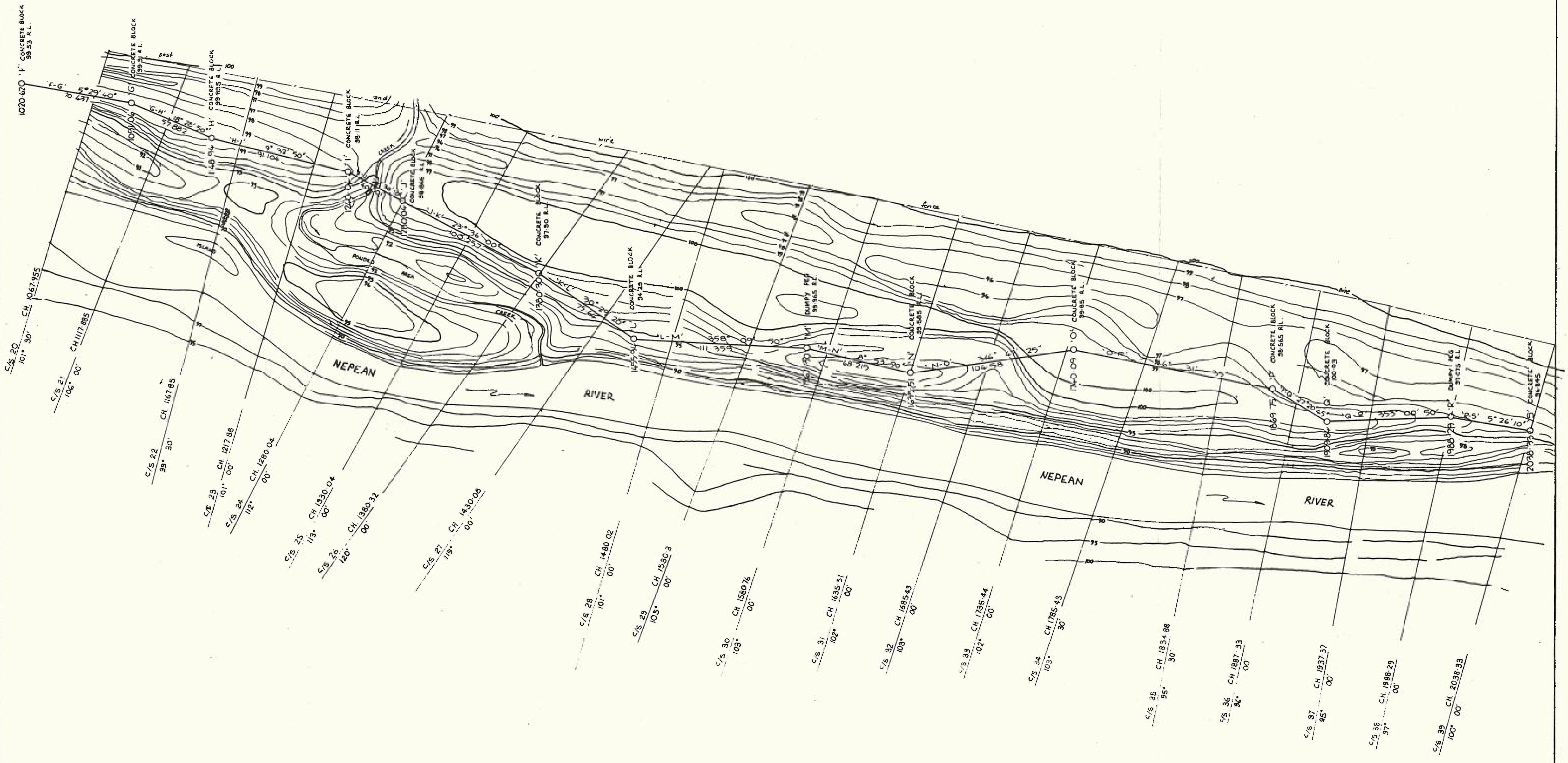
4h



CH. 1017·1

C.S. 19.

SCALE 1:1000 H / 1:200 V



PLAN

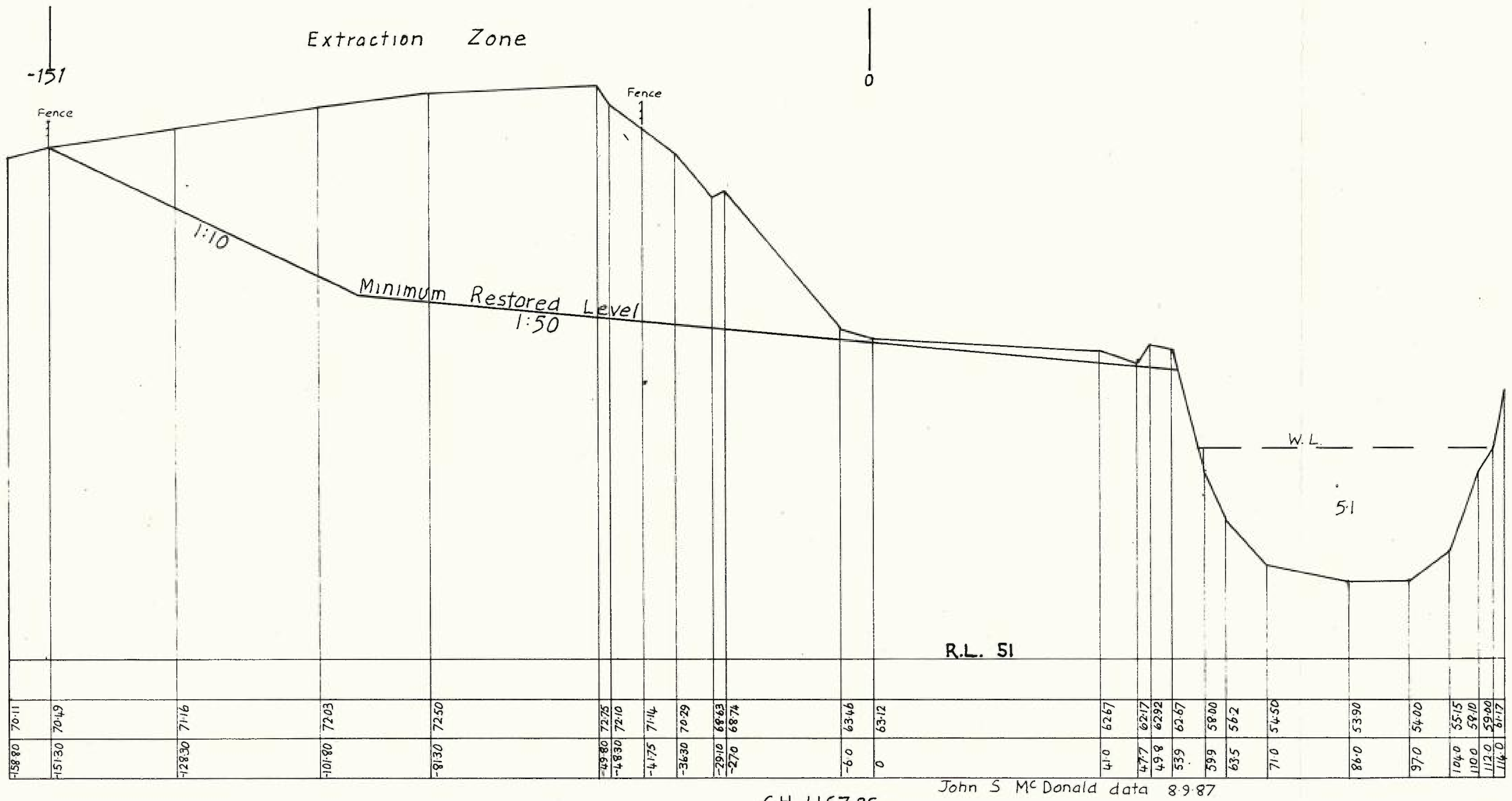
STAGE 3 DEVELOPMENT

MARKED G to S

SCALE RATIO 1:2400

0 100m.

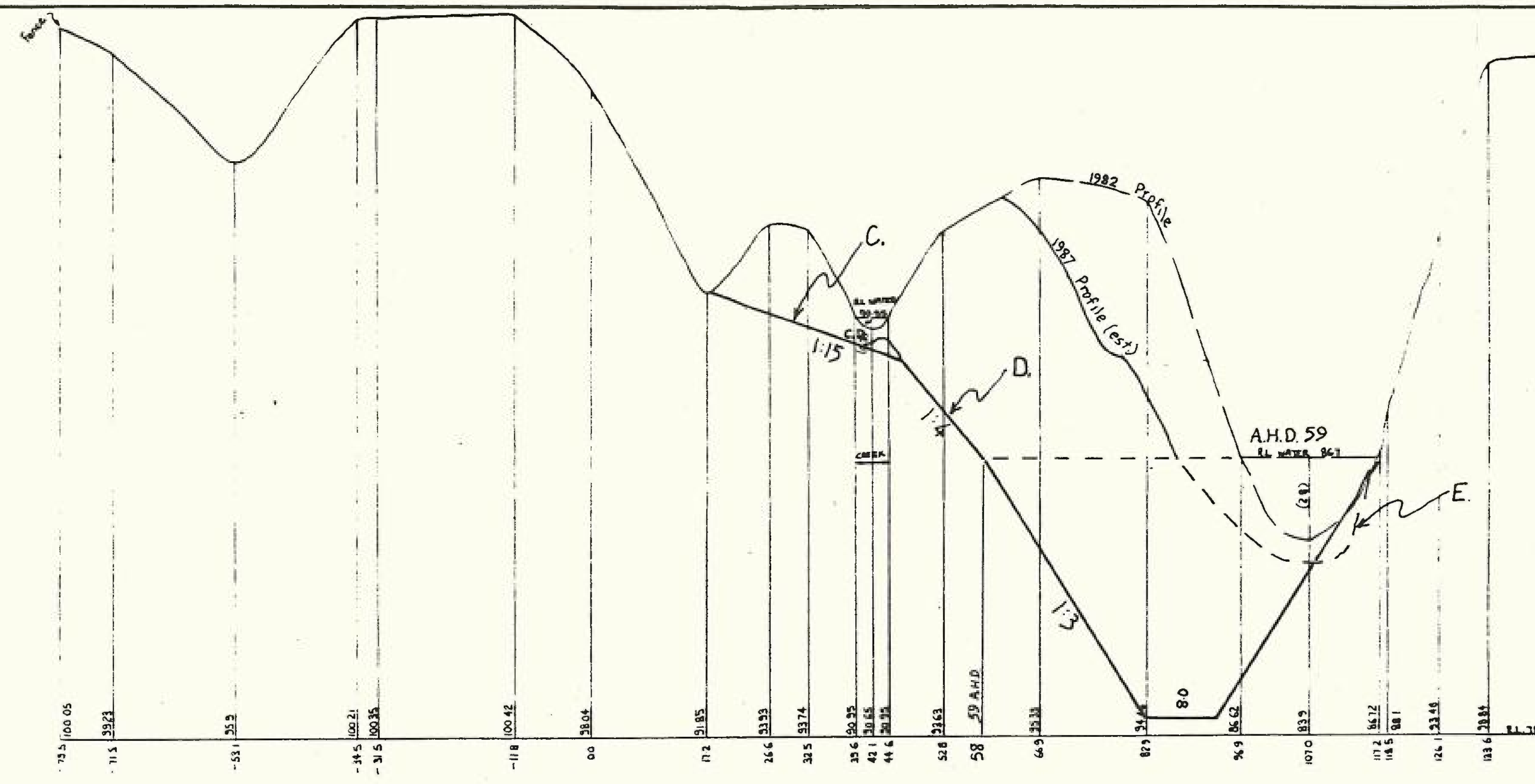
SCALE AS SHOWN	**B. A. HOMANN & ASSOCIATES PTY. LIMITED** CONSULTING SURVEYORS Land, Engineering and Mining 240 George Street, Liverpool 2170 - P.O. Box 183 - DX 5011 - Ph: 602 8551, 602 8700 **5a**
DATUM ASSUMED	
SURVEYED P.G. R.T.	
DESIGNED	
PLAN No. 55-374/710-55	MENANGLE RIVER SAND & SOIL SUPPLIES PTY LTD
	PLAN STAGE 3 DEVELOPMENT
SHEET 1 OF 11 SHEETS	
DATE JULY-AUGUST 1982	SHIRE WOLLONDILLY — AMENDED



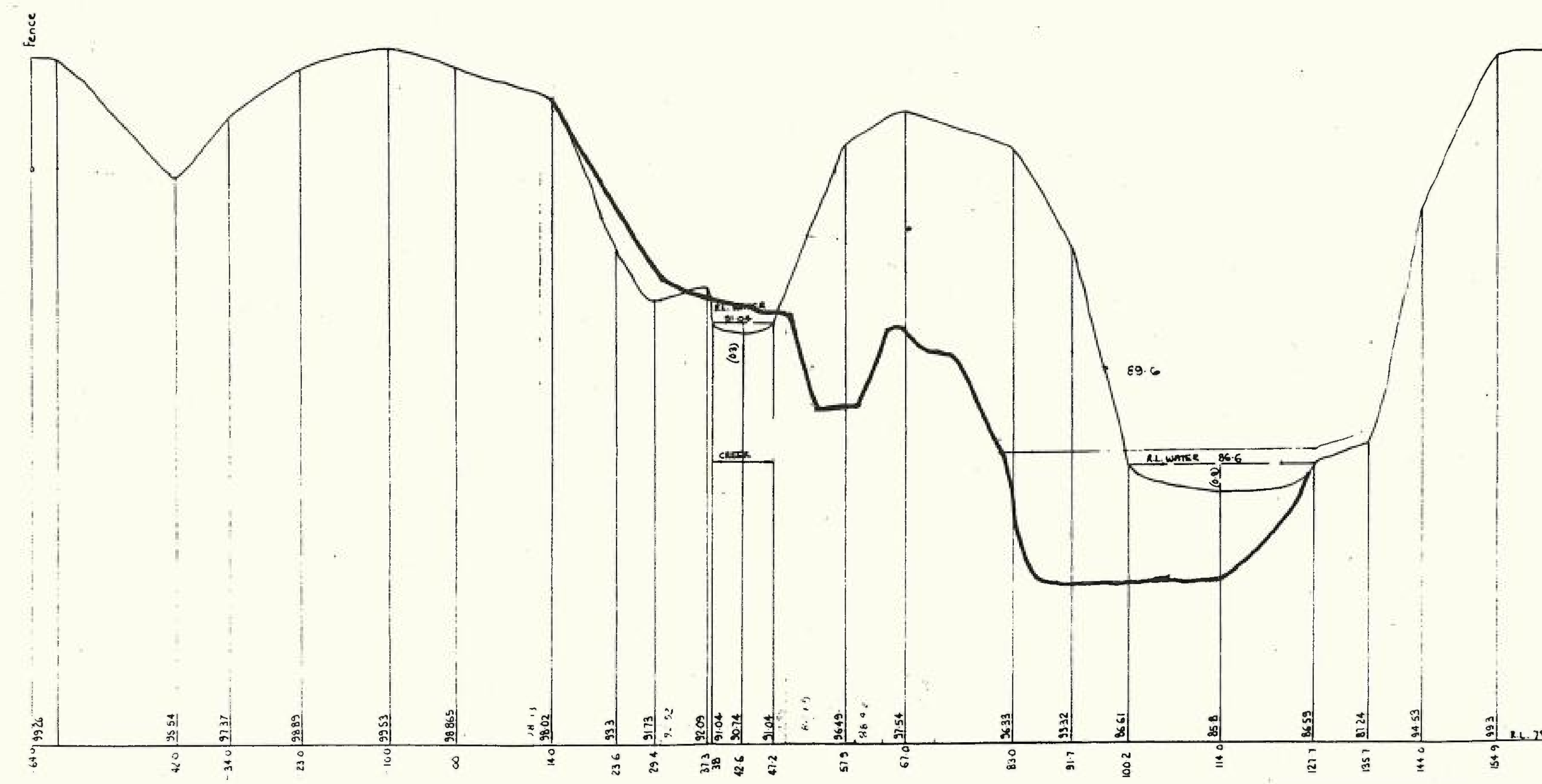
CH. 1167-85
C.S. 22.

SCALE 1:1000H / 1:200V

5b



CROSS-SECTION '25' CH. 1330·04



CROSS-SECTION '24' CH. 1280·04

K. R. STEGGLES & ASSOCIATES PTY. LTD.
(Incorporated in N.S.W.)
CONSULTING GEOLOGISTS — RESOURCE DEVELOPMENT & TRADING
15 GLENVIEW CRESCENT, HUNTERS HILL. N.S.W. 2110.

TITLE: PROPOSED MINING SCHEME - NEPEAN RIVER, MENANGLE.	
CLIENT: MENANGLE SAND & SOIL PTY. LIMITED.	
SCALE: I : 500 Hor. ; 1 : 100 Vert.	**DATE:** 24.9.87.

DATA SUPERIMPOSED ON ORIGINAL CROSS-SECTIONS BY B.A. HOMANN & ASSOCIATES PTY. LIMITED, CONSULTING SURVEYORS OF LIVERPOOL, N.S.W.- DATED JULY/AUGUST 1982.

LEGEND.

A. Initial slope to provide flat area back from 3m high bank as a travel access to dredge and for dredge pipeline.

B. Cut and Fill to final restoration profile when relocating Dredge.

C. Maximum steepness restoration profile with Catch Drain cut along basal zone of 1:5 slope.

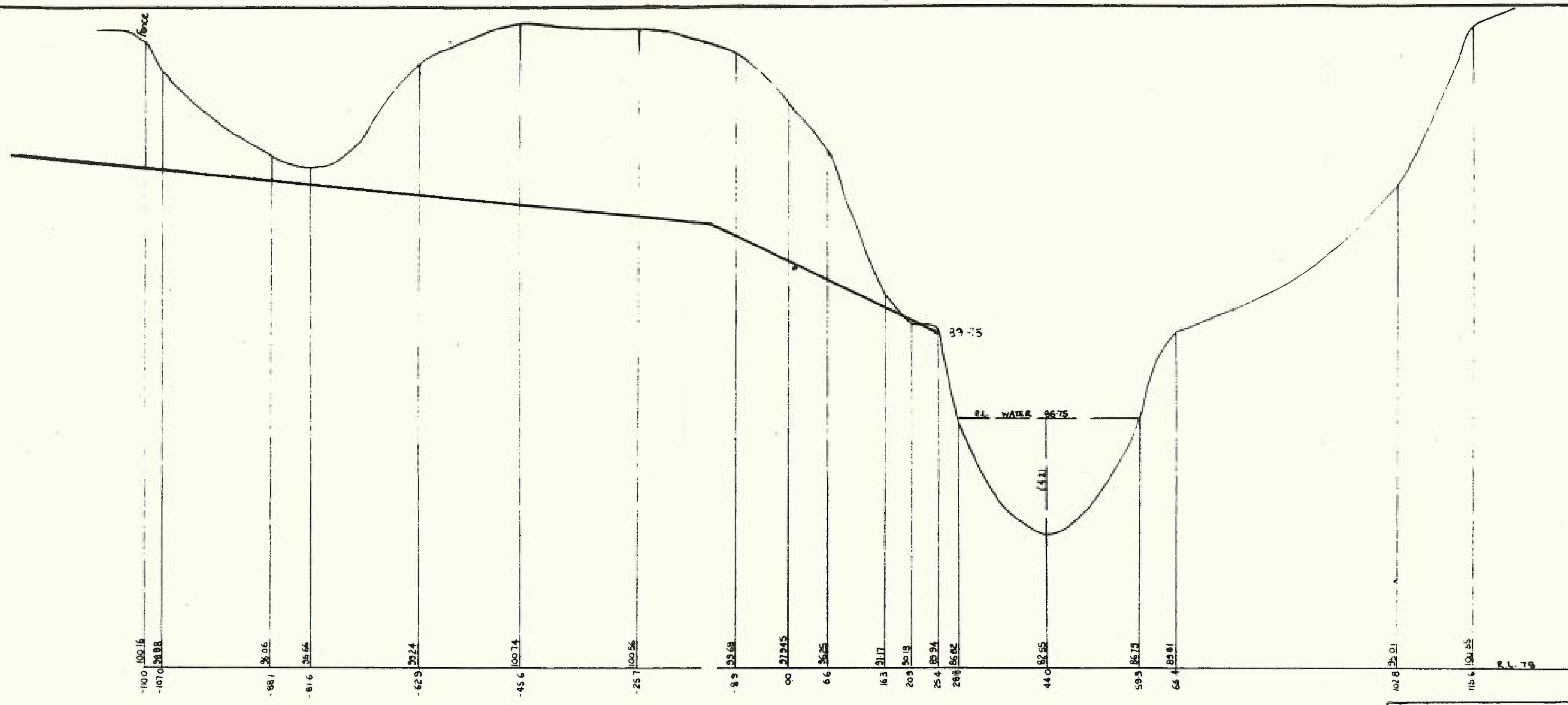
D. This section to be restored to minimum of 3m above water level immediately after Dredge widening of the River.

E. Assessed current underwater profile from extrapolation of April 1987 data supplied by The Department of Planning and Environment New South Wales.

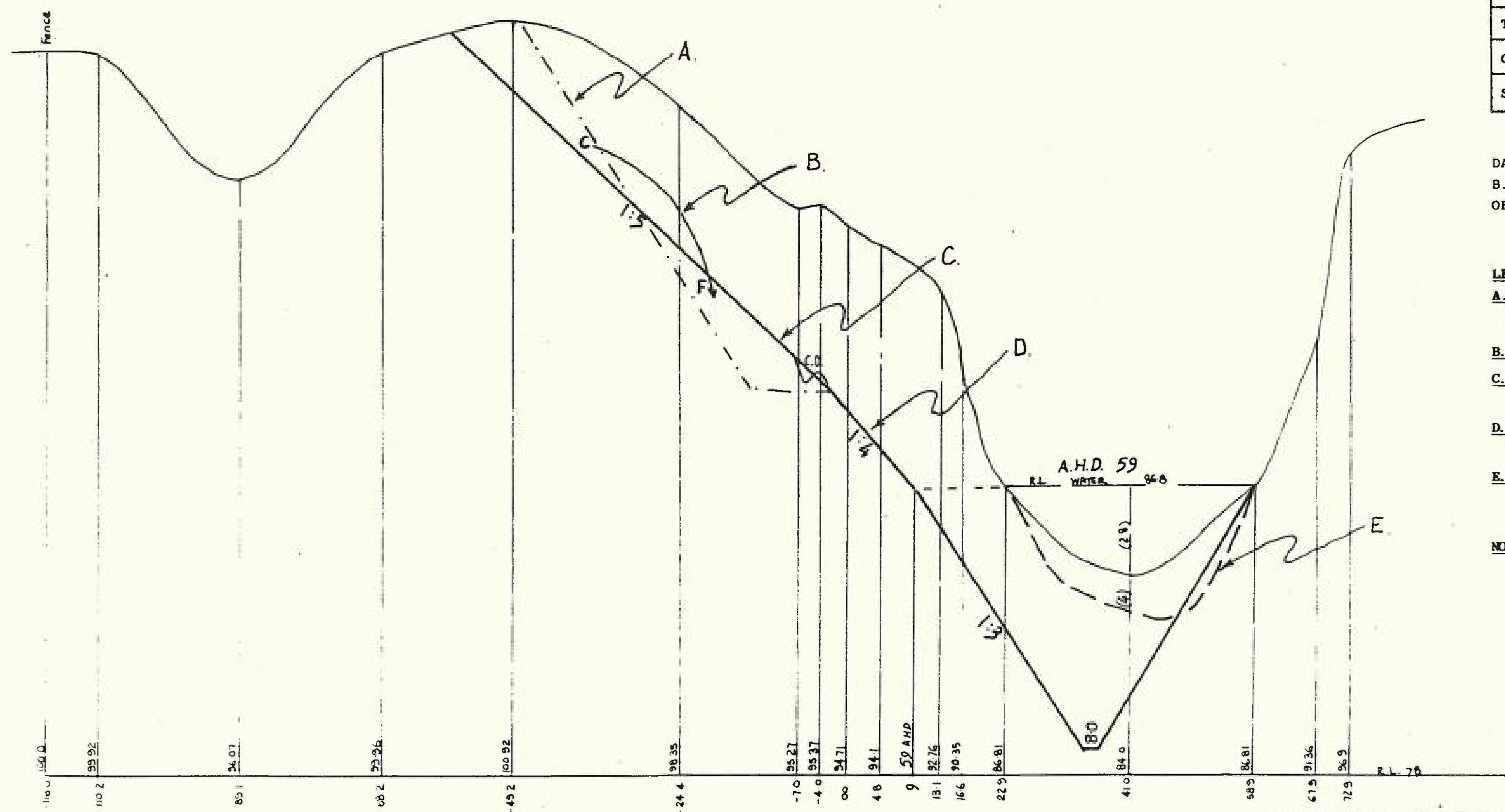
✓ **NOTE.** Cross-section 25 has been partly modified by extraction since 1982 and current profile estimate is shown. No Cut and Fill is involved and blending to existing topography and the Creek discharge causes the 1:15 profile which steepens downstream to 1:5.

SCALE 1:1000H / 1:200V

SCALE HOR. 1:500 VERT 1:100	**B. A. HOMANN & ASSOCIATES PTY. LIMITED** CONSULTING SURVEYORS Land, Engineering and Mining 240 George Street, Liverpool 2170 – P.O. Box 183 – DX 5011 – Ph: 602 8551, 602 8700 **5c**
DATUM ASSUMED	
SURVEYED PG AJ MW	
DESIGNED	
PLAN No 55-374/710/53	MENANGLE RIVER SAND & SOIL PTY. LTD. CROSS-SECTION Nos. 24, 25
SHEET 4 OF 11 SHEETS	
DATE JULY - AUGUST 1982	WOLLONDILLY — AMENDED



CROSS- SECTION '29' CH. 1530·30



CROSS-SECTION '28' CH. 1480·02

K. R. STEGGLES & ASSOCIATES PTY. LTD.
(Incorporated in N.S.W.)
CONSULTING GEOLOGISTS — RESOURCE DEVELOPMENT & TRADING
15 GLENVIEW CRESCENT, HUNTERS HILL. N.S.W. 2110.

TITLE: PROPOSED MINING SCHEME - NEPEAN RIVER, MENANGLE.

CLIENT: MENANGLE SAND & SOIL PTY. LIMITED.

SCALE: 1 : 500 Hor. ; 1 : 100 Vert. DATE: 24.9.87.

DATA SUPERIMPOSED ON ORIGINAL CROSS-SECTIONS BY B.A. HOMANN & ASSOCIATES PTY. LIMITED, CONSULTING SURVEYORS OF LIVERPOOL, N.S.W.- DATED JULY/AUGUST 1982.

LEGEND.

A. Initial slope to provide flat area back from 3m high bank as a travel access to dredge and for dredge pipeline.

B. Cut and Fill to final restoration profile when relocating Dredge.

C. Maximum steepness restoration profile with Catch Drain cut along basal zone of 1:5 slope.

D. This section to be restored to minimum of 3m above water level immediately after Dredge widening of the River.

E. Assessed current underwater profile from extrapolation of April 1987 data supplied by The Department of Planning and Environment New South Wales.

NOTE. Cross-section 25 has been partly modified by extraction since 1982 and current profile estimate is shown. No Cut and Fill is involved and blending to existing topography and the Creek discharge causes the 1:15 profile which steepens downstream to 1:5.

SCALE 1:1000 H / 1:200 V

SCALE	HOR 1:500 VERT 1:100
DATUM	ASSUMED
SURVEYED	F6 RJ MW
DESIGNED	
PLAN No	55-374/710/53
SHEET 6 OF 11 SHEETS	
DATE	JULY - AUGUST 1982

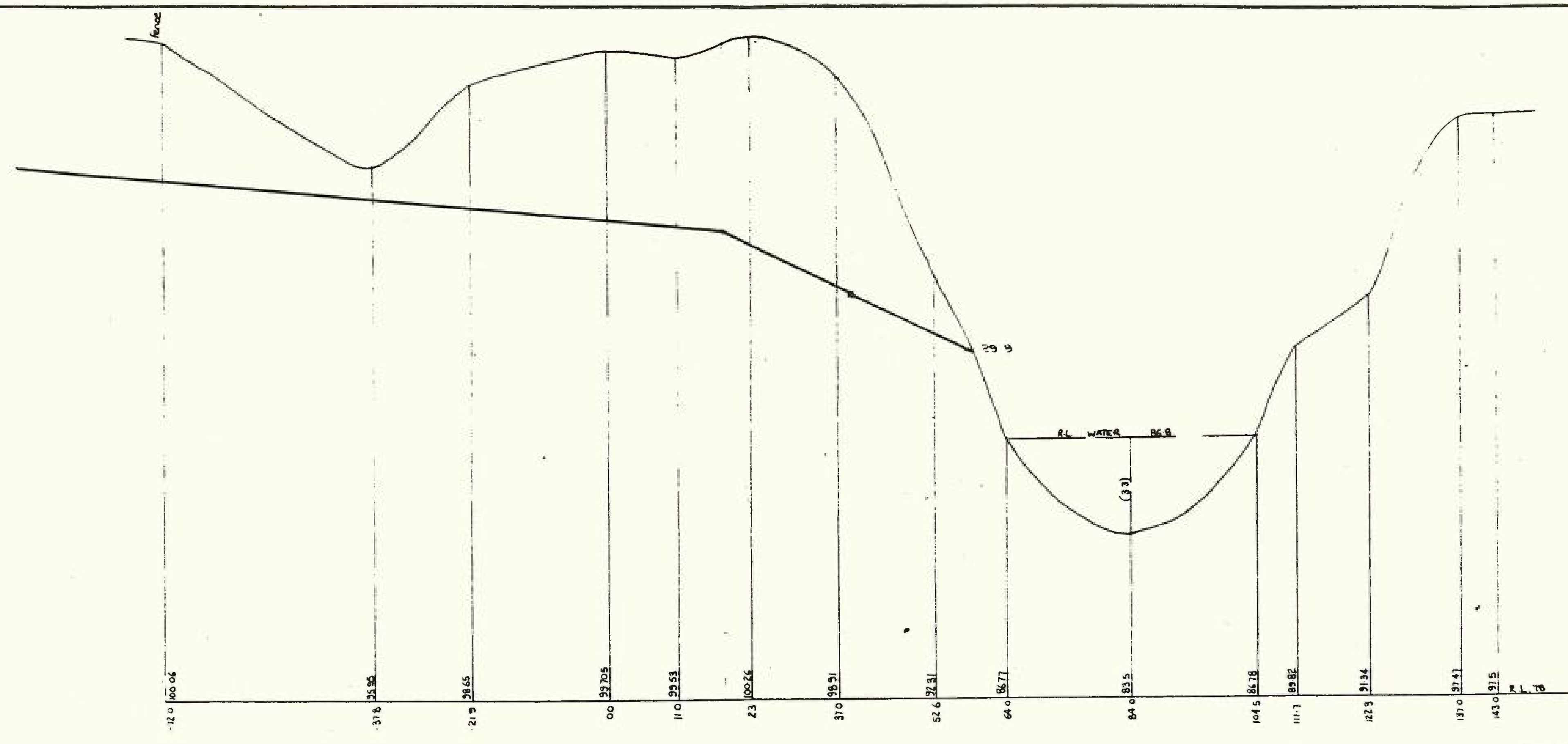
B. A. HOMANN & ASSOCIATES PTY. LIMITED
CONSULTING SURVEYORS
Land, Engineering and Mining
240 George Street, Liverpool 2170 - P.O. Box 183 - DX 5011 - Ph: 602 8551, 602 8700

5d

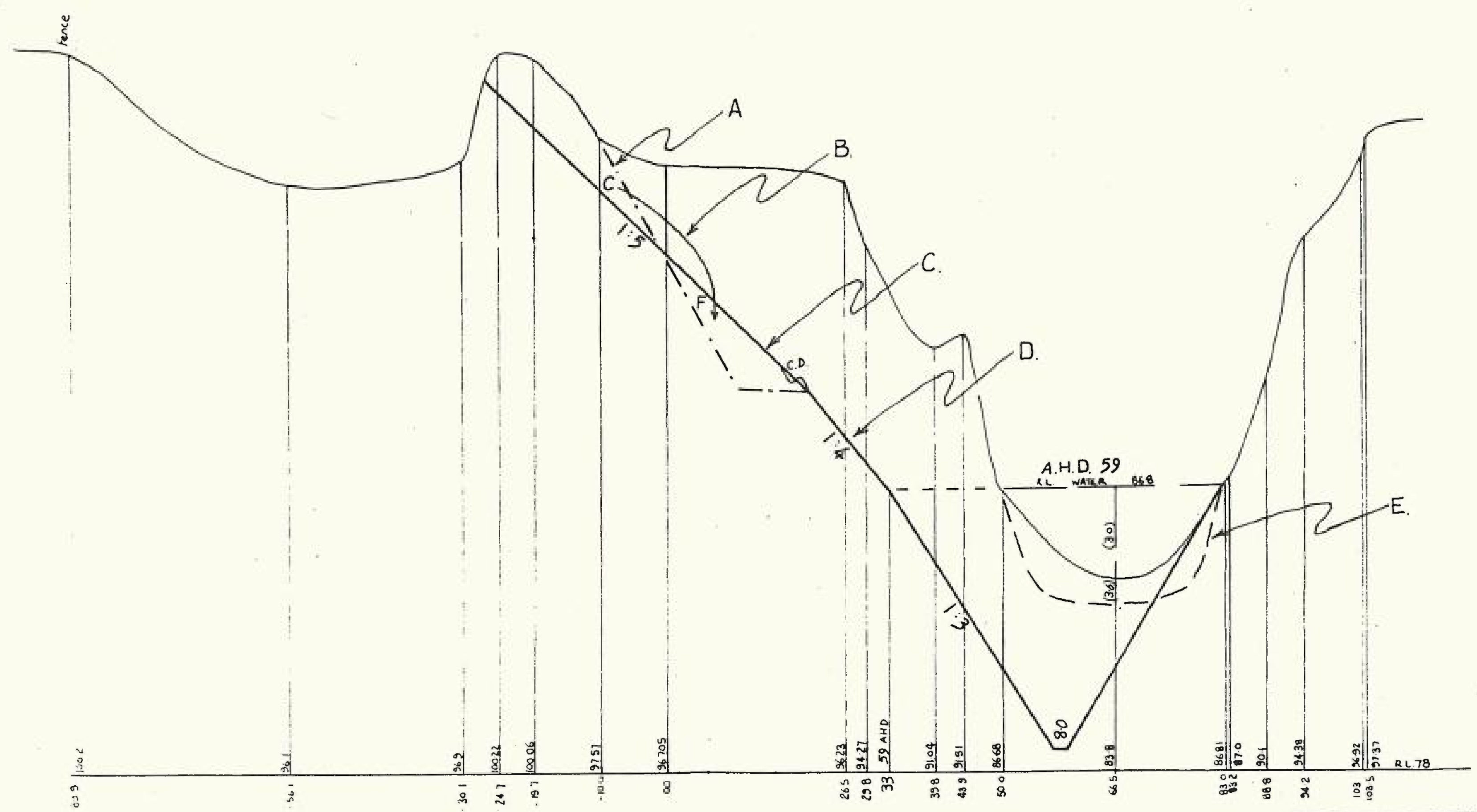
MENANGLE RIVER SAND & SOIL PTY. LTD.
CROSS SECTION Nos. 28, 29.

WOLLONDILLY

AMENDED



CROSS-SECTION '33' CH. 1735·44



CROSS-SECTION '32' CH 1685·49

K. R. STEGGLES & ASSOCIATES PTY. LTD.
(Incorporated in N.S.W.)
CONSULTING GEOLOGISTS — RESOURCE DEVELOPMENT & TRADING
15 GLENVIEW CRESCENT, HUNTERS HILL. N.S.W. 2110.

TITLE: PROPOSED MINING SCHEME - NEPEAN RIVER, MENANGLE.

CLIENT: MENANGLE SAND & SOIL PTY. LIMITED.

SCALE: 1 : 500 Hor. ; 1 : 100 Vert. DATE: 24.9.87.

DATA SUPERIMPOSED ON ORIGINAL CROSS-SECTIONS BY B.A. HOMANN & ASSOCIATES PTY. LIMITED, CONSULTING SURVEYORS OF LIVERPOOL, N.S.W.- DATED JULY/AUGUST 1982.

LEGEND.

A. Initial slope to provide flat area back from 3m high bank as a travel access to dredge and for dredge pipeline.

B. Cut and Fill to final restoration profile when relocating Dredge.

C. Maximum steepness restoration profile with Catch Drain cut along basal zone of 1:5 slope.

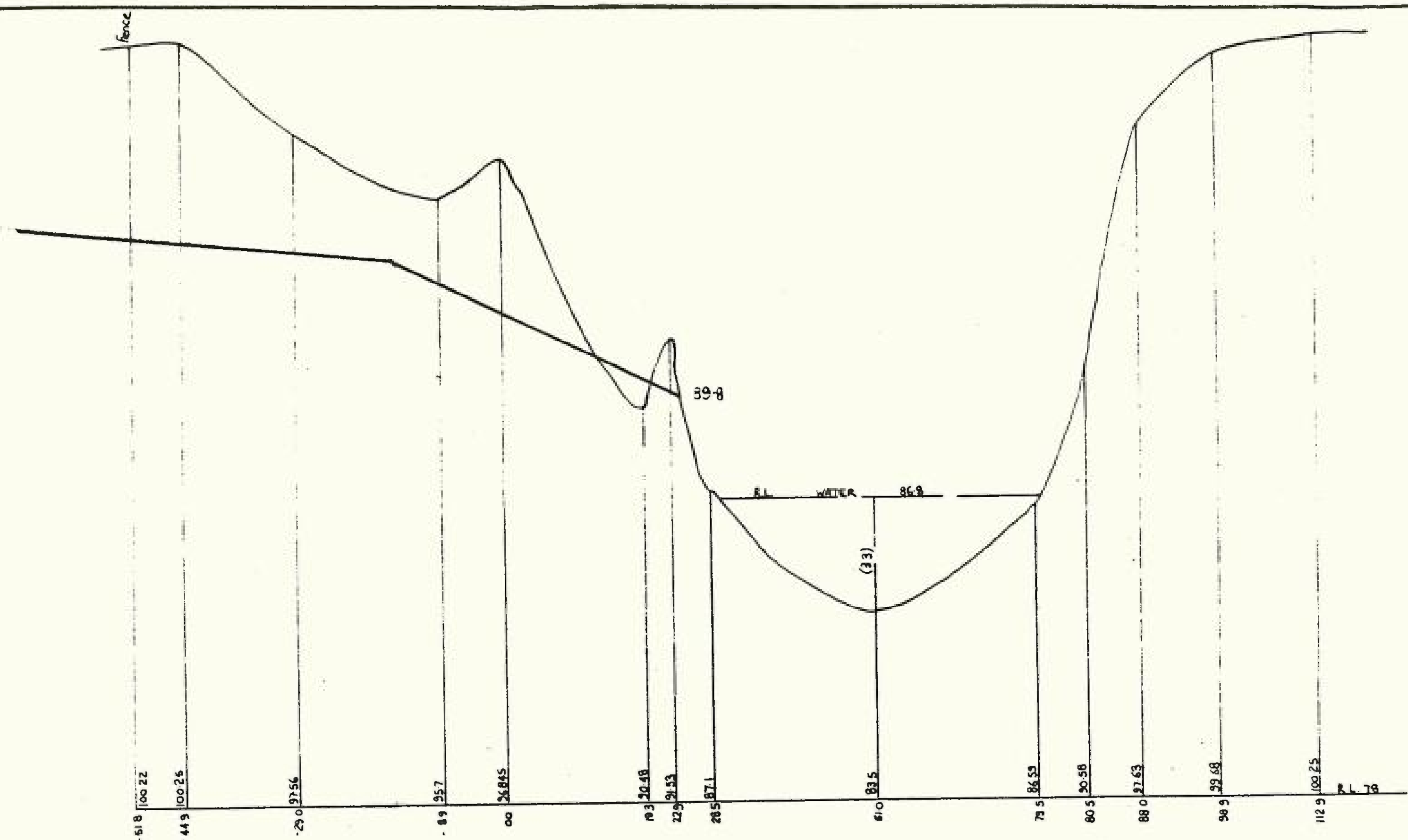
D. This section to be restored to minimum of 3m above water level immediately after Dredge widening of the River.

E. Assessed current underwater profile from extrapolation of April 1987 data supplied by The Department of Planning and Environment New South Wales.

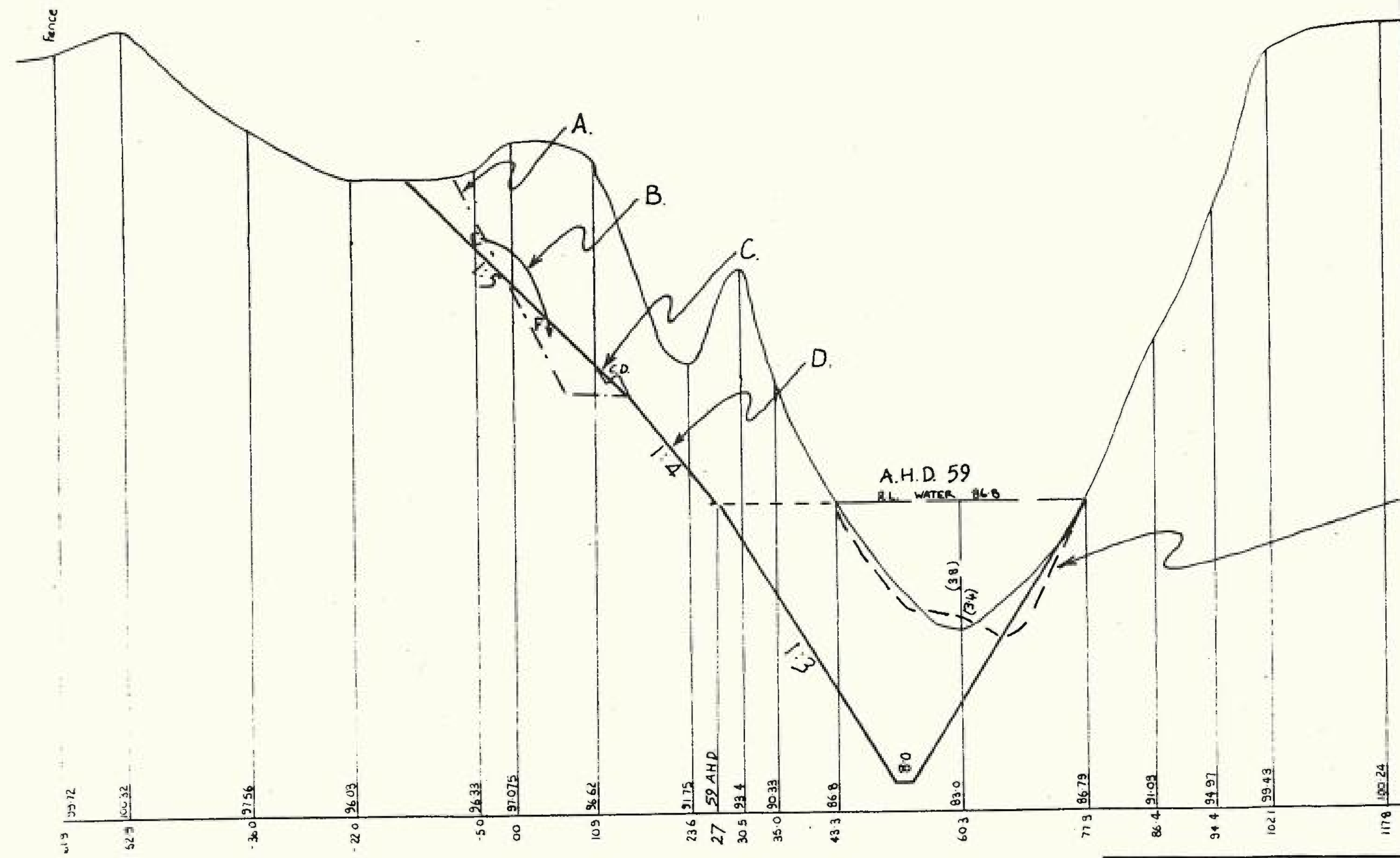
NOTE. Cross-section 25 has been partly modified by extraction since 1982 and current profile estimate is shown. No Cut and Fill is involved and blending to existing topography and the Creek discharge causes the 1:15 profile which steepens downstream to 1:5.

SCALE 1:1000 H / 1:200 V

SCALE HOR. 1:500 VERT. 1:100	**B. A. HOMANN & ASSOCIATES PTY. LIMITED** CONSULTING SURVEYORS Land, Engineering and Mining 240 George Street, Liverpool 2170 – P.O. Box 183 – DX 5011 – Ph: 602 8551, 602 8700 **5e**
DATUM ASSUMED	
SURVEYED PG RJ MW	
DESIGNED	
PLAN No 55-374/710/53	MENANGLE RIVER SAND & SOIL PTY. LTD. CROSS-SECTION Nos. 32, 33.
SHEET 8 OF 11 SHEETS	
DATE JULY- AUGUST 1982	WOLLONDILLY — AMENDED



CROSS-SECTION '39' CH. 2038·33



CROSS-SECTION '38' CH. 1988·29

K. R. STEGGLES & ASSOCIATES PTY. LTD.
(Incorporated in N.S.W.)
CONSULTING GEOLOGISTS — RESOURCE DEVELOPMENT & TRADING
15 GLENVIEW CRESCENT, HUNTERS HILL. N.S.W. 2110.

TITLE: PROPOSED MINING SCHEME - NEPEAN RIVER, MENANGLE.

CLIENT: MENANGLE SAND & SOIL PTY. LIMITED.

SCALE: 1 : 500 Hor. ; 1 : 100 Vert. DATE: 24.9.87.

DATA SUPERIMPOSED ON ORIGINAL CROSS-SECTIONS BY B.A. HOMANN & ASSOCIATES PTY. LIMITED, CONSULTING SURVEYORS OF LIVERPOOL, N.S.W.- DATED JULY/AUGUST 1982.

LEGEND.

A. Initial slope to provide flat area back from 3m high bank as a travel access to dredge and for dredge pipeline.

B. Cut and Fill to final restoration profile when relocating Dredge.

C. Maximum steepness restoration profile with Catch Drain cut along basal zone of 1:5 slope.

D. This section to be restored to minimum of 3m above water level immediately after Dredge widening of the River.

E. Assessed current underwater profile from extrapolation of April 1987 data supplied by The Department of Planning and Environment New South Wales.

NOTE. Cross-section 25 has been partly modified by extraction since 1982 and current profile estimate is shown. No Cut and Fill is involved and blending to existing topography and the Creek discharge causes the 1:15 profile which steepens downstream to 1:5.

SCALE 1:1000 H / 1:200 V

SCALE HOR. 1:500 VERT. 1:100	
DATUM ASSUMED	
SURVEYED PG AT MW	
DESIGNED	
PLAN No 55 - 374 / 710/53	
SHEET 11 OF 11 SHEETS	
DATE JULY - AUGUST 1982	

B. A. HOMANN & ASSOCIATES PTY. LIMITED
CONSULTING SURVEYORS
Land, Engineering and Mining
240 George Street, Liverpool 2170 - P.O. Box 183 - DX 5011 - Ph: 602 8551, 602 8700

5f

MENANGLE RIVER SAND & SOIL PTY. LTD.
CROSS SECTION Nos. 38, 39

WOLLONDILLY

AMENDED

planning workshop

APPENDIX III

Report on Hydrology, Hydraulics, Geomorphology and Sedimentology

CAMPBELLTOWN CITY COUNCIL

→ Princ. Geol. Cent. Coast region.

BE MINDFUL

With the

Town Clerk's Compliments

Proposed Sand/Soil Ext.
Camden Park Estate 87-0016

L87/16

planning workshop urban and regional planners, economists and social planners environmental analysts, statutory and advocate planners

346 Kent Street Sydney N.S.W. PO Box C 183 Clarence St. 2001 DX 10246 Fax 296186 Telephone 29 5288

4527-1-88

3 February 1988 Our Ref:87094/BP/mr

The Town Clerk
Campbelltown City Council
PO Box 57
CAMPBELLTOWN NSW 2560

COPY

LANDS
11 FEB 1988
87-0016
DEPT. OF MINERAL RESOURCES

Attention: Mr B. Knowles

Dear Sir,

Re: MENANGLE SAND AND SOIL PTY LIMITED - PROPOSED SAND AND SOIL EXTRACTION EIS.

Please find enclosed a number of minor corrections to the report of Dr Stephen Riley (Appendix III - EIS) which we regret were omitted from earlier copies of the EIS Appendix report. Could you please forward the attached copies to the relevant government departments.

RECEIVED
MINERAL RESOURCES
16 FEB 1988
GEOLOGICAL SURVEY OF N.S.W.

Yours faithfully,
PLANNING WORKSHOP

Bruce Penman
ASSOCIATE

RECEIVED
11 FEB 1988
Department of Mineral Resources

cc Menangle Sand and Soil Pty Ltd
Mallesons Stephen Jaques
Office of the Commissioners of Inquiry
Department of Environment and Planning
State Pollution Control Commission
Soil Conservation Service
Department of Water Resources
National Trust
Department of Mineral Resources
Joint Councils River Committee
Camden Municipal Council
Water Board
Royal Botanic Gardens Sydney
Camden Branch, ALP
Department of Agriculture
Residents of Caernarvan Close
National Parks Association of NSW

replacement to page 28, paragraph 5

Details of the results of extraction between 1978 and 1987 by Menangle Sand and Soil P/L are given in Table 2.1. The total extraction of sand in this period was 307 415 tonnes and of soil was 1 101 682 tonnes. The period 1981 to 1986 was the most intensive, especially for sand extraction, presumably from dredging operations up to 1983 and thereafter from extraction from the floodplain and upper banks. Total extraction has averaged 196 000 tonnes of material per year (1981-86) which is, as will be demonstrated in Chapter 4, considerably more than the annual average sediment load of the river.

p.40 Table 3.3

add headings to 3rd and 4th column: DATE; GAUGE HEIGHT

p.42, para 3, 1.3: 1945

p.57, last line: the margin

p.95, 1.4: strata

p.101, para 3, 1.1: this deposit in reach 1 is the

p.104, para 5, 1.3: rates

p.104, para 6, 1.7: sediment

p.119, units are :mg/m^3

p.121, units are: mg/m^3

p.136, para 2, 1.7: usually

p.145, para 4, 1.6: groundwater

p.147, para 8, 1.4: machinery

p.150, para 2, 1.8: accumulation

p.152, para 4, 1.3: in the

p.153, para 4, 1.2: landslide-type

p.155, last line: be a long

p.156, para 2, 1.1: significantly

p.157: replace with the following

c) Quarrying of the floodplain materials on the right and left hand bank of the Bergins weir reach of river will have a significant effect on the river by greatly increasing storage during floods. This increased storage will cause a significant decrease in channel slope which will consequently cause a significant decrease in sediment transport capacity.

e) There will be a significant increase in flood frequency for all quarried areas. Some areas will be flooded as frequently as once a year as a result of the quarrying.

Impact on depth and width

f) Channel depth will increase in stages 1 and 2 and depth and width will increase in stages 3 and 4.

Impact on stream velocity

g) Stream velocity will decrease in most sections of the river except near the railway bridge. Velocities will increase on some sections of the floodplain simply because the lowering of the floodplain makes the areas subject to flooding.

Impact on scour potential

h) Scour potential will generally decrease along the river but will increase over the quarried sections of floodplain because of increased depths of flow.

Impact on sediment transport

i) Sediment transport will slightly decrease in stage 7 but will significantly decrease in stages 1,2,3 and 4 by at least 50 percent of the present load.

Impact on bank stability

j) Bank stability will not be effected except in stage 3 and 4 where the left hand bank will be excavated during dredging.

p.162, last line: capacity

p.164, para.3, 1.5: program would enable

pl67, para.4, 1.3: given

p.167, para.7, 1.1: state of

p.167, para.10, 1.4: sedimentary

p.167, para.14, 1.1: contained

p.168, para.2, 1.1: entering

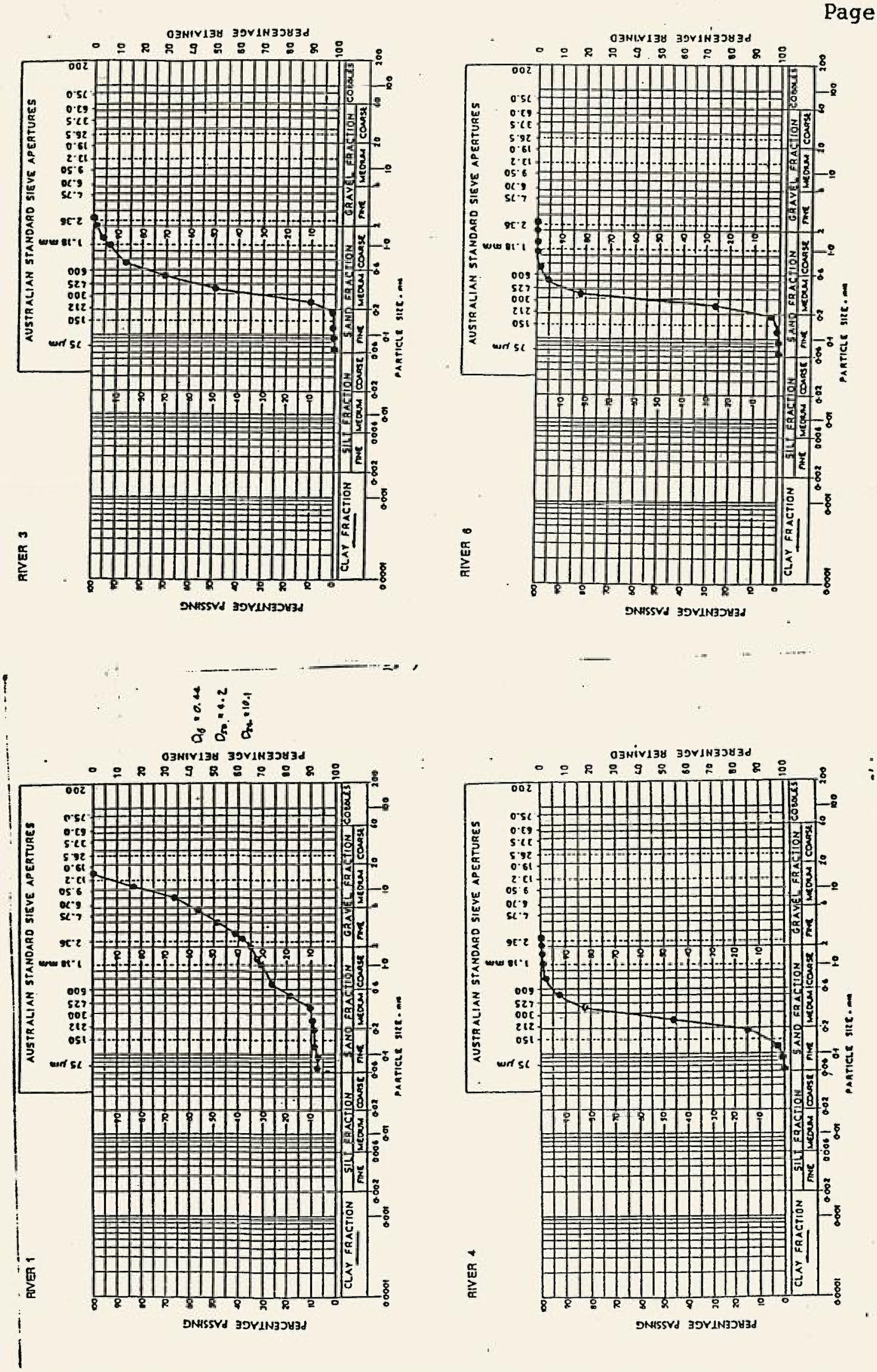


Figure 4.5 textural curves for river bed and bank sediments obtained by grab sampler

REPORT ON

THE HYDROLOGY, HYDRAULICS, GEOMORPHOLOGY AND SEDIMENTOLOGY

OF THE NEPEAN RIVER AND FLOODPLAIN

IN THE VICINITY OF MENANGLE, NSW

AS THEY RELATE TO PROPOSED SAND AND SOIL EXTRACTION

BY MENANGLE SAND AND SOIL P/L

S.J.Riley
School of Earth Sciences
Macquarie University

17 September 1987

CONTENTS

SECTION C

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Under instruction from Menangle Sand and Soil P/L and Planning Workshop, Dr Riley, through Unisearch Limited (Macquarie University Branch), undertook a study of the Nepean River in the vicinity of Menangle. This report details the findings of that study.

1.1 PURPOSE OF THE STUDY

Menangle Sand and Soil P/L are engaged in extraction of sand, loam and soil material from the floodplain and banks of the Nepean River centred around grid reference Wollongong 913225 (1:100 000 topographic sheet 9029; Fig 1.1). The available resources in the areas of present quarrying are rapidly being depleted and the Company seeks to extend its operations to areas in the immediate vicinity.

Menangle Sand and Soil P/L requested information on the likely impact of its proposed operations on the physical aspects of the river system. The specific issues to be addressed were:

- the existing conditions, including water quality and river conditions
- the effect of the extraction on the sediment transport rate in the river
- the likely stability of the bed and bank of the Nepean River during and after completion of the operations
- any possible siltation, sedimentation or downstream effects of the operation
- stability of the weirs
- any likely cumulative effects of the proposed operation when considered together with other operations in the Nepean River
- flooding conditions and impacts
- measures to mitigate likely adverse impacts
- groundwater conditions

Details of the biological impacts are being assessed in other studies.

In order to address these issues the following aspects of the Nepean River and its environment were investigated:

- the characteristics of the present river morphology including a historical analysis of morphological changes in the river and possible causes of these changes

1.1

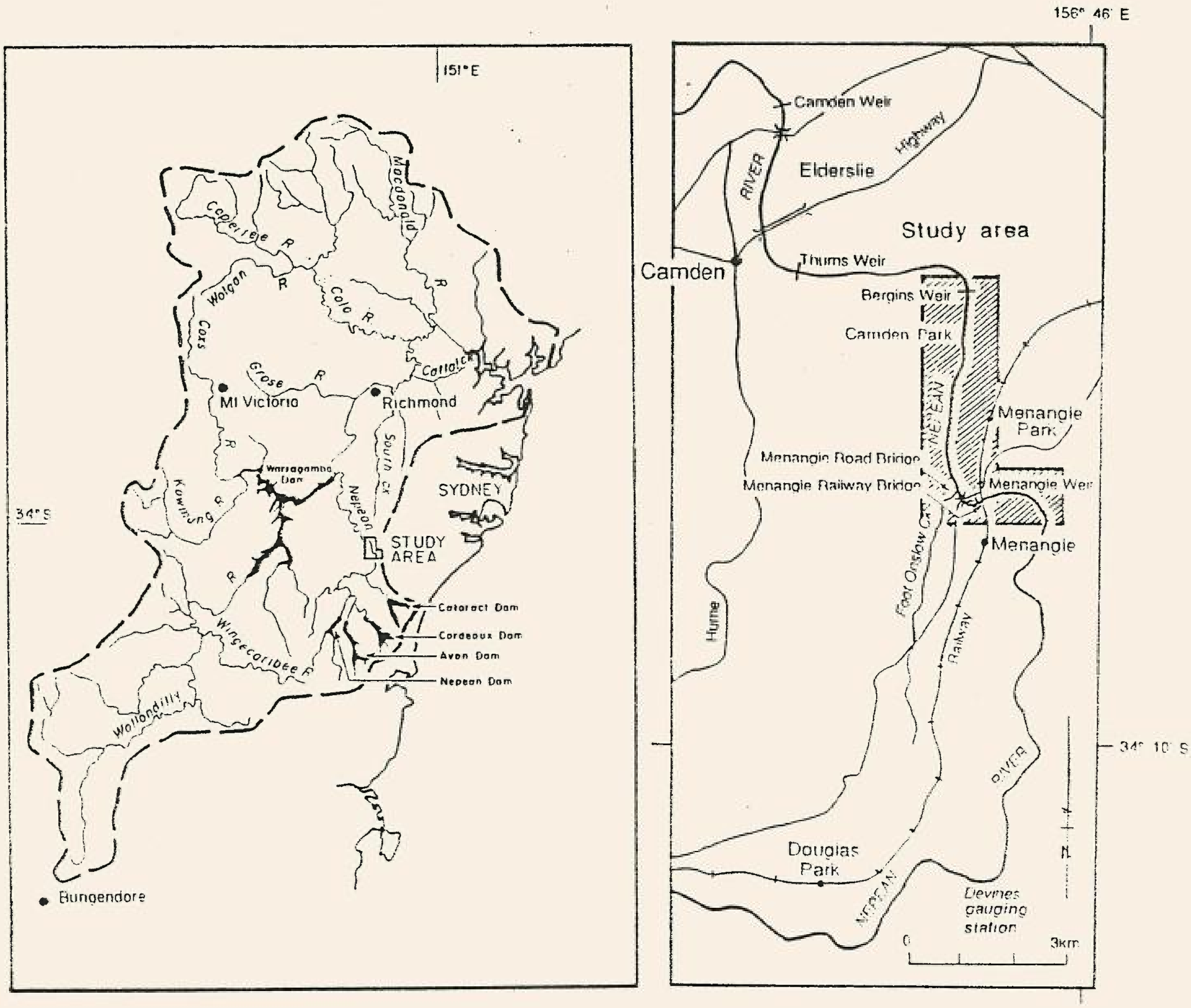


Figure 1.1 Location of Menangle study site, Menangle, NSW, Australia

- the nature of sedimentation within the river including the nature and origin of the river and floodplain sediments and estimates of the sediment load of the river under existing and future conditions

- the water quality characteristics of the river and evidence of the effect of past quarrying activities on water quality and the effect of proposed future quarrying

- the stability of Bergins and Menangle weirs in the present and in the future

- the hydraulics of low and overbank (flooding) flows, including velocities and depths of flow, power distribution and the likely impact of quarrying on flows

- the nature of flooding within the river; the magnitude and frequency of flooding, the duration of low and high flows and the likely impact of quarrying on the hydrology of the river, including groundwater

- the stability of the bed and banks in the past, at the present and in the future with the proposed extraction

This report details the likely physical impact of the proposed quarrying and makes recommendations concerning the ways in which deleterious impacts can be minimised. This report also makes recommendations concerning the monitoring of the river in association with future extraction.

This report does not address either the aspects of the extraction proposals that concern impact on the various biological systems in, and adjacent to, the river, or the economic value of the deposit or the socio-economic implications of its extraction.

1.2 OUTLINE OF THE REPORT

The report is divided into three sections. Section A is a review of the present physical condition of the river, and incorporates Chapters 2,3,4 and 5. Section B examines the impact of the extraction proposals at various points along the river and incorporates Chapters 6 and 7. Section C makes recommendations concerning procedures that should be used to reduce the impact of recommended extraction proposals, in Chapter 8. Chapter 9 incorporates recommendations concerning future monitoring of the river.

Chapter 2 defines the area of interest and sets it within the geographic and physical environmental context and describes the general characteristics of the geology, hydrology, topography, climatology and soils of the area. The history of mining in the area is also presented.

Chapter 3 describes the hydrology and hydraulics of the present river system, the nature and level of flooding and flood frequency.

Chapter 4 describes the geomorphology and sedimentology of the river and floodplain of the present river system, defining the nature and extent of the available mineral resource. A model for the formation of the resource and its context within the Quaternary history of the Nepean river system is proposed. Estimates of long term and present day sediment load rates are presented.

Chapter 5 examines the historical water quality data and assseses the changes in water quality in terms of past mining activity and the hydrology and hydraulics of the river.

Chapter 6 reviews the impact of dredging in the Nepean river and quarrying on the floodplain and identifies the issues as they relate to the physical impact of the operation.

Chapter 7 presents the extraction proposal and evaluates it in terms of the hydrology, sedimentology, water quality, morphology and hydraulics of the river at the site and downstream.

Chapter 8 makes recommendations concerning procedures that may be adopted to reduce the impact of the mining operation on the environment.

Chapter 9 presents the conclusions of this study together with a program of monitoring aimed at extending the information base on the Nepean River and providing a solid basis for assessing the impact of this operation with a view to being able to more fully assess the impact of future proposals.

1.3 ACKNOWLEDGMENTS

This work was undertaken by several persons acting under the direction of Dr Riley. Principal persons involved in the project were:

Mr G.Luscombe
Mr R.Thwaites
Mr D.Gore

A number of organisations and their personnel contributed data to the project. In particular, we would like to thank the following:

Bureau of Meteorology
Camden Shire Council
Department Environment and Planning
Department of Lands
Department of Main Roads
Department of Water Resources
Soil Conservation Service NSW
State Emergency Services
State Rail Authority
Sydney Water Board

1.4 MAJOR FINDINGS OF THE REPORT

A: Present conditions

Sediment

1. The Nepean River appears to be in condition of sediment transport deficit (ie. carrying less than its sediment capacity). This condition is best seen in the rivers' active incision of its bed (degrading) as it compensates for the lack of sediment. This deficit appears to be a feature of the last 30 to 40 years. Prior to that the river was in a sediment transport excess (aggrading) phase.

2. The maximum estimate of annual average sediment load of the river is approximately 60 000 tonnes.

3. The sediment deposit at the site was probably the result of a single or several 'catastrophic' events. This deposit may be part of an episodic pattern of scour and deposition and not a unique event.

4. Until recently the river was in an active phase of aggradation, with major aggradation on in-channel benches.

Groundwater

5. There appear to be no significant groundwater conditions that would inhibit extraction operations.

6. The major lagoons, and in particular Barragal Lagoon, appear to be fed by surface runoff rather than by groundwater.

Water quality

7. Existing water quality in the Nepean River at Menangle is generally good.

Weir stability

8. Weir stability has not been affected by past extraction operations on the river upstream of Bergins weir or Menangle weir. Recent problems appear to be related to the age of the structures and to the general degradation of the river.

Bank stability

9. Banks are unstable in the vicinity of Bergins weir but not in the reaches of channel further upstream and there is no evidence that banks have been made unstable by quarrying and dredging.

Hydrology

10. The floodplain is inundated at least once every 2.5 years and the depth of flooding of the 20 year flood is of the order of 1 metre over the floodplain with flow velocities of the order of 0.3m/sec.

11. The depth of flow in the channel during a 20 year flood is of the order of 17 metres with flow velocities of the order of 1m/sec. These depths and flow velocities vary along the channel, being highest in the reach upstream of the Railway bridge.

B: Effect of extraction

12. The proposed extraction will have a minor effect on flow dynamics within the River at Menangle in stages 2,3 6 and 7. Velocities will decrease, flood levels will decrease slightly, depths of flow over the floodplain will increase by 3 to 6 metres because of its excavation.

13. Extraction of materials from the floodplain on the right hand bank along the Bergins weir reach and in stage 7 will increase the frequency of inundation from once every 2.5 years to at least once every year.

14. Extraction of sediment from the river bed and floodplain will interrupt the flow of sediment through the river but the exact quantity of material that will 'drop out' of the load is not predictable. It could be a large proportion, of the order of 50 percent of total load.

15. The loss of sediment to the downstream sediment load may cause an increase in sediment deficit downstream.

16. Bed stability and bank stability is unlikely to be affected in the proposed area of extraction or downstream to Bergins weir primarily because banks in the areas of quarrying will be substantially lowered. Meandering will not be initiated by the dredging.

17. The proposed extraction may have a significant effect on the downstream quarrying and dredging operations by reducing the sediment load of the river; however problems downstream are more related to major changes in the dynamics of the river that are largely independent of mining at Menangle.

18. The Menangle and Bergins weirs are stable, although Bergins weir shows some evidence of bank collapse on the left side and scour downstream. The dredging and quarrying are unlikely to affect the weirs.

19. Water quality will be affected to only a minor extent and the effect is unlikely to be seen below Bergins weir. Salinity is not an issue.

20. Problems of water quality and stability of channel morphology downstream of Bergins weir to Broken Bay are related to factors that are largely independent of the quarrying and dredging operation at Menangle. The proposed operation may contribute further to problems of channel stability by reducing the flow of sediment downstream, but the exact nature and degree of the change introduced by the proposed operation cannot be predicted.

C: Amelioration of impacts

21. Standard Soil Conservation Service of NSW procedures should reduce the erosion of sediment from exposed surfaces during local rainstorms. Erosion control structures such as settling basins, graded banks and sediment traps along drainage lines should be used as soon as areas are quarried and until revegetation has established good ground cover.

22. A management plan for extraction and rehabilitation should aim to minimise exposure of excavated areas which will then minimise sediment losses.

23. Restricting dredging to low flow conditions (less than 5 cumecs) will reduce turbidity and water quality problems downstream. This will limit dredging operations for less than 10 percent of the time.

24. Wherever possible bank vegetation should be left intact or established as soon as dredging is completed. Similarly, quarried areas should be re-vegetated as soon as possible.

25. Provision should be made to firmly anchor the dredge during floods

26. Every effort should be made to store equipment and locate fixed structures, such as workshops, above the 20 year flood level.

27. Stockpiles of material should either be kept to a minimum or be stored on the highest areas within the extraction site.

28. Settling ponds should be located as far away from the river as is possible.

29. Detailed monitoring should be carried out to assess the exact nature of changes in the river as a result of the quarrying and dredging and be of such a standard that changes resulting from causes other than the proposed operation can be assessed.

==

SECTION A: PRESENT PHYSICAL CONDITION OF THE NEPEAN RIVER

==

CHAPTER 2

PHYSICAL GEOGRAPHY OF THE MENANGLE EXTRACTION SITE

2.1 INTRODUCTION

River basins are integrated systems where the processes that are involved in the movement of water and sediment and the development of landforms in one section will interact with the processes influencing the movement of water and sediment and landform development in another section (Chorley, 1969).

The time to completion for these interactions varies depending on the nature of the interactions, the spatial characteristics of the changes that are taking place within the basin, and the magnitude of the changes. These interactions can be relatively rapid, eg. excess rainfall on the catchment slopes will result in runoff into creek and river systems in a matter of minutes to hours. Conversely, the interactions can be relatively slow: such as the changes in valley slope geometry that result from changes in channel sediment transport capacity and runoff regime which may take several tens of thousands of years to work themselves out in the drainage basin system. In many cases the response times for the river are of the order of tens to hundreds of years. Included within this time frame is the response of channel geometry to alteration of sediment load and discharge (Richards 1982, p.252ff).

The response of a drainage basin to imposed changes is complicated by the fact that drainage basins and the rivers within them seldom reach an 'equilibrium' state in which there is stability of channel and valley morphology in terms of the hydro-meteorological regime. Consequently it is difficult to separate the changes that are taking place in a river system as a result of geomorphic processes and human interaction and those changes resulting from events (human and natural) that took place tens and even thousands of years previously (Thornes, 1977).

It is unwise to assume that river systems in Eastern Australia are in equilibrium with the prevailing environmental conditions. Furthermore it is important that aspects of these non-equilibrium conditions be examined in order to assess the impact of the proposed extraction. This problem of river equilibrium will be reviewed in Chapter 3.

It should be realised from the preceding discussion that a simple evaluation of a river system in terms of prevailing environmental conditions is likely to give an erroneous impression. It is important that the history of the river and its catchment be understood if future changes and the impact of future actions are to be assessed.

This chapter reviews the environmental conditions of the drainage basin. Environmental problems pertinent to an assessment of the proposed sand, soil and loam extraction from the bed, banks and floodplain of the Nepean River in the vicinity of Menangle are defined.

Section 2.2 reviews the general physiography of the river basin. Section 2.3 outlines the major characteristics of the climatology and hydrology of the basin. The soils and geology of the area are reviewed in section 2.4. Aspects of human settlement as they relate to the Nepean River in the Menangle area are discussed in section 2.5.

2.2 PHYSIOGRAPHY OF THE UPPER NEPEAN RIVER CATCHMENT

The Upper Nepean River catchment is defined in this report as the area upstream of the junction of the Nepean and Warragamba Rivers (Fig 2.1). There are several distinct physiographic regions in the catchment (Taylor, 1970). Near the junction of the Nepean and Warragamba Rivers in the Blue Mountains region the rivers are deeply incised into sandstone, the topography is of high relief and valleys are canyon-like. The river bed is steep and is typically scoured down into sandstone. Upstream of Wallacia the Nepean River flows across the Cumberland Basin, and is dominated by the low relief and rounded hills in Wianamatta Group shales. The floodplains are wide (0.5-2 km) and the river bed is commonly alluvial. In the vicinity of Menangle, approximatly 3 km upstream from the Menangle Road bridge, the Nepean River enters the Nepean Ramp where the rivers are increasingly incised upstream. Incision is not as great as in the Blue Mountains region of the lower catchment. Again the river bed is commonly scoured to sandstone; there are few alluvial deposits on the bed, although the banks are often alluvial. The floodplain is narrow, of the order of tens of metres. Near the Illawarra escarpment the valleys tend to widen out and the low order tributary streams often have extensive low gradient swampy sections where the distinction between valley floor and hillslope is obscure.

2.3 CLIMATOLOGY AND HYDROLOGY OF THE UPPER NEPEAN CATCHMENT

The major rivers of the Upper Nepean River catchment are the Nepean, the Cataract, the Cordeaux and the Avon. These rivers have their headwaters along the sandstone Illawarra escarpment, in most cases up to the very edge of that escarpment. The rivers appear to be structurally controlled in their headwater areas, flowing in the direction of the dip slope and aligned with major joint patterns. In the lower regions, beyond the sandstone gorges and on the Wianamatta Group shale plains the geological control on drainage pattern is less certain, although there is probably some conformity to major structural units.

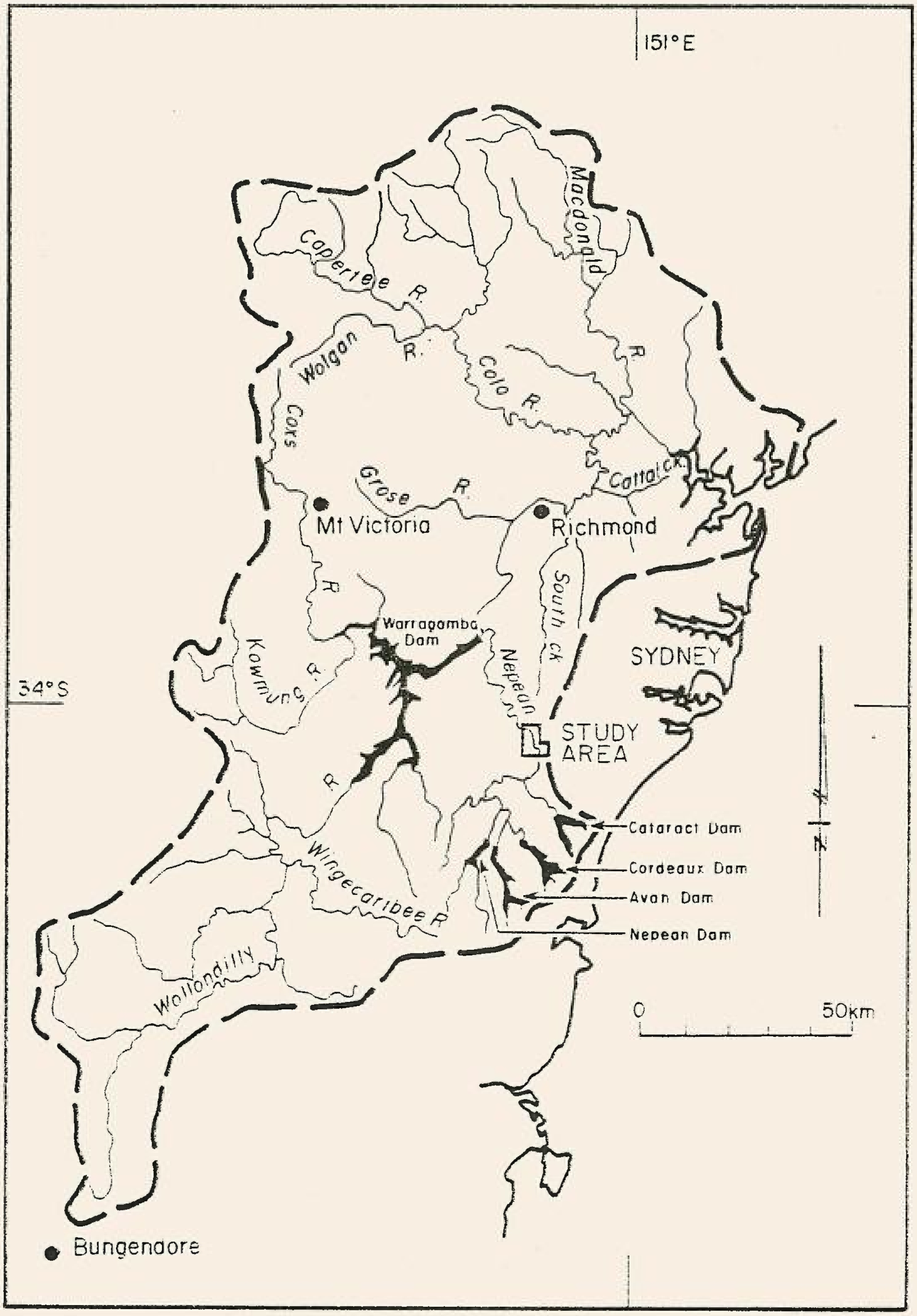


Figure 2.1 The Hawkesbury-Nepean catchment, showing the location of major dams and rivers.

The rivers have highly variable flow characteristics and all have records of long periods of zero flow (Water Conservation and Irrigation Commission, 1973). The river baseflow is largely determined by seepage of rainwater through the porous sandstone aquifers and is rapid. Hence, long dry periods result in zero baseflow.

2.3.1 Rainfall

The annual median rainfall in the Upper Nepean Catchment increases towards the south, with the Illawarra escarpment area receiving the highest annual rainfall (Fig 2.2). There is also a marked decline in annual rainfall towards the west. For Menangle the average annual rainfall is 724mm (Bureau of Meteorology; Menangle site: 1966 to 1985) and for the 22 year period of record the maximum annual rainfall is 1191 mm and the minimum annual rainfall is 360 mm (Fig 2.3). On average there are 92 raindays per year.

Local runoff from small catchments and areas less than 1ha would probably be produced on those days with more than 20mm rainfall. This figure would vary with antecedent moisture conditions and represents an average for initial and continuing loss (Cordery, 1970; Cordery and Webb, 1974). Fig 2.4 shows the monthly distribution of raindays and those with greater than 20mm rainfall. The frequency of raindays per month appears to be evenly distributed through the year. There is a greater frequency of 7 to 10 raindays in the late summer and early autumn period and a high frequency of 1 to 6 raindays in the winter and spring period. There is approximately a 50% chance that at least one day of rainfall in excess of 20mm (producing runoff) will occur in any one month, and a 10% chance that this will occur on two days. Days of heavy rainfall are less frequent in late winter and early spring.

2.3.2 Secular changes in rainfall and runoff

Major changes in rainfall and flood frequency have been noted for the whole of Eastern Australia. Rainfall records show an increase in the annual total rainfall and an increase in the incidence of storms for the whole of Eastern Australia. Changes have also been noted in the interior of the continent and to the west. Cornish (1977) showed that for New South Wales annual rainfall increased by up to 30% in the period between 1946 and the present, relative to the preceeding years of record. The greatest increase was in the central region of the state. He showed that the majority of this increase was accounted for by an increase in summer rainfall; in some areas of the state the change was of the order of 60%.

Runoff records also show significant changes in flow between the two periods 1900-1946 and 1947 to the present (Erskine and Bell, 1982). There has been a significant increase in flood frequency and flood magnitude. The increases have been so large that even major engineering structures, such as Warragamba Dam, have failed to mask the change (Riley, 1981).

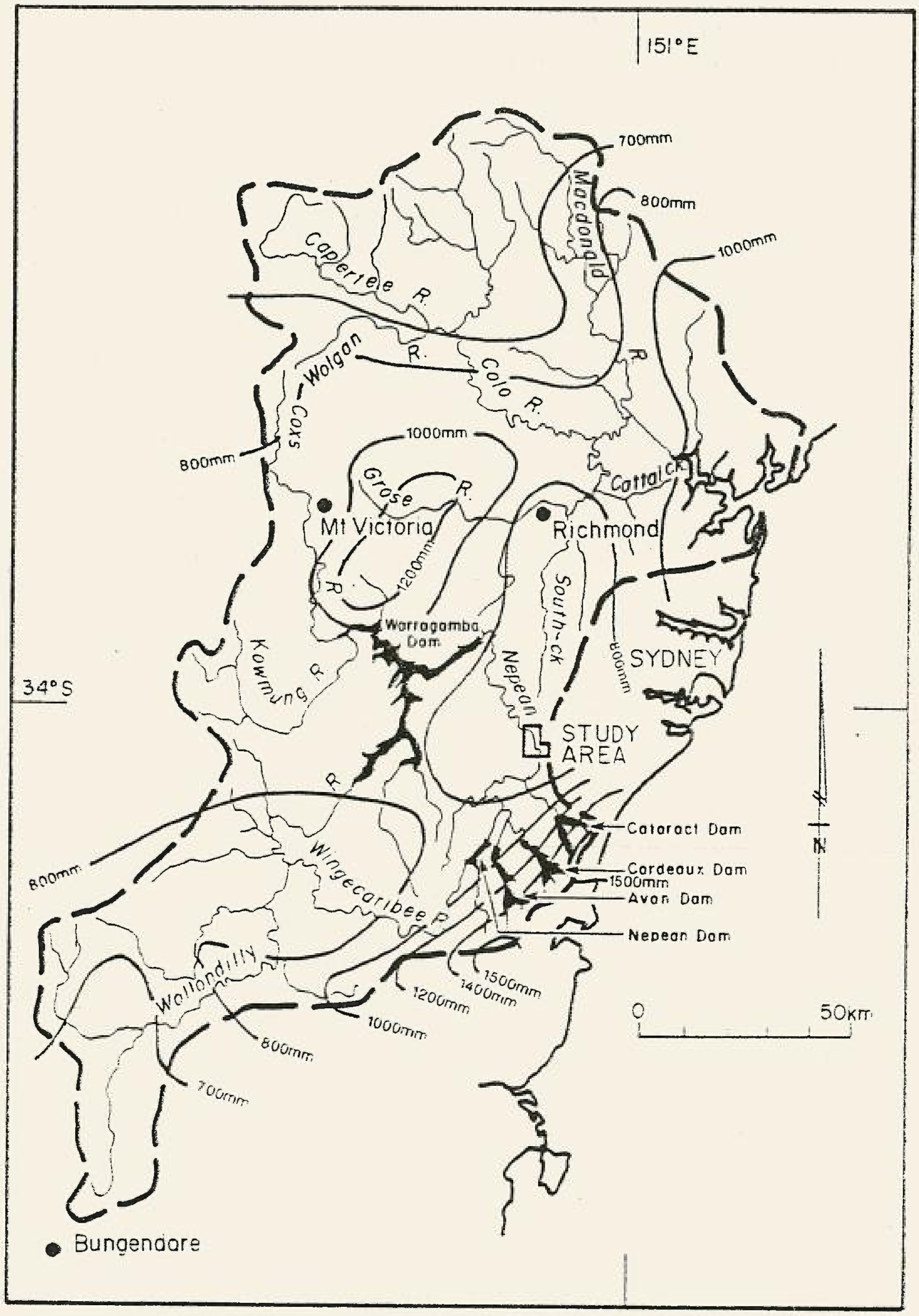


Figure 2.2 Median annual rainfall in the Nepean River catchment (Source: Water Conservation and Irrigation Commission, 1973).

2.3

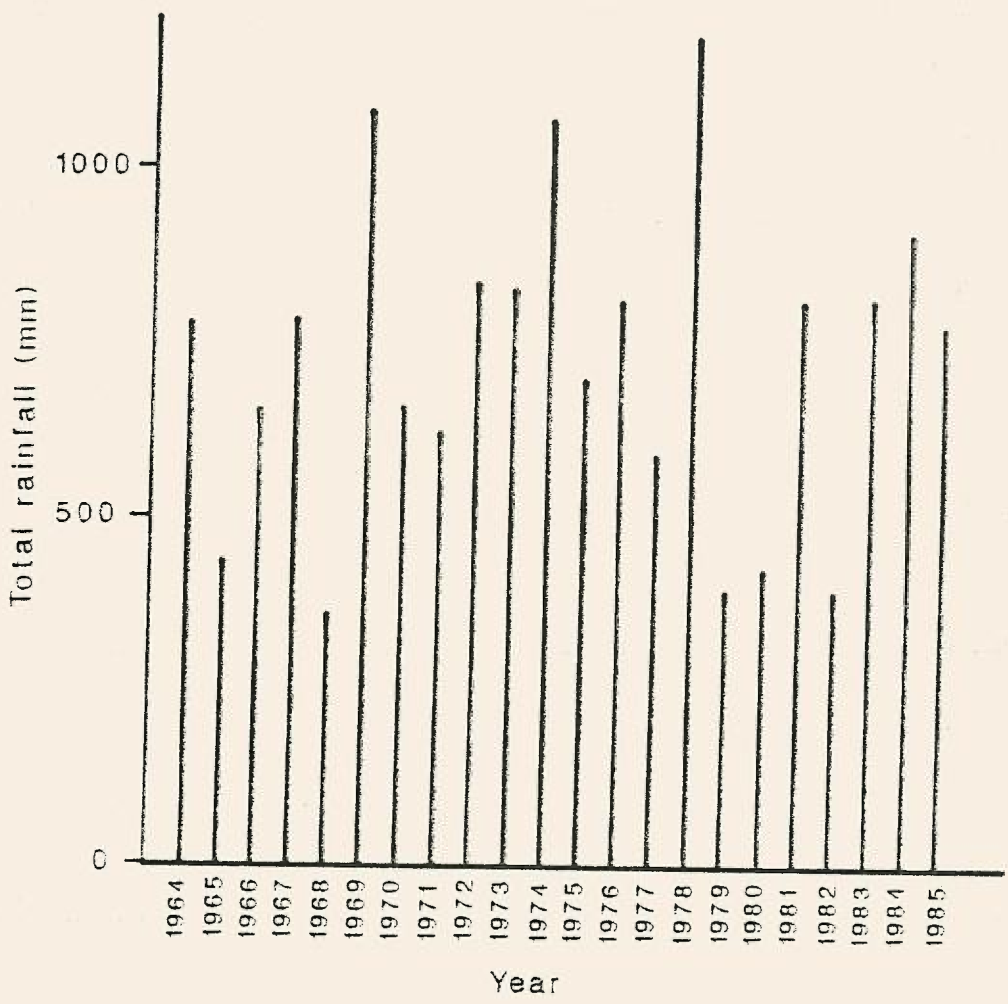


Figure 2.3 Annual rainfall for the period 1964 to 1985, Menangle.

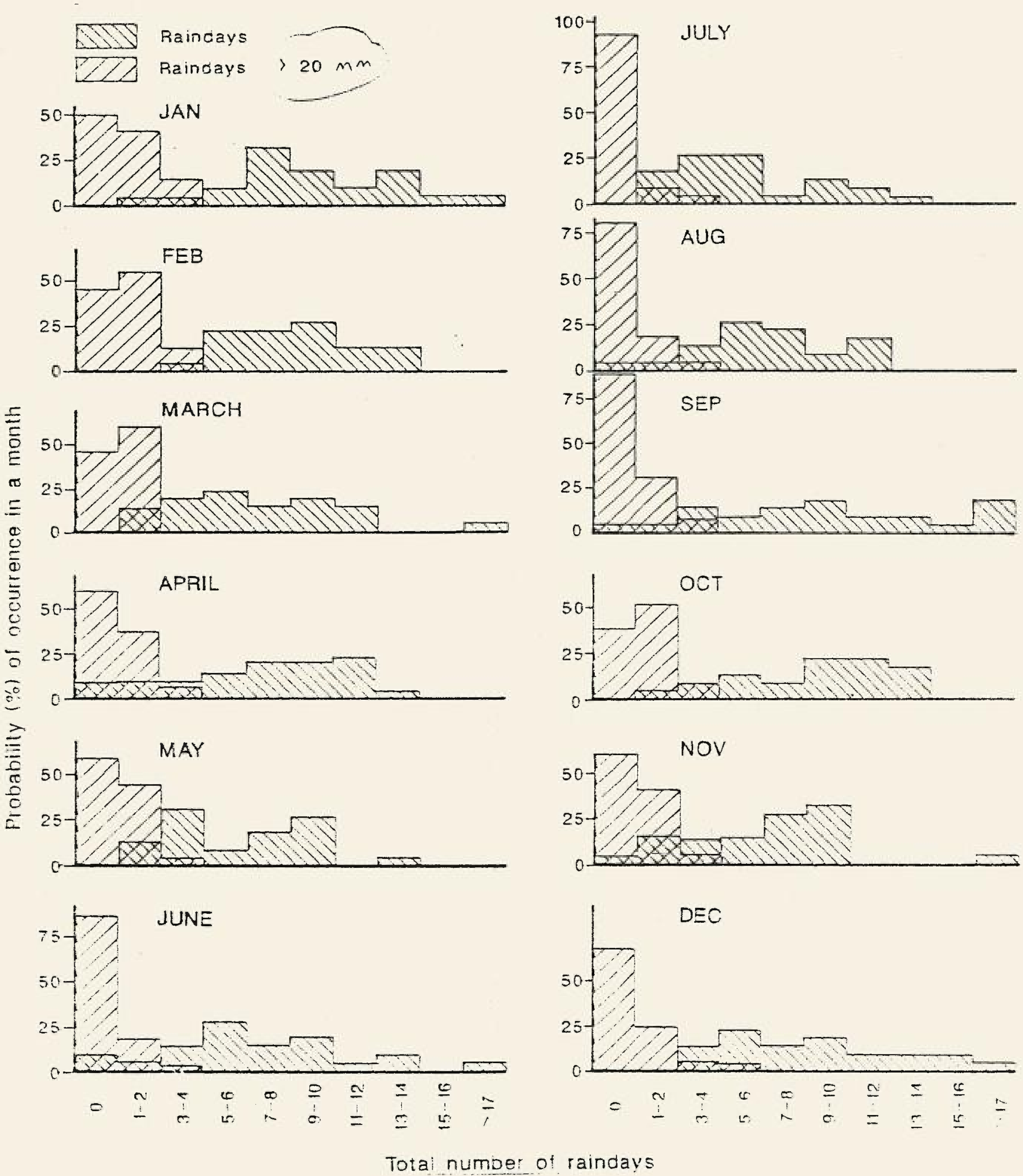


Figure 2.4 Frequency of occurrence of raindays at Menangle for each month. Based on Menangle daily rainfall data. Graph shows the probability of occurrence of given number of raindays.

The impact of the changes are not fully understood and may not be fully manifest in the catchments, the lag times being largely unknown. It is thought that recent 'catastrophic' changes that have been noticed in the Manning, Hunter and MacDonald Rivers may be related to an increase in flood frequency and flood magnitude (Erskine and Bell, 1982; Henry, 1977; Nanson, 1986). Increased scour of hillslopes, channel beds and banks and increased mobilisation of channel sediment have all been noted in a number of catchments throughout Eastern Australia, particularly for the eastward flowing streams (Pickup, 1976). There is evidence that the eastward draining channel systems and their catchments are in a phase of change and are far from stable (Erskine, 1986). If river channel geometry is adjusted to medium and low frequency events (Pickup and Warner, 1976), then the increased frequency and magnitude of flooding of the last three decades would contribute to these morphologic changes.

These changes are important, for the increase in flood frequency and annual flows of the Eastern Australian rivers has triggered some major changes in channel geometry in the last three decades. These changes are still working their way through the river systems, but one of the consequences appears to be increased scour, channel widening and sediment transport. It is not clear from the available evidence whether this change in hydrological regime since the mid-1940's is a result of secular fluctuations and will be followed by a more quiescent period similar to that between 1900 and 1940 or whether the change is more permanent, (ie. a response to changes in global climatic patterns). What can be said is that there are now more floods per unit time passing through the river system than in the past and that these floods are having an erosive effect on the river systems of Eastern Australia. This issue will be examined in chapters 3 and 4 of this report.

2.4 GEOLOGY AND SOILS OF THE UPPER NEPEAN RIVER CATCHMENT

The study area lies at the southern margin of the Cumberland Basin structural sub-division of the Sydney Basin (Bembrick et al., 1973). This is the point where the sandstones of the Triassic Hawkesbury Group dip below the landsurface of the Woronora Plateau. Rocks at the study site are shales of the Triassic Wianamatta Group which outcrop in the steeper hillslopes and sandstones of the Hawkesbury Group which is exposed in the channel bed and banks. The rocks are essentially horizontally bedded with a gentle dip to the north west.

Ashfield Shale of the Wianamatta Group is exposed in a quarry 100 m south of the Barragal Lagoon. Further north, stratigraphically higher Bringelly Shale outcrops (Herbert, 1979). The contact between the Hawkesbury Group and the Wianamatta Group rocks occurs at various elevations across the study area. The contact increases in elevation towards the south and east. At Barragal Lagoon the weathered shale was encountered below floodplain level in auger profiles 1, 2, 3 and 5 (Chapter 4) at approximately 67m AHD with sandstone being reported at 45m AHD below the bed of the Nepean River (BMI drill hole 17). Sandstone outcrops at approximately 70m AHD in the Nepean River left bank above the Menangle Road bridge and at 69m AHD in the left bank at the F5 Freeway bridge.

The jointing pattern at Menangle is unknown, however the conspicuously straight channel pattern indicates some structural control on channel pattern. Even the open curve upstream of the Menangle weir is composed of a sequence of straight reaches.

The soils pattern strongly reflects the geology in that the major lithological units have distinctive weathering products. The sandstone weathers to yellow non-coherent sands, clayey sands and sandy clays which are commonly less than one metre deep. Steeper slopes may contain thinner stoney soils or no soil at all. Walker (1956) described these soils in the Hawkesbury Series. The shales weather to a red clay described by Walker (1956) as the Cumberland, Glenlee and Menangle Series. Shale soils in the area are dark brown clay loam over reddish brown heavy clay and are one to two metres thick. The Menangle and Glenlee Series are the weathering product of calcareous beds in the upper Wianamatta Group, forming an upper and lower hillslope catena (Walker, 1956). On the steeper slopes to the north of the Glenlee Coal Washery mass movement (flow type) is common on the steeper shale hillslopes.

The third major lithological unit is the Nepean River alluvium. This is of unknown age but probably of recent origin and, until recently, actively aggrading. Materials are sandy near the channel, becoming increasingly clayey away from the channel. The soil are commonly dark and organic rich to depth. It is with this unit that the report is primarily concerned. Detail of materials are given in Chapter 4.

The Elderslie sands, which are reported to exist in the right hand floodplain, are considered to be stratigraphically older than the modern alluvium seen along the river banks. Details of the character of the Elderslie sands are given in Longworth and McKenzie (1981).

2.5 HUMAN INTERACTIONS WITH THE NEPEAN RIVER

2.5.1 Early phase

Human occupancy of the catchment has probably extended over a period of 30 to 40 thousand years if the recent finds in the Castlereagh gravel beds near Penrith are reliable (Nanson and Stockton, pers. comm.). The interaction of Aboriginals with the environment is not fully understood, although there is a significant body of evidence to suggest that they actively used fire in their hunting. Hughes and Sullivan (1981) have suggested that erosion and sedimentation rates increased dramatically with the Aboriginal firing regimes in the late Holocene (approximately 4000 years BP). Young, Nanson and Bryant (1986) showed the largest number of dated alluvial bodies occur in the last 4000 years (53% of the total) although the authors did not attribute this to a particular event. Changes in the fire regime may have caused increases in the sediment loads of streams and possibly aggradation. Many of the floodplain sediments of the Menangle area do not suggest considerable age in terms of weathering characteristics, although there are no Carbon 14 dates on the floodplain material in the Upper Nepean which could be used to test this hypothesis. It cannot be definitely stated whether the sediment released by burning practices (if indeed sediment was released) has reached the channel system. Material may be stored on the lower slopes and be effectively locked-up in stable storage sites. If sediment reached the rivers then many river deposits would be recent (Holocene in age) and would relate to a specific event in the catchment i.e. the flushing of sediment released by aboriginal occupation. It could then be argued that the resource is limited and related to a one-off event.

2.5.2 Agricultural phase

The second major phase of human occupancy was white settlement of the early 19th century. It is well established that European agricultural practices in Eastern Australia have resulted in increased rates of erosion from hillslopes (Douglas, 1969; Warner, 1984). Whether this sediment has reached the rivers and been exported from the upper catchments is unknown. It is highly likely that sediment availability has increased in the catchment as a result of land use and that this sediment is now working its way through the river system. The extent of the increase of sediment transport as a result of European occupancy is unknown, however, the fact that erosion has taken place and that erosion rates are now higher than before white settlement implies an increase in sediment availability in the catchment until such time as the reservoir of sediment on hillslopes has been depleted. On the other hand, more recent agricultural practices have tended to include soil conservation measures and the available evidence suggests that pastural activities which maintain good grass cover can reduce sediment losses to nearly the same level as pre-agricultural erosion rates. If this is so then there may be a significant decline in the availability of sediment for river transport.

It is highly likely that humans, both Aboriginal and European, have had a significant effect on the erosion and sediment supply of the Nepean River system. However, the data are not available to accurately discriminate between the impacts of human activities and non-human inputs on the sediment supply and consequent effects on the Nepean River at Menangle.

The other major influence of humans has been the construction of reservoirs along the Nepean River and across the headwater streams (1907, 1926, 1927 and 1935 for the Cataract, Cordeaux, Avon and Nepean dams respectively; DEP, 1986). Menangle weir and Bergins weir were built in the early 1900's after the completion of Cataract Dam (Aird, 1961). The major impact has been to reduce the low flow regime; flood flows are less likely to have been effected. The impact of these reservoirs, dams and weirs, will be discussed in Chapters 3 and 4.

2.5.3 Mining at Menangle

Records of mining are incomplete. A reconnaisance survey of the area and detailed aerial photograph interpretation delineated a number of areas (Fig 2.5). Conversations with those familiar with the history of the area also confirmed previous interpretations and provided historical information.

There appears to have been a long history of mining in the immediate environs of the Nepean River at Menangle. A number of small quarries may be found in the densely vegetated levees upstream of Bergins weir.

Many of these sites are old, as there is well established vegetation within them.

There is evidence that the levee on the right hand bank of the Nepean River between the F5 Freeway bridge and the railway bridge has been extensively mined. It is present in the 1956 and 1966 photographs but is absent from 1984 photographs. The river banks upstream of the F5 Freeway have been mined, there is still mining equipment on the left hand bank. The contrasting width of the river between the Freeway bridge and the Railway bridge and downstream of Menangle Road bridge in the 1956 aerial photographs is extraordinary. It suggests a width similar to that which now exists in the dredged section of the river downstream of the road bridge. However, dredging in the Nepean River between the freeway and railway bridges could not be confirmed.

The area between the railway bridge and the road bridge may have been mined and the river dredged. A verbal report of mining was given by one resident.

The river has been dredged between 1978 and 1982 for a two kilometre stretch downstream of the Menangle Road bridge. The left and right hand bank of the river, levee and floodplain have also been extensively mined over a number of years, and mining is actively underway on both banks at present. Figure 2.5 shows two cross sections of the left hand bank of Bergins weir pond, one before and one after the quarrying of the floodplain. The channel was dredged before 1981, hence changes in it are not shown.

Details of the results of extraction between 1978 and 1987 by Menangle Sand and Soil P/L are given in Table 2.1. The total extraction of soil in this period was 442 372 tonnes and of sand was 994 992 tonnes. The period 1981 to 1986 was the most intensive, especially for sand extraction, presumably from dredging operations up to 1983 and thereafter from extraction from the floodplain and upper banks. Total extraction has averaged 197 000 tonnes of material per year which is, as will be demonstrated in Chapter 4, considerably more than the annual average sediment load of the river.

2.5

Figure 2.5 Reconnaissance map of quarry sites in the Menangle area. Constructed from aerial photograph interpretation (1984 aerial photographs, NSW Dept Lands) and field observations.

(SEE FOLIO)

TABLE 2.1

Sand, soil and total extraction at Menangle
1977-1987 (tonnes)

YEAR	SOIL	SAND	TOTAL
1978-77	42 796	45 622	88 414
1979	109 143	26 171	135 314
1980	6 429	64 055	70 484
1981	135 695	68 400	204 095
1982	140 830	88 902	229 732
1983	139 054	29 074	168 128
1984	174 527	2 693	177 220
1985	178 052	12 138	190 190
1986	181 592	31 575	213 167
1987*	145 503	10 503	156 081
TOTAL	1 101 682	307 415	1 409 097

* to June 1987

2.6 CONCLUSIONS

a) It can not be assumed that the river is in a 'classical' equilibrium state.

b) Sediment production may be episodic.

c) The river and floodplain at Menangle is on the boundary of the Triassic Hawkesbury Group sandstone and Wianamatta Group shales. Both rock types are found in the area.

d) The field site is located at the point where the Nepean River debouches from the Woronora Plateau sandstone gorge country, allowing deposition in the broader and less steep shale valleys.

e) There is at least a 50% chance of runoff from the slopes on one day in any one month at Menangle.

f) Rainfall and runoff have increased for the period following 1947 over the period 1900-1946.

g) Human activity is likely to have increased erosion rates, probably only to the extent that stores of sediment are being reworked. It is unlikely that increased erosion is producing new sand and soil material from bedrock at any great rate.

h) Increased erosion does not necessarily imply increased sediment delivery.

i) There has been a long history of mining in the area involving large tracts of the floodplain and channel. The most extensive mining has taken place in the last 15 years.

j) over the last 5 years an average of 196 000 tonnes of sand and soil has been extracted each year.

2.7 REFERENCES

Aird,W.V. 1961. The water supply, sewerage and drainage of Sydney. Metropolitan Water Sewage and Drainage Board.

Bembrick,C.S., Herbert,C., Scheibner,E., and Stunz,J. 1973. Structural subdivision of the NSW portion of the Sydney-Bowen Basin Quaterly Notes Geological Survey NSW, 11,1-13

Cordery,I. 1970 Antecedent wetness for design flood estimation. Civil Eng. Trans. Inst. Engrs. Aust. Vol CE12(2)

Cordery,I. and Webb,S.N. 1974 Flood estimation in eastern New South Wales - a design method. Civil Eng. Trans. Inst. Engrs. Aust. Vol CE16(1)

Chorley,R.J. 1969. The drainage basin as the fundamental geomorphic unit. In R.J.Chorley (ed) Water earth and man. Methuen, London, 77-100.

Cornish,P.M. 1977. Changes in seasonal and annual rainfall in New South Wales. Search, 8(1-2),38-40.

Department of Environment and Planning. 1986. Environmental heritage. Macarthur regional environmental study. Working Report No.3

Douglas, I. 1969. Man, vegetation and the sediment yield of rivers Nature, 215,925-8

Erskine,W.D. 1986. River metamorphosis and environmental change in the MacDonald Valley, New South Wales, since 1949. Australian Geographical Studies, 24(1),88-107.

Erskine,W.D. and Bell,F.C. 1982. Rainfall, floods and river channel changes in the upper Hunter. Australian Geographical Studies,20,183-196.

Henry,H.M. 1977. Catastrophic channel changes in the MacDonald Valley, New South Wales, 1949-1955. J. Proc. Royal Society N.S.W., 110,1-16.

Herbert,C. 1979. The geology and resource potential of the Wianamatta Group. Geological Survey NSW Bulletin. 25.

Hughes,P.J. and Sullivan,M.E. 1981. Aboriginal burning and late Holocene geomorphic events in Eastern N.S.W. Search, 12(8),277-278.

Longworth and McKenzie. 1981. Elderslie sand and soil deposits, Land management study Volume VI. Summary environmental impact statement.

Nanson,G.C. 1986. Episodes of vertical accretion and catastrophic stripping: a model of disequilibrium flood-plain development.

Geological Society America Bull., 97,1467-1475.

Pickup,G. 1976. Geomorphic effects of changes in river runoff, Cumberland Basin, N.S.W. Australian Geographer,13,188-193.

Pickup,G. and Warner,R.F. 1976. Effects of hydrologic regime on magnitude and frequency of dominant discharges. J. Hydrology,29,51-75.

Richards, K. 1982. Rivers; form and process in alluvial channels. Methuen, 358pp.

Riley,S.J. 1981. The relative influence of dams and secular climatic change on downstream flooding, Australia. Water Resources Bulletin, 17,361-366.

Taylor,G. 1970. 3rd ed. Sydneyside scenery and how it has come about. Angus and Robertson, 241pp.

Thornes, J.B. 1977. Hydraulic geometry and channel change In K.J.Gregory (ed) River channel changes. John Wiley, Chichester, 91-100.

Walker,P.H. 1960. A soil survey of the County of Cumberland. NSW Department of Agriculture Soil Survey Unit Bulletin No.2

Warner, R. 1984. Man's impact on Australian drainage systems Australian Geographer, 16(2),133-141.

Water Conservation and Irrigation Commission. 1973. Survey of thirty-two NSW river valleys. Report No.25. Water resources of the Hawkesbury Valley including Tuggerah Lakes and Lake Macquarie systems.

Young,R.W, Nanson,G.C. and Bryant,E.A.. 1986. Alluvial chronology for coastal New South Wales: climatic control or random erosional events? Search, 17(10-12),270-272.

CHAPTER 3

HYDROLOGY

3.1 INTRODUCTION

It is necessary to understand the hydrological regime of the Nepean River in the vicinity of the proposed extraction site in order to assess the impact of the operation on the river and <u>vice versa</u>. In the context of this study the river flow and the shallow groundwater regime are of prime importance. Other aspects of the hydrological cycle are of less importance and have been covered in Chapter 2.

The character of flooding is important for the following reasons;

a) the frequency of inundation of tracts of land defines the extent to which extraction activities will be disturbed by the river;

b) the depth, slope and velocity of flow within the river and over the banks and floodplain determines the ability of the river to move material and cause erosion and deposition;

c) the quality of water is significantly related to flood flow regime.

The flow duration at low and high flows is important because;

a) the quantity of water passing through the river system affects water quality;

b) the duration of flow at specific levels will determine the siting of operations;

c) the duration of flows as well as their magnitudes determine the quantities of sediment that are carried by the river into, through and beyond the area of extraction;

d) flow duration has a significant effect on pollution and the dispersal of pollutants in the downstream direction.

An understanding of the shallow groundwater regime of the area is important because:

a) groundwater flows in this environment may be important in sustaining certain aquatic ecosystems;

b) groundwater may be a potential problem to water quality;

c) groundwater may significantly influence slope stability and contribute to unstable slopes.

In this chapter details of the hydrology of the Menangle site are presented. In section 3.2 the available hydrological data is reviewed, including its sources and reliability. In section 3.3 a stage-based flood frequency curve for the area is presented and the extent of flooding based on this curve is examined for floods of different recurrence interval. The levels of flooding for different recurrence intervals presented by the Water Resources Commission are examined and compared with those based on the present study of the Menangle data. A flood frequency curve based on estimates of the discharge for different recurrence intervals is presented in section 3.4. In section 3.5 a one-dimensional backwater model is used to estimate flood levels and velocities along the reach of Nepean River that is the subject of this investigation. In section 3.6 the groundwater condition of the site is investigated, particularly in relation to Barragal Lagoon.

3.2 NEPEAN RIVER FLOODS: STAGE AND DISCHARGE

The flood flow data for the Menangle area is not extensive, although there are a number of records of flood peaks and discharges. The two most reliable sources of information are the gauging records for the nearby stations of Camden and Devines (operated by the Sydney Water Board and the Bureau of Meteorology) and records of flood peaks and stage hydrographs of floods. These latter records are obtained and kept by the State Emergency Services, the Bureau of Meteorology and local Councils, as part of their flood warning and emergency procedures.

3.2.1 Flow Duration

Devines gauge (Fig 3.1) (AWRC no.212206) was an automatic water level station installed in September 1968 by the Metropolitan Water Sewage and Drainage Board and abandoned in March 1983. This gauge was established in the pool created by Menangle weir, which acted as its control for low flows. At high flows the control structure was 'complex', ie there was not a simple relation between flow height at Devines and the discharge at the Menangle weir (Metropolitan Water Sewage and Drainage Board, 1985).

The catchment area of the Nepean River at Devines is 1275 sq kms. There are a number of small streams that enter the river between the lower reach of the investigation site and the control for Devines, most notably Foot Onslow Creek, which enters on the left hand bank approximately 100m downstream of the Menangle road bridge (Fig 3.1). A number of small creeks enter the Nepean River between Menangle weir and Devines gauge, eg. Menangle Creek, but the discharge from these would be taken into account in the Devines' records as the control for the gauge is at the weir.

3.1

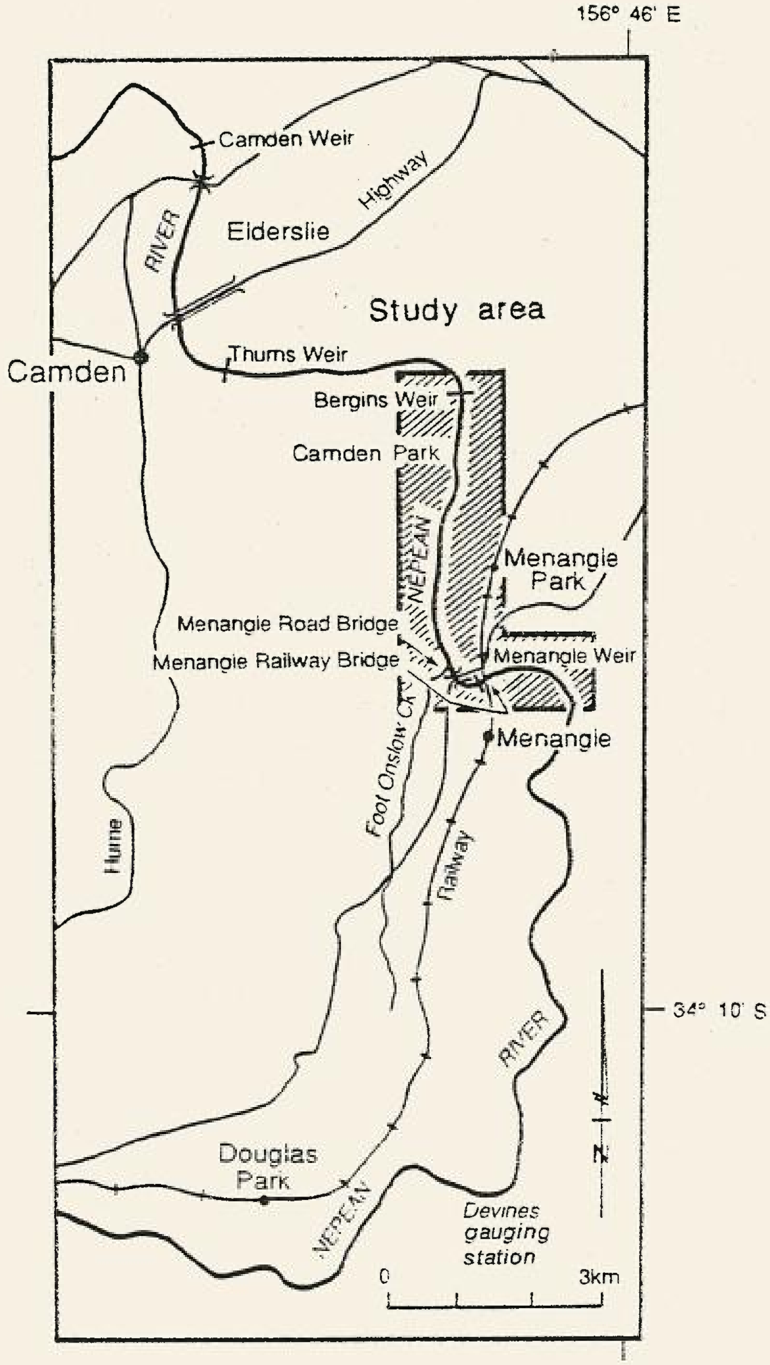


Figure 3.1 Location of stream gauges and weirs in the Nepean River that are relevant to the Menangle study.

The flow duration curve (Fig 3.2, Table 3.1) based on the 14 years of data shows that the Nepean River ceases to flow for 35 percent of time and that discharges are less than 1 cumec for 87 percent of the time (1 cumec represents approximately 1 cm depth of flow over Bergins weir). Discharges greater than 10 cumecs occur less than 9 percent of the time and discharges greater than 100 cumecs occur less than 1 percent of the time (Fig 3.2). The discharge that fills the channel at Menangle road bridge, approximately 70m AHD is 430 cumecs. This flow is exceeded less than 0.1 percent of the time.

TABLE 3.1

Discharges and elevations for selected times of exceedence

Discharge (cumecs)	Elevation (m AHD)	Percentage of time exceeded
0	*	65
1	59.6 (approx)	13
10	60.6	9
100	63.4	1
430	69.3	0.1

3.2.2 Flood stage

A manually read gauge is located at Camden for the purpose of flood warning. At this gauge (AWRC no.212900), which is operated by the Bureau of Meteorology, peak stages are recorded and discharge are estimated (Australian Water Resources Council, 1984). The gauge is located approximatley 9 km downstream of Bergins weir; the Nepean catchment has an area of 1380 sq km at this point. The record (Table 3.2) provides a check on the ommission of floods in the record of the Menangle road bridge site and has been used to estimate flood levels at Menangle.

The Menangle road bridge is an important transport corridor across the river. It is also located near settled areas and the Menangle weir. For these, and a variety of other reasons, records of floods are kept (AWRC no.212904). A gauge plate has been located on the bridge for a number of years (since at least 1963), although the zero of the gauge has been relocated at least once. Flood records are kept by the State Emergency Services in Camden and by the Bureau of Meteorology. Information on the flood levels was also obtained from the Department of Water Resources for this study.

The flood record for Menangle road bridge extends from 1860 to 1987 (Tables 3.3 and 3.4). There is a flood height recorded in the Department of Water Resources file for 1806. This flood may have occurred but there has to be considerable doubt about its value and for this reason the record is not used.

3.2

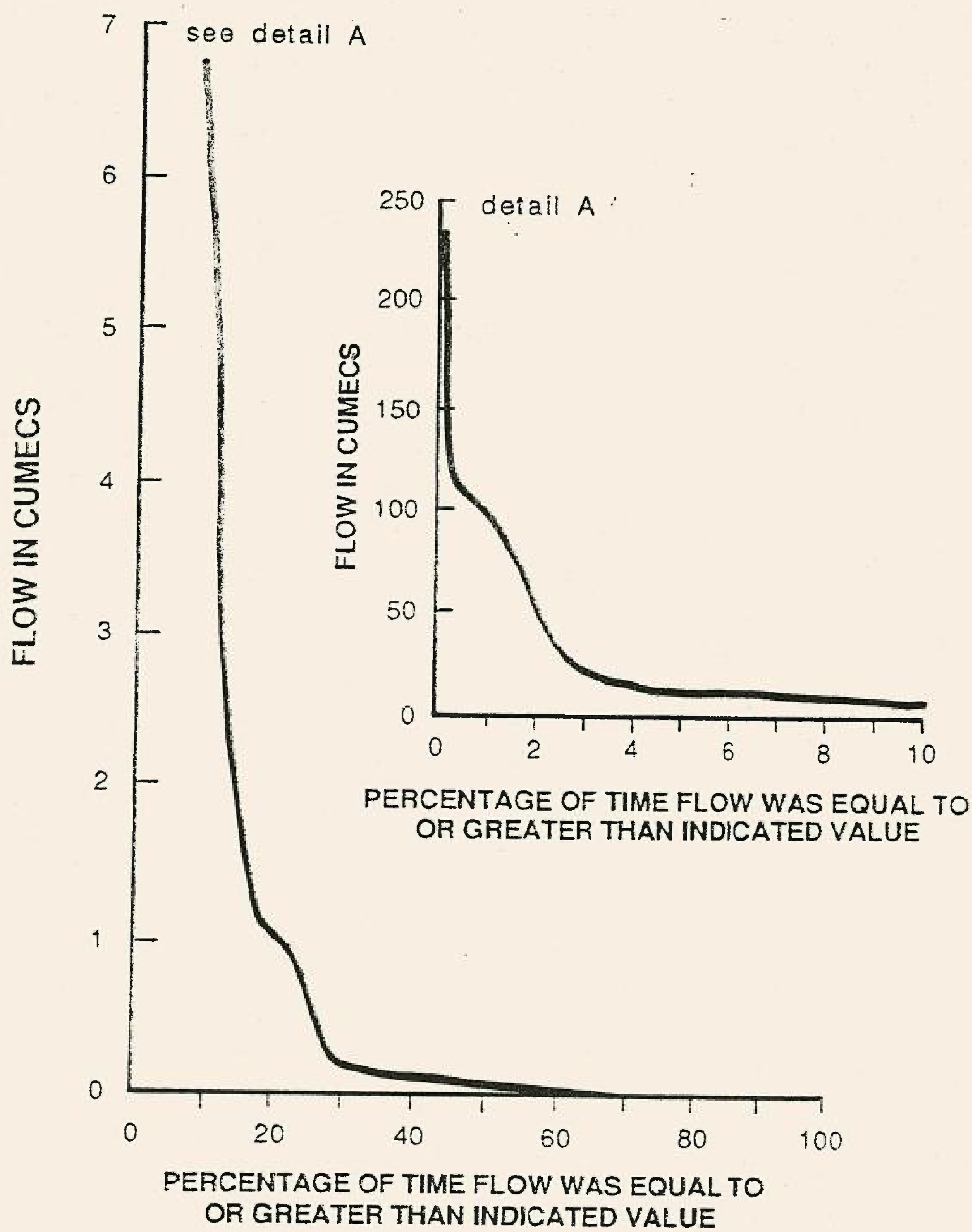


Figure 3.2 Flow duration curve for Devines gauging station (Source: modified from the Metropolitan Water Sewage and Drainage Board, 1985).

TABLE 3.2

Flood records at Camden (Cowpasture Bridge) for the period 1860-1987

DATE	GAUGE HEIGHT (m AHD)	DISCHARGE (Estimated) (cumecs)
1860 (Oct)	69.90	4856
1861	66.41	1503
1864	71.11	7399
1866	66.01	1330
1867 (Jun)	69.72	4393
1868	68.21	2717
1870	70.21	5318
1871	69.71	4278
1873 (Feb)	72.74	10058
1874	66.51	1549
1875	69.61	4046
1877	70.21	5318
1878	65.91	1283
1879	69.91	4856
1889	69.51	3873
1890	69.41	3757
1891	65.70	1145
1892	65.15	925
1894	67.00	1908
1895	67.50	2139
1897	65.50	1064
1898 (Feb)	70.92	7168
1900	69.20	6584
1904	69.51	3873
1906	64.91	856
1907	A 66.76	1734
1911	66.35	1503
1912	67.91	2543
1913	65.11	902
1914	66.51	1561
1916	69.31	3700
1922	66.45	1526
1925	67.70	2254
1934	66.20	1410
1943	65.20	936
1949 (Jun)	68.32	2275
1950 (Jun)	68.17	2659
1951	65.00	879
1952 (Jul)	67.19	1965
1955	65.05	890
1956 (Feb)	68.13	2664
1961 (Nov)	68.22	2717
1963 (Aug)	66.67	1619
1964 (Jun)	69.79	4509
1966 (Nov)	63.62	497
1967 (Aug)	65.51	1075
1969 (Nov)	66.72	1711
1971 (Feb)	60.89	198
1972 (Apr)	62.44	329
1974 (Aug)	66.51	1561
1975 (Jul)	68.41	2832
1976 (Mar)	64.87	844
1977 (Mar)	65.62	1098
1978 (Mar)	69.16	3584
1978 (Jun)	65.54	-
1986 (Sept)	65.51	-
1984 (Feb)	62.91	-
1984 (Nov)	63.01	-

gauge zero = 55.71m AHD
(source: Dept. of Water Resources)

TABLE 3.3

Flood heights at the Menangle Road and rail bridges
for the period 1860-1987

At Menangle road bridge gauge zero=58.10 mAHD
At Menangle rail bridge gauge zero=59.06 mAHD

DATE	GAUGE HEIGHT (m AHD) Road Br.	Rail Br.
1986 (Aug)	72.37	
1978 (Jun)	72.85	
1978 (Mar)	75.45	
1977 (Mar)	73.27	
1976 (Oct)	66.97	
1976 (Mar)	70.64	
1975 (Jul)	69.34	
1975 (Jun)	75.46	
1975 (Mar)	70.06	
1974 (Aug)	73.98	
1974 (Jun)	71.08	
1974 (May)	72.49	
1974 (Mar)	72.58	
1973	63.44	
1972 (Apr)	68.19	
1972 (Jan)	66.31	
1971 (Feb)	66.40	
1970	62.56	
1969 (Nov)	73.64	
1969 (Jun)	65.29	
1969 (Apr)	70.15	
1967 (Aug)	73.09	
1967 (Mar)	66.18	
1966 (Nov)	69.74	
1964 (Jun)	74.99	
1963 (Dec)	65.42	
1963 (Sept)	66.18	
1963 (Aug)	74.03	
1961 (Nov)	74.56	
1956 (Feb)	74.56	
1952 (Jul)	73.65	
1951	72.45 (E)	
1950 (Jun)	74.56	
1949 (Jun)		72.45 (E)
1943		72.60 (E)
1934		73.25 (E)
1925		74.20 (E)
1922		73.40 (E)
1916		75.25 (E)
1914		73.45 (E)
1913		72.50 (E)
1912		74.35 (E)
1911		73.35 (E)
1907		73.60 (E)
1906		72.40

1904 (Mar)	62.11	-incompatible with Camden data
1903 (Sept)	65.77	
1903 (Aug)	66.04	
1902 (Dec)	65.39	
1901 (Aug)	62.42	
1900 (Jul)	75.06	
1900 (Jun)	66.38	
1900 (May)	73.09	
1900 (Feb)	65.03	
1899 (Aug)	69.48	
1899 (Jul)	71.26	
1898 (Feb)	76.90	
1898 (Jan)	65.31	
1897 (Jul)	71.41	
1897 (Jun)	72.68	
1896 (Jun)	69.05	
1895 (Feb)	74.45	
1895 (Jan)	74.00	
1894 (Apr)	69.73	
1894 (Mar)	74.07	
1893 (Jun)	67.45	
1893 (Mar)	71.10	
1893 (Jan)	71.33	
1892 (Sept)	72.09	
1892 (Apr)	67.90	
1891 (Sept)	64.93	
1891 (Jun)	72.88	
1890	75.30 (E)	
1889	75.40 (E)	
1879	75.65 (E)	
1878	73.00 (E)	
1877	75.85 (E)	
1875	75.41 (E)	
1874	73.45 (E)	
1873 (Feb)	77.84	
1871	75.50 (E)	
1870	75.85 (E)	
1868	74.50 (E)	
1867 (Jun)	75.50 (E)	
1866	73.10 (E)	
1864 (Jan)	75.88	
1861	73.40 (E)	
1860 (Oct)	75.65 (E)	
1806 (Aug)?	69.22	

E = estimated from graphical correlation with Camden

Source: Department of Water Resources

TABLE 3.4

Recent flood height Menangle Road bridge

Gauge zero up to 27.05.1969 = 61.15 mAHD
Gauge zero after 27.05.1969 = 58.10 mAHD

DATE	GAUGE HEIGHT (m AHD)	DISCHARGE [instantaneous. max.] (Cumecs)
30.08.63	74.03	No data
25.09.63	66.18	"
11.12.63	65.42	"
12.06.64	75.99	"
09.11.66	69.74	"
06.03.67	66.18	"
07.08.67	73.22	"
16.04.69	70.19	497.69
New gauge zero height 27.05.69		
21.06.69	65.39	156.25
25.08.69	63.10	116.00 (E)
16.11.69	73.65	979.17
10.12.70	62.56	70.25
01.02.71	61.56	28.93 (D)
07.02.71	65.79	170.14
11.02.71	66.40	135.42 (D)
15.01.72	66.31	194.44
17.01.72	66.19	156.25 (D)
26.01.72	64.05	104.98 (D)
04.04.72	68.19	296.30
24.02.73	63.44	92.82
12.01.74	67.75	275.46
12.03.74	72.58	819.44
11.04.74	65.36	140.05
21.04.74	68.87	354.17
26.05.74	72.49	918.98
05.06.74	71.08	587.96
28.08.74	73.90	1070.60
11.03.75	70.06	439.81
21.06.75	75.46	1157.00 (E)
04.07.75	69.34	421.30
24.01.76	65.46	164.35
04.03.76	70.64	476.85
18.10.76	68.97	393.52
23.02.77	64.47	153.94 (D)
04.03.77	73.27	989.58
19.05.77	64.92	151.62
29.01.78	63.34	125.00
20.03.78	75.45	1863.43
09.04.78	68.39	363.43
02.06.78	72.85	717.60 (D)
15.06.78	66.52	210.65 (D)
19.02.84	68.30	No data
08.04.84	61.20	"
28.07.84	63.80	"
08.11.84	68.05	"
03.05.85	62.70	"
06.08.86	72.37	"
20.11.86	62.85	"

A check was performed on the Menangle and Camden flood data by graphical correlation (Fig 3.3). The relationship is a good one, essentially because the two stations are relatively close. The reading for the flood in 1904 appears to be anomalous at Menangle. A number of additional floods were added to the Menangle record, particularly for the periods 1860 to 1890 and 1907 to 1949.

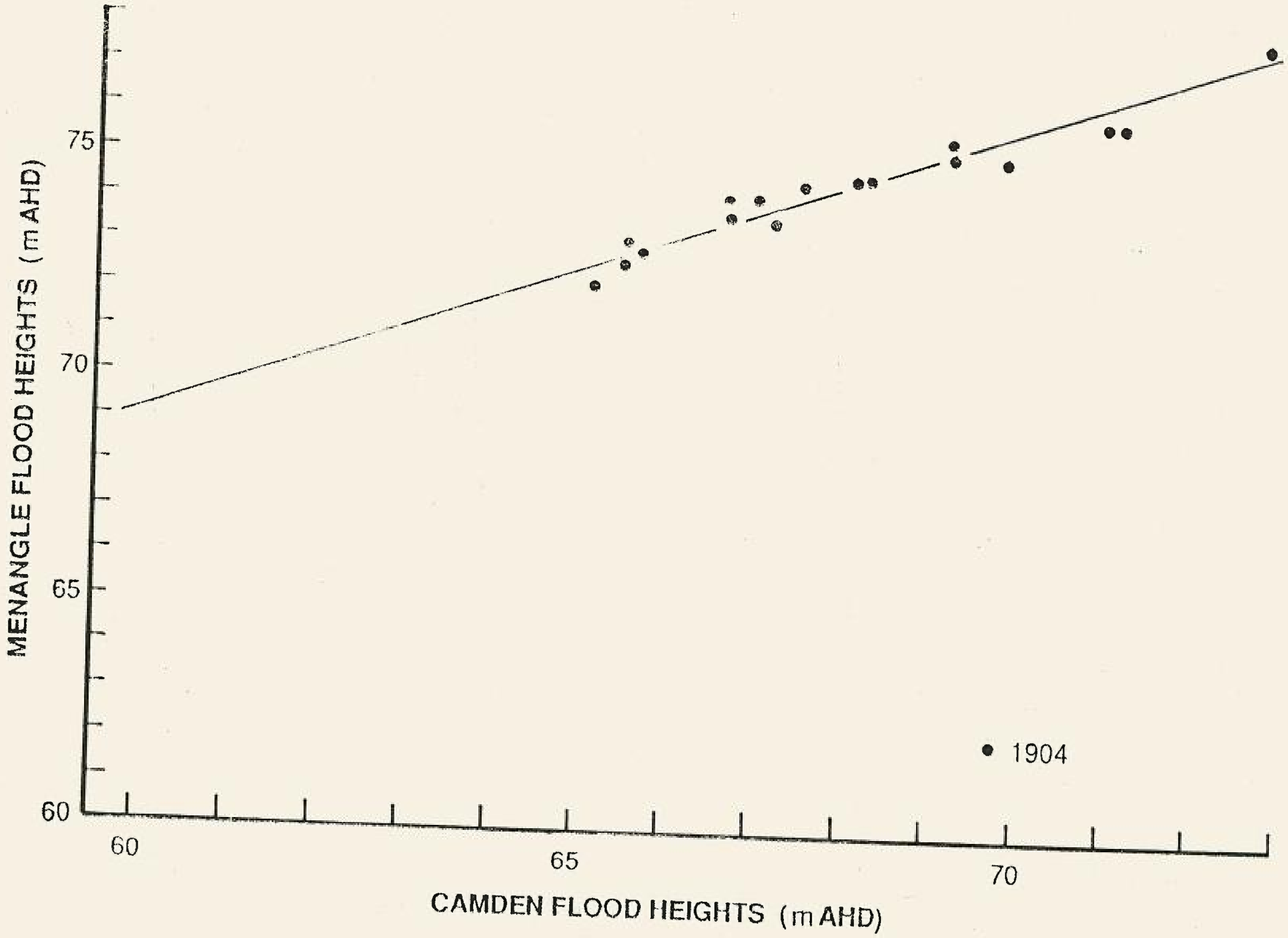
3.2.3 Flood duration

The stage hydrographs for the peaks of three recent floods (Fig 3.4) show the duration of the flood above the critical level of 71m AHD. The flood of 17 to 21 March 1978, which reached a peak of 75.45mAHD, was above 71m elevation for approximately 47 hours. The smaller floods of the 31 May to 2 June 1978 and 5 to 7 August 1986 were above 71mAHD for 15 and 35 hours respectively. The three stage hydrographs suggest that inundation lasts for between 30 to 50 hours. The duration of flood-producing rains controls the duration of the overbank flows. Floods produced by shorter duration rainfalls than those causing the three floods examined above would last for shorter periods. The converse is also true: longer period excess rainfalls will produce longer periods of overbank flow. Major channel flows, that is the combined period of in-channel and overbank flows, last for 5 to 10 days for each of the major floods.

3.3 STAGE-BASED FLOOD FREQUENCY

Two stage-based frequency curves have been produced for this analysis. The first is based on the floods larger than 71m AHD (the approximate level of the floodplain) that have occurred since 1947, the approximate time at which the present wet period began (see discussion Chapter 2). The second is based on the complete period of record for all floods larger than 71m AHD. Recurrence intervals were calculated using Gringortens formula (Cunnane, 1978).

A comparison of the two curves (Fig 3.5) shows that the frequency of flooding has been much less in the last 40 years than in the previous 127 years. That is, there were more and bigger floods passing through the Nepean River at this site in the period from 1860 to 1899 than in the period 1945 to 1987. Two floods, the 1873 and the 1898 are much higher than any of the other floods and they distort the frequency curve. It should also be noted that for the earlier period many of the flood heights are estimated from the Camden data, and there may be errors associated with the extrapolation and correlation with Camden that are biasing the results of the graphical analysis of flood frequency. An error is apparent when the State Rail Authority plan for Menangle Bridge is examined. On the plan the 1860 flood level is shown as occurring on February 10th with a height of 148.96 feet and the 1864 flood in June with a height of 145.37 feet. Apart from a problem with the dates the relative heights are the reverse of those in Table 3.3 and the relative difference in heights are not the same.



Data source :
Dept. Water Resources

Figure 3.3 Graphical correlation between Menangle and Camden flood levels.

3.4

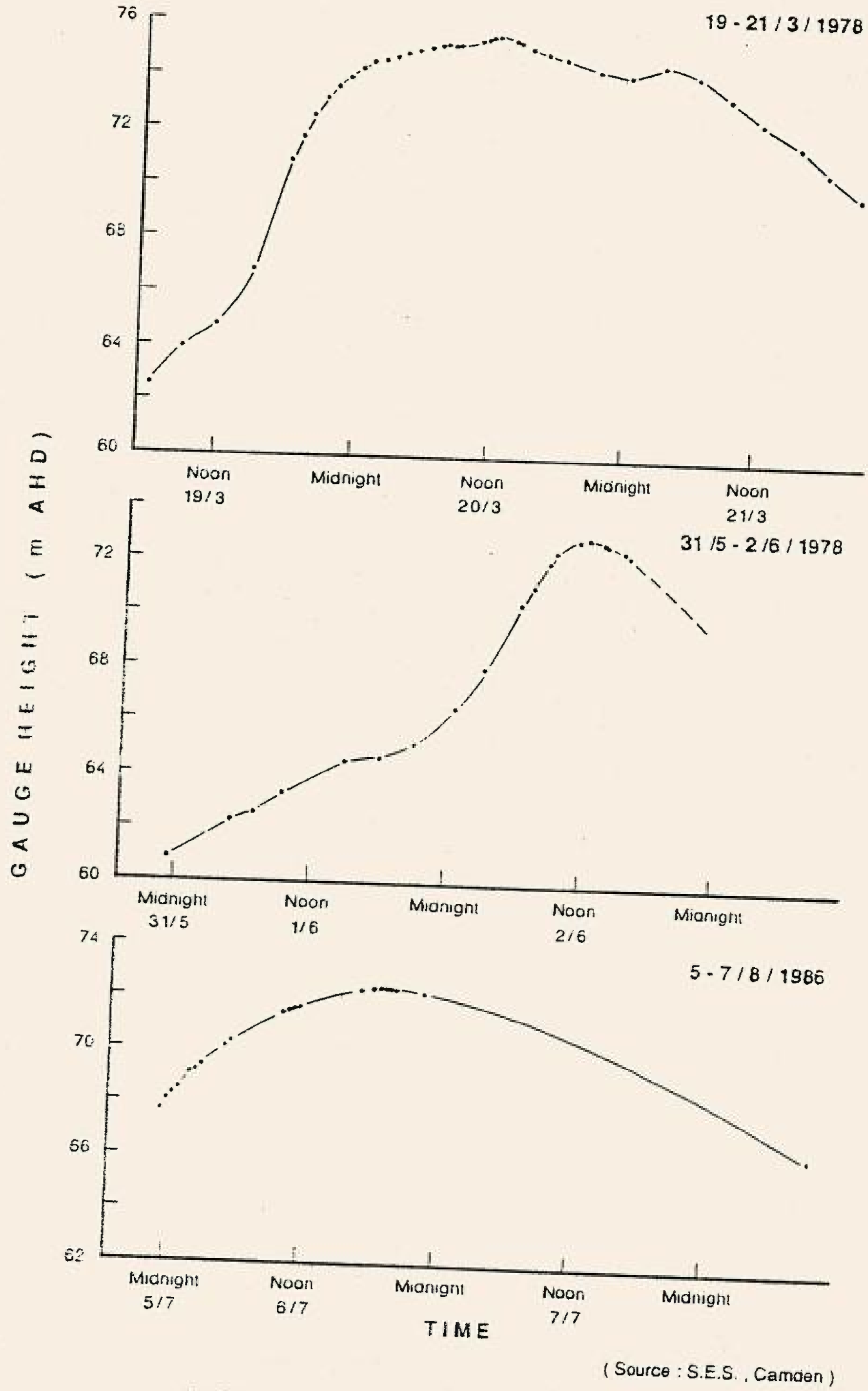


Figure 3.4 Stage hydrographs of three recent floods at Menangle

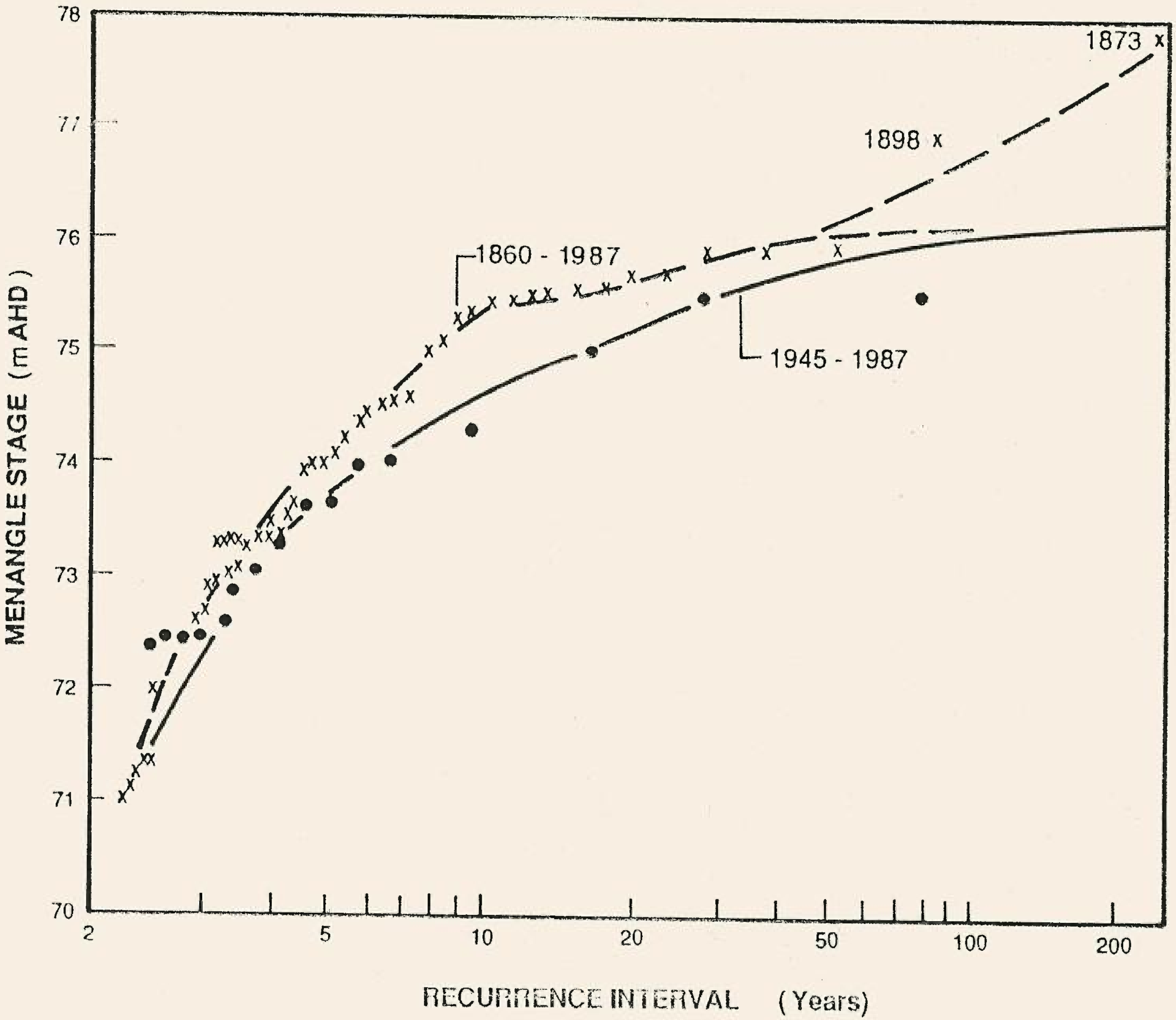


Figure 3.5 Stage-frequency curve for Menangle. Based on data presented in Table 3.2. The upper curve ('x' points) is for the period 1860 to 1987. The lower curve ('.' points) is for the period 1945-1987.

Detailed examination of the flood record (Tables 3.3 and 3.4) shows that there were 19 floods greater than 71mAHD in the period 1945 to 1987, six in the period 1900 to 1944, and 27 in the period 1860 to 1899 and that the largest floods occurred in the period 1860 to 1899. This pattern is consistent with results obtained elsewhere; wet in the latter 19th century, dry in the early 20th century, and a wet period since the mid 1940's (Riley, 1981).

One problem associated with using the earlier data is that many of the heights are related to the railway bridge, whereas latter readings are related to a gauge at the road bridge. Readings at the railway bridge should be consistently higher than those of the road bridge simply because it is upstream. If the readings were taken on the upstream side of the bridge then they will be higher still, the bridge acting as a constriction on the floodplain at high stages.

The more reliable stage-frequency curve is based on the 1945 to 1987 data. It differs in some respects from the frequency curve for the total period, mostly by underestimating the height of floods for particular frequencies. The difference in stage between the two curves is of the order of 0.5m except for recurrence intervals in excess of 100 years. No analysis of flood data and flood hydraulics will be undertaken for floods with recurrence intervals greater than 100 years.

3.3.1 Frequency of inundation

On the basis of the curve presented in Fig 3.5 the flood heights for various recurrence intervals are given in Table 3.5 The recurrence intervals suggest that the river is filled to near floodplain level approximately once every two years and that a substantial part of the floodplain is inundated once every 5 years (on average).

TABLE 3.5

Recurrence interval of flood heights at Menangle

interval (years)	height (m)
2.33	71.0
5	73.75
10	74.5
20	75.2
50	75.75
100	76.0

3.3.2 Probability of inundation

It is worth considering the probability of occurrence of these floods in a ten year period which is the likely **maximum** operational period of extraction in any one section of the river (Table 3.6).

The channel filling flow (recurrence interval 2.33 years) has a 12 percent chance of recurring twice and a 17 percent chance of recurring five times in a ten year period (Table 3.6). The twenty year flood, which would just cover the natural levee and cover the floodplain by 2 to 4 metres has a 61 percent chance of not occuring at all but a 30 percent chance of occuring once. The probability of multiple recurrence of the 20 year flood is low. There is a 10 percent chance that the 100 year flood will occur once in the 10 year operational life of the proposal.

Lowering of the levee and floodplain will increase the frequency of flooding of the floodplain in the quarried areas. For a floodplain at 3m above the low flow water level (approximately 63m AHD) the floodplain would be inundated more frequently than once every year. Further details of the implications of the quarrying on flooding will be discussed in Chapter 7.

TABLE 3.6

Probability of a specified number of floods in 10 year period for floods of given recurrence intervals

Recurrence interval (years)	Probability of n occurrences in 10 years 0	1	2	5
2.33	0.01	0.05	0.12	0.17
5	0.14	0.27	0.27	0.03
10	0.36	0.36	0.18	0.003
20	0.61	0.30	0.07	0.0002
50	0.82	0.16	0.02	0.000002
100	**	0.10	0.005	0.00000009

** probability is nearly 1.0

3.4 DISCHARGE-BASED FREQUENCY

The discharge-based frequency curve is compiled from the stage-frequency curve for the post World War II period, using the rating table for Menangle road bridge.

The rating curve for the Menangle road bridge gauge is largely based on data obtained from the period when the Devines gauge was operational (Fig 3.6) and on backwater analysis. The rating extends only to 75.1mAHD (17m on the gauge) but the Department of Water Resources have estimated the discharge for higher flows (77.5mAHD, 9000cumecs).

3.6

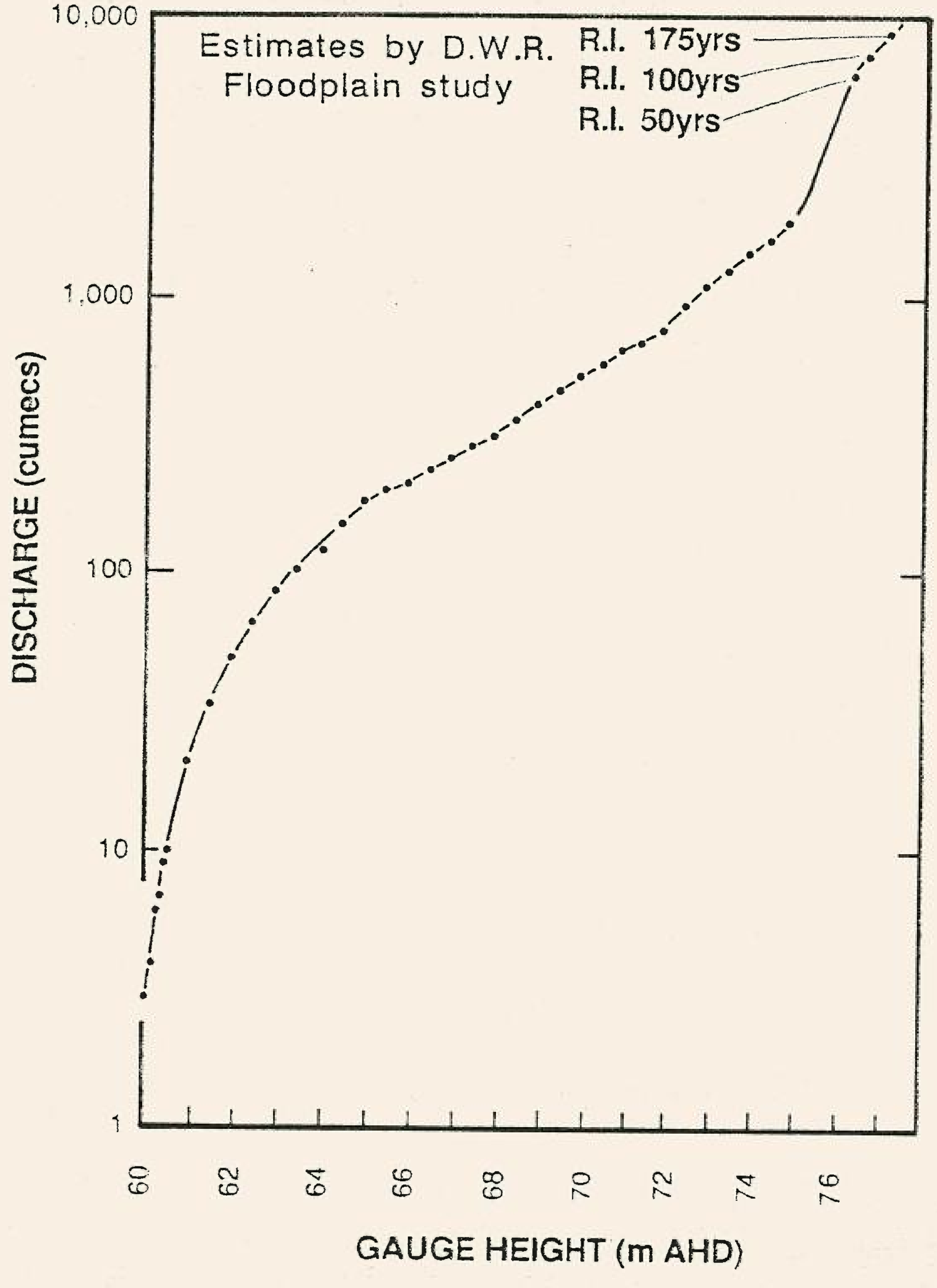


Figure 3.6 Rating curve for Menangle Road bridge. Based on rating for Devines gauging station and the Department of Water Resources backwater analysis.

The 20 year flood discharge is approximately 2000 cumecs, the 50 year 3000 cumecs and the 100 year 4000 cumecs. These latter figures contrast with the Department of Water Resources estimates, they define the 50 and 100 year discharges as 6200 and 7200 cumecs respectively. The Department of Water Resources used a discharge of 2200 cumecs for their 20 year flood which accords with the value derived in this report. The discrepancy between the 50 and 100 year flood discharges can be largely attributed to the use of the total period of record from 1860 to 1982 in the Department's flood frequency analysis for Camden. Fig 3.5 shows that if the curve for the total record had been used the stage and hence discharge values for the low frequency events would have been the similar to those obtained by the Department of Water Resources. Arguments were advanced in section 3.2 for the use of the 1945-1987 data set in preference to the total data record.

3.5 FLOOD HYDRAULICS

Estimates of flood heights and velocities along the Nepean River between Bergins weir and approximately 500m upstream of the freeway bridge were derived using the HEC2 one dimensional backwater flow program (US Army Corps of Engineers, 1976). The model was calibrated on the Department of Water Resources floodplain study of the Menangle area, using their estimate of the 20 year discharge of 2200 cumecs. Once the calibration was established the 20 year discharge of 2200 cumecs was used in all subsequent calculations of the 20 year flood.

The level of the 20 year flood as estimated by the Department of Water Resources and that estimated herein differ along the river (Fig 3.7) although the trends are essentially the same. The greatest difference occurs in the reach of river upstream of the railway bridge. According to the Department's analysis the flood height at the F5 Freeway Bridge is above the bridge level and well above the flood level of 77.90mAHD shown on the plans for the bridge (Regn no.6005 076 BC0133). This difference between the two sets of backwater analyses is of concern. The difference is not great downstream of the railway bridge but is considerable upstream. A backwater analysis was also undertaken of the 100 year flood level using the Department of Water Resources estimate of the 100 year discharge and the estimate used herein (Fig 3.7). The results suggest a degree of similarity between the 100 year flood levels if the 4000 cumec discharge is used but if the 7200 cumec discharge is used the predicted water level profile along the river in this study is considerably higher than that of the Department of Water Resources. For the purposes of this study it is considered that the estimate of the 20 year flood levels along the river derived in this study is probably the most realistic, it matches the Menangle road bridge gauge height and does not give an answer that suggests inundation of the Freeway bridge.

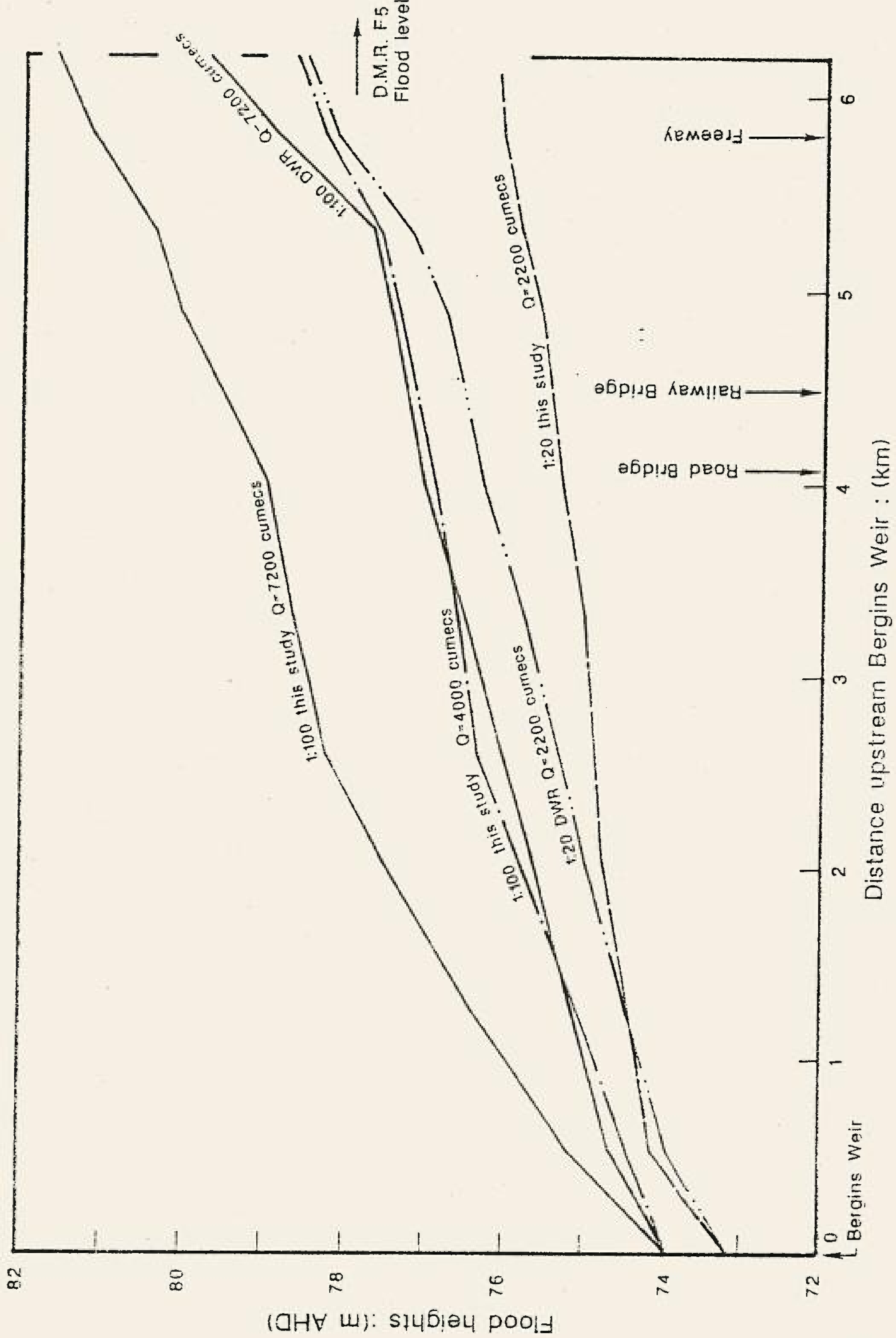


Figure 3.7 Comparison of Department of Water Resources flood profile for the Nepean River at Menangle and those derived in this report. Note the position of the NSW Department of Main Roads flood height for the F5 Freeway bridge.

Velocities and slopes and depths for the channel and floodplain have been derived (Fig 3.8). Velocities are of the order of 0.2 to 0.4 m/sec for the left and right hand bank along the majority of the floodplain The velocities along the channel range from 1.7m/sec to 0.8m/sec. The velocities are high at the Railway bridge, a constriction in the channel. They decline rapidly downstream. Through the reach between the F5 Freeway and the railway bridge the velocities are also higher than elsewhere in the river system, but the depth of flow and velocity of flow is low over the adjacent floodplain. Stream power per unit area is approximately twenty times higher in the channel than on the floodplain for the 20 year flood. For the majority of the channel downstream of the road bridge velocities are of the order of 1 m/s in the channel.

3.6 GROUNDWATER

There are no detailed piezometer data to evaluate the general groundwater condition of the area under investigation from Bergins weir to upstream of the F5 Freeway Bridge. There are no reports of springs and most of the creeks draining the shale hillslopes appear to be ephemeral and not affected by significant groundwater flow. Water in sands found at depth in auger holes adjacent to the river is related to the river and is unlikely to be connected to the hillslopes. There was no evidence of a connection in the valley cross section on which the Barragal Lagoon piezometers were located. The easternmost piezometer was dry, indicating minimal groundwater connection between the river and the western area of hillslopes. Water movement through the lower weathered shale and shale materials is likely to be insignificant.

3.6.1 Barragal Lagoon groundwater study

Five piezometers were installed along the margins of Barragal Lagoon in order to establish the interaction between the lagoon and groundwater in the alluvial sediments to the east of the lagoon. The piezometers were installed in a manner as outlined in (Water Resources Commission, 1978) and as recommended by the Department of Water Resources (1987 letter to Menangle Sand and Soil P/L. Details of their depths and locations are given in Figs 3.9 and 3.10. These piezometers may be used for future monitoring of the groundwater flow on the eastern side of the lagoon. A number of auger holes were also located further to the east of these piezometers, adjacent to the left and right hand bank of the river.

3.8

Figure 3.8 Hydraulic analysis of the floodplain and channel of the Nepean River at Menangle. The 20 year flood level computed in this study is shown. Velocity and depth of flow across the floodplain are approximate values.

(SEE FOLIO)

The pattern of piezometers (Fig 3.9) establishes the potentiometric gradient near the lagoon at the time of sampling. The eastern most piezometer(1) is dry, as is the southernmost piezometer(4). All others contained water. Readings of the piezometers were taken on the 1 Sept 1987 after a period of rain when the lagoon would have received substantial runoff from surrounding slopes and inflowing creeks. The results are presented below:

Table 3.7

Piezometer readings of 1-9-87

Piezometer	Water depth relative to ground level (m)
1	dry
2	4.42
3	4.69
4	dry
5	2.30

A stratigraphic section along the west-east line of the piezometers established that there is a ridge of weathered shale separating the lagoon from the river (Fig 3.10). The outlet through this ridge is to the north, near the location of piezometer 5. However, the stratigraphy of the auger and other drill holes in this area suggest that the outlet is plugged with clay, consistent with deposition of clays from the surrounding hillsides that drain into the lagoon. These clays would have been trapped in the lagoon and not been washed into the river because the river had built a levee and was probably in an active phase of aggradation.

3.6.2 A model for the formation of Barragal Lagoon

A model for the formation of Barragal Lagoon is presented below. It should be noted that there are several lagoons at various stages of formation along the margins of the floodplain. These are almost entirely leveed-dammed lagoons, owing their original formation to active aggradation in the Nepean River. The model presented for Barragal Lagoon probably applies to the other lagoons, at least in general detail.

3.9

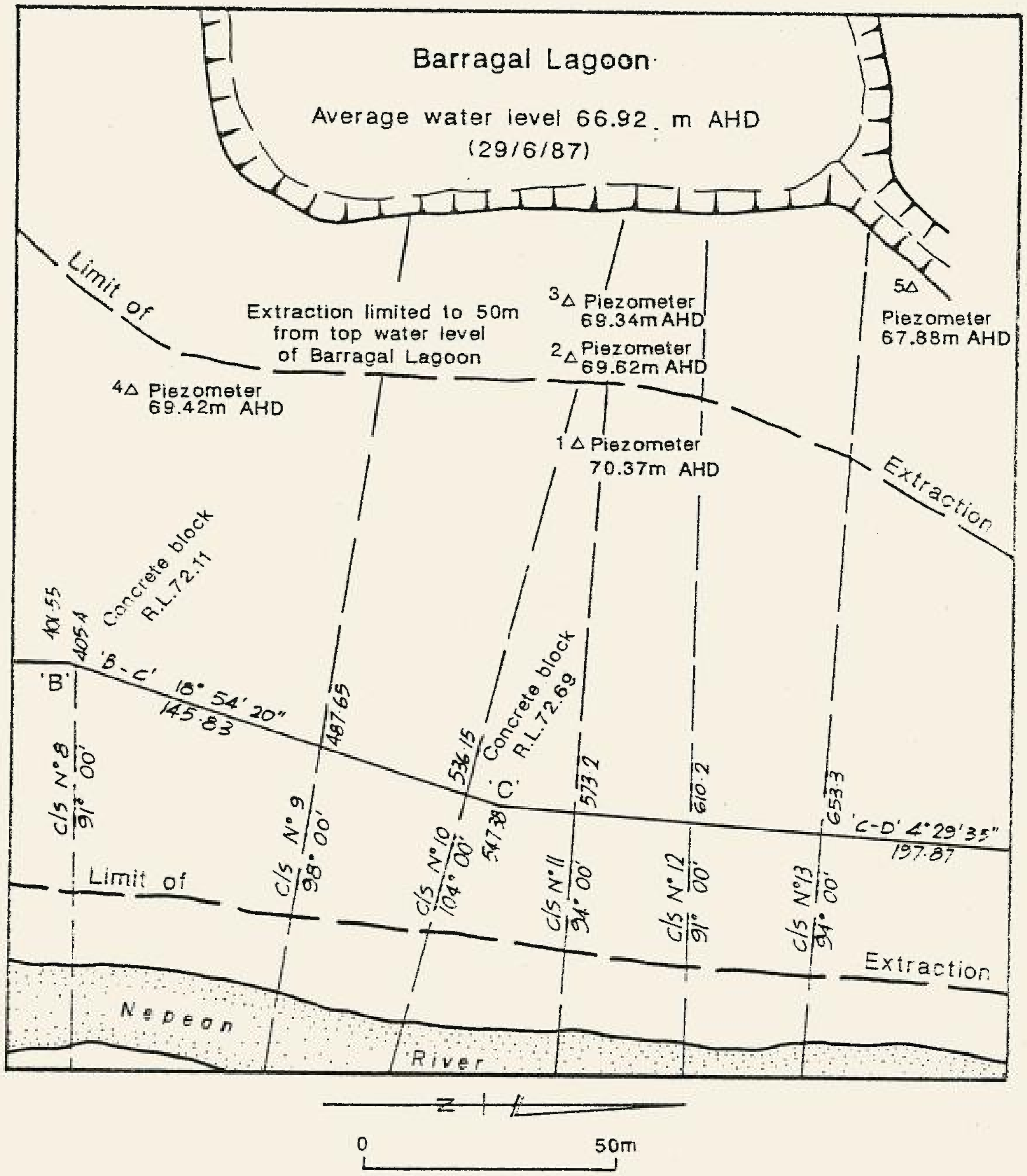


Figure 3.9 Location of piezometers to the east of Barragal Lagoon. Surface elevation of ground beside the piezometers is indicated as are cross sections.

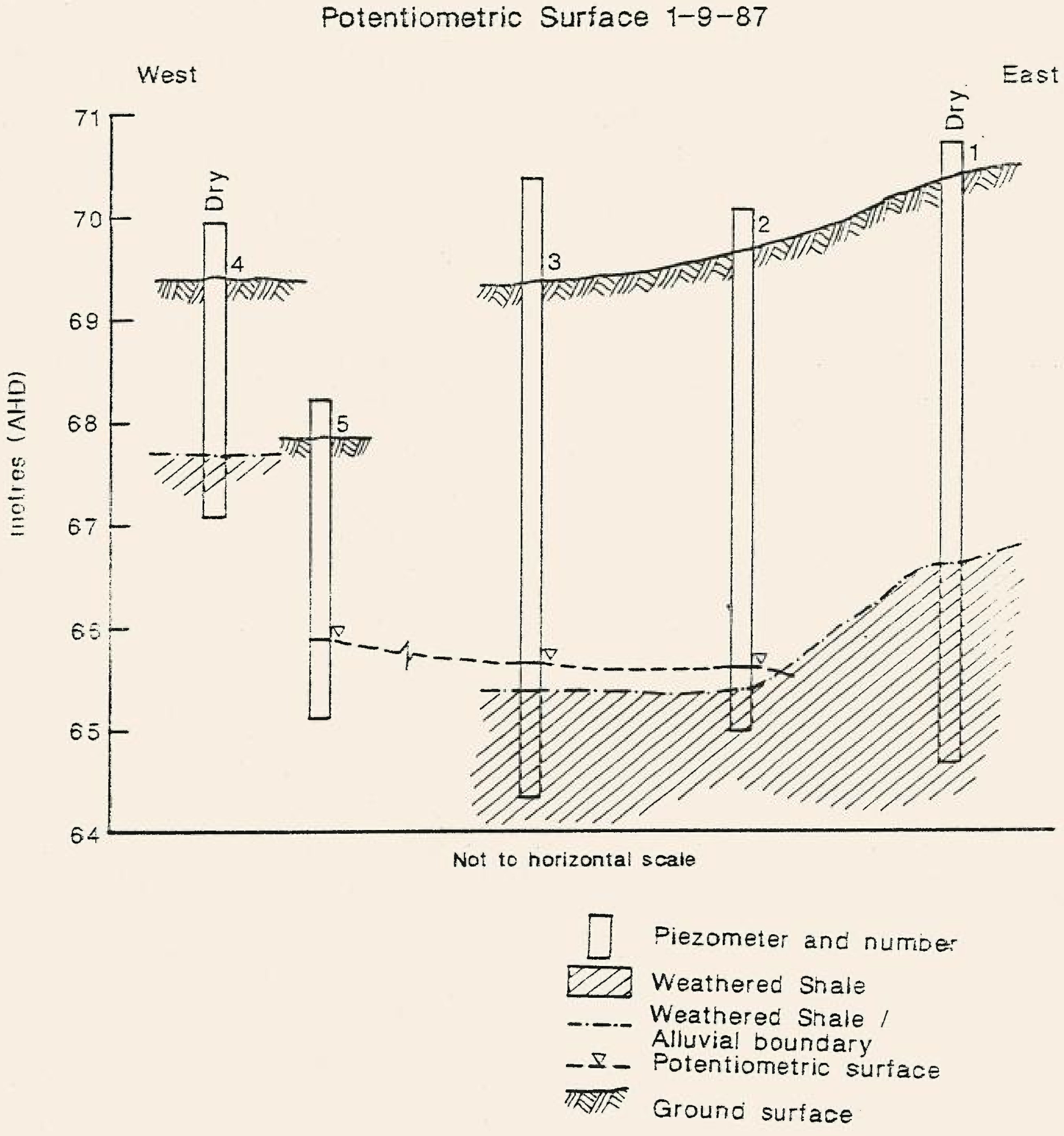


Figure 3.10 Relative altimetric position of piezometers (refer to Fig 3.9) showing position of bedrock and potentiometric surface on 1-9-87.

At a time when the Nepean River was more deeply incised than it is at present and when its floodplain was at a much lower level, the area now recognised as Barragal Lagoon would have been a tributary valley of the river (Fig 3.11). The tributary valley was probably steep sided in the vicinity of the river but may have widened upstream, especially where it bifurcates. A phase of aggradation in the Nepean River caused the outlet of the valley to be blocked. This blockage was very effective which implies a rapid rate of aggradation in the Nepean River. With the blockage of the outlet the sediment load of the tributary stream would have been deposited behind the levee. The thick deposits of gleyed clays discovered at piezometer site 5 (Chapter 5) confirm a relatively deep lacustrine environment similar to that of the modern lagoon. The outlet for the lagoon in the 1956 photographs is along the margins of the valley wall to the north, the Nepean River being confined by the levee which is some 4 to 6 metres higher than the lowest section near the valley wall. This high levee effectively blocks the tributary valley and aggradation of the lagoon continues. It must be noted that the lowest section of the levee lies at the outlet of Barragal Lagoon at an elevation of approximately 71mAHD.

3.6.3 Human modification of lagoons

Barragal Lagoon has been partly drained: a channel has been cut from the normal northern outlet through the levee. The date of this drainage is unknown, but must have occurred sometime between 1966, when it is not seen on the aerial photographs, and 1975, when it is to be seen. The drainage has probably lowered the lagoon, there being ample evidence from the 1956 aerial photographs and from the presence of strand lines that the lagooon has been higher in the past, and had been at these high levels for sometime (it may reach a high level for a short period during extremely high local runoff events and during periods of flooding in the Nepean River). It is unlikely that there is any significant groundwater supply to this lagoon, although tests have not been undertaken in the western margin of the lagoon to confirm this. Even if there is a groundwater supply to the lagoon it is more likely to be from the west and not from the direction of the Nepean River because water levels in the river are at least 6 metres below the lagoon water level.

The four major lagoons on the left hand floodplain downstream of Menangle Road bridge all exhibit signs of having been deepened. Aerial photographs from 1945 and 1960 show a well bounded, deeper section consistent with an excavated morphology, in each lagoon.

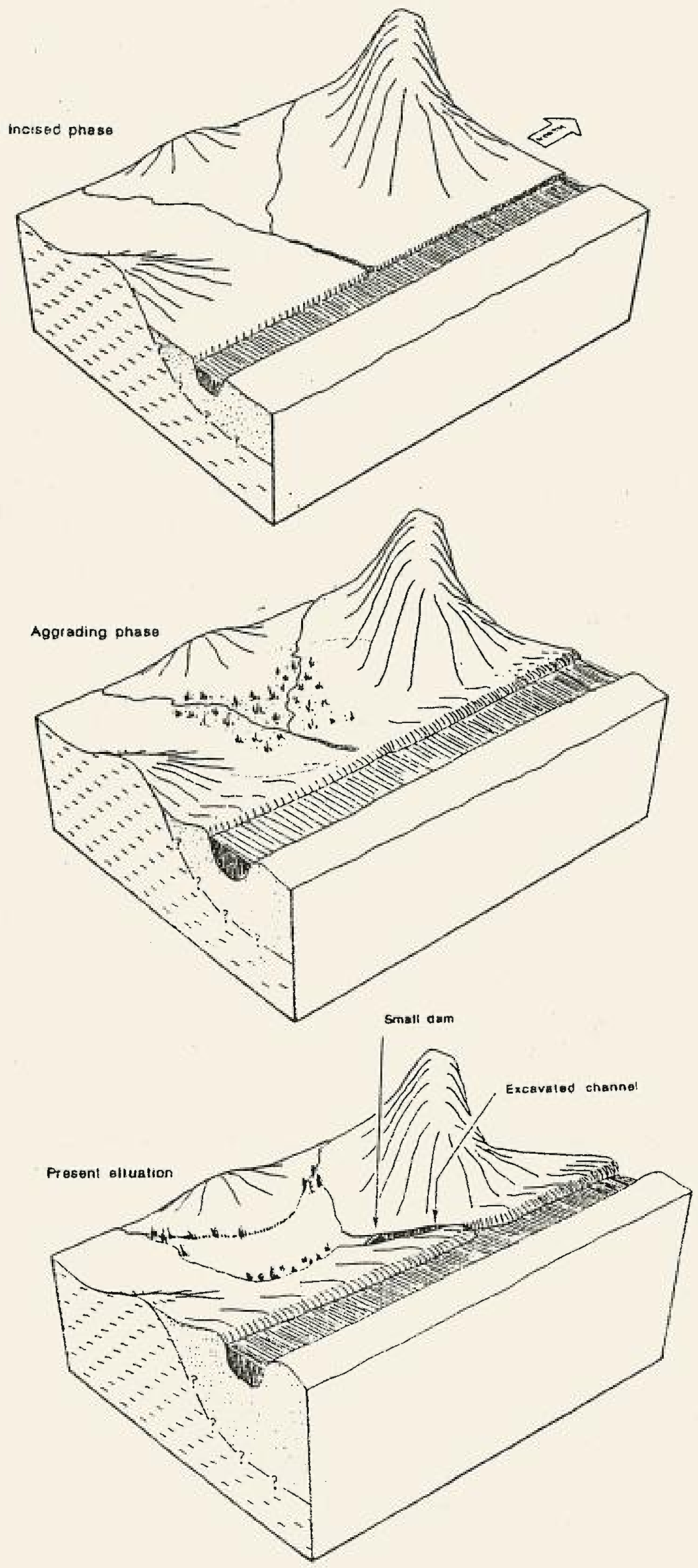


Figure 3.11 Model for formation of Barragal lagoon. Stage 1 is an incised river system with a tributary from the west. Stage 2 is an aggrading river and a ponded tributary. Stage 3 is the present situation with a considerable depth of fill in the Nepean valley and a substantial levee along th emargin of the river.

3.7 CONCLUSIONS

Flow duration:

a) River flows are less than 100 cumecs for 99 percent of the time.

b) The river ceases to flow for 35 percent of the time.

Flood frequency:

a) The river floods to bankfull at 71mAHD once every 2.3 years on average and the 20 year flood level is 75.2mAHD.

b) Lowering of the floodplain by quarrying will result in more frequent inundation. This will have future landuse implications.

c) The period from 1900 to 1945 has been a relatively quiescent one in terms of floods, the periods 1860 to 1899 and 1945 to 1987 being more typical.

d) The largest floods occurred in the period of most frequent floods, namely 1860 to 1899.

Hydraulics:

a) During a 20 year flood flow velocities are of the order of 0.2 to 0.4 m/s on the floodplain and 0.8 to 1.7 m/s in the channel.

Groundwater:

a) Groundwater flow within the general area of investigation to a depth that is significant for the extraction operation appears to be negligible.

b) Barragal Lagoon appears to be an isolated body of water that is fed by surface flow from surrounding hillslopes and the river during floods.

3.8 REFERENCES

Australian Water Resources Council. 1984 (6th ed). Stream gauging information, Australia. Water Resources Series No.2.

Cunnane,C. 1978. Unbiased plotting positions - a review. J. Hydrology, 37,205-222

Metropolitan Water Sewage and Drainage Board. 1985. Upper Nepean River stream gauging data. Report No.GSB 9026.

Riley,S.J. 1981. The relative influence of dams and secular climatic change on downstream flooding, Australia. Water Resources Bulletin, 17,361-366.

U.S. Army Corp of Engineers. 1976. HEC-2 Water surface profiles. Davis, California.

Water Resources Commission. 1978 (2nd ed). Observation bores - their completion, sampling and monitoring. Hydrogeological Section. Instruction Manual No.1

CHAPTER 4

GEOMORPHOLOGY AND SEDIMENTOLOGY OF THE NEPEAN RIVER IN THE VICINITY OF PROPOSED EXTRACTION

4.1 INTRODUCTION

In this chapter a model will be presented to explain the morphology and sedimentology of the Nepean River in the reach between Bergins weir and 500m upstream of the Freeway Bridge. Geomorphology and sedimentology must be linked in this situation because the Nepean River in this reach is dominantly alluvial, although bedrock does outcrop in some sections of the bank.

4.2 MORPHOLOGICAL CLASSIFICATION OF THE RIVER

There are four morphological channel and floodplain types in this stretch of the Nepean River. They consist of the reach from Bergins weir to the Menangle Road bridge, the reach from the road bridge to the railway bridge, the curved reach to immediately upstream of the F5 Freeway bridge, and finally the entrenched section further upstream (Fig 4.1).

Primary geomorphological mapping was undertaken using the 1956 aerial photographs. These photographs were chosen because they pre-date major quarrying and dredging in the area. The 1984 aerial photographs were used to assess changes in channel geometry, which are shown as schematic cross sections in Fig 4.1. The geomorphological mapping was field checked.

4.2.1 River reach 1: Bergins weir to Menangle Road bridge

The Bergins weir reach incorporates stages 1,2,3 and 4 of the quarrying and dredging operation and the proposed quarrying of the right hand bank covered by DA consent DA83-377 on lands owned by Campbelltown City Council and NSW Trotting Club.

The reach from Bergins weir to the Menangle Road bridge is relatively straight, sinuosity is less than 1.1, although there is a large radius of curvature in the southern section. Prior to dredging and mining the river banks and bed had a cross section geometry and pattern similar to that seen at the present time in the northern half of this section. The river was between 20 to 40 metres wide at the low flow stage with a series of linear ridges of low amplitude, their long axes oriented downstream. A major levee existed on both the left and right hand banks at an elevation between 70 and 74 mAHD. In the 1956 aerial photographs a well vegetated ridge appears in the centre of the river approximately 500m downstream of Menangle road bridge.

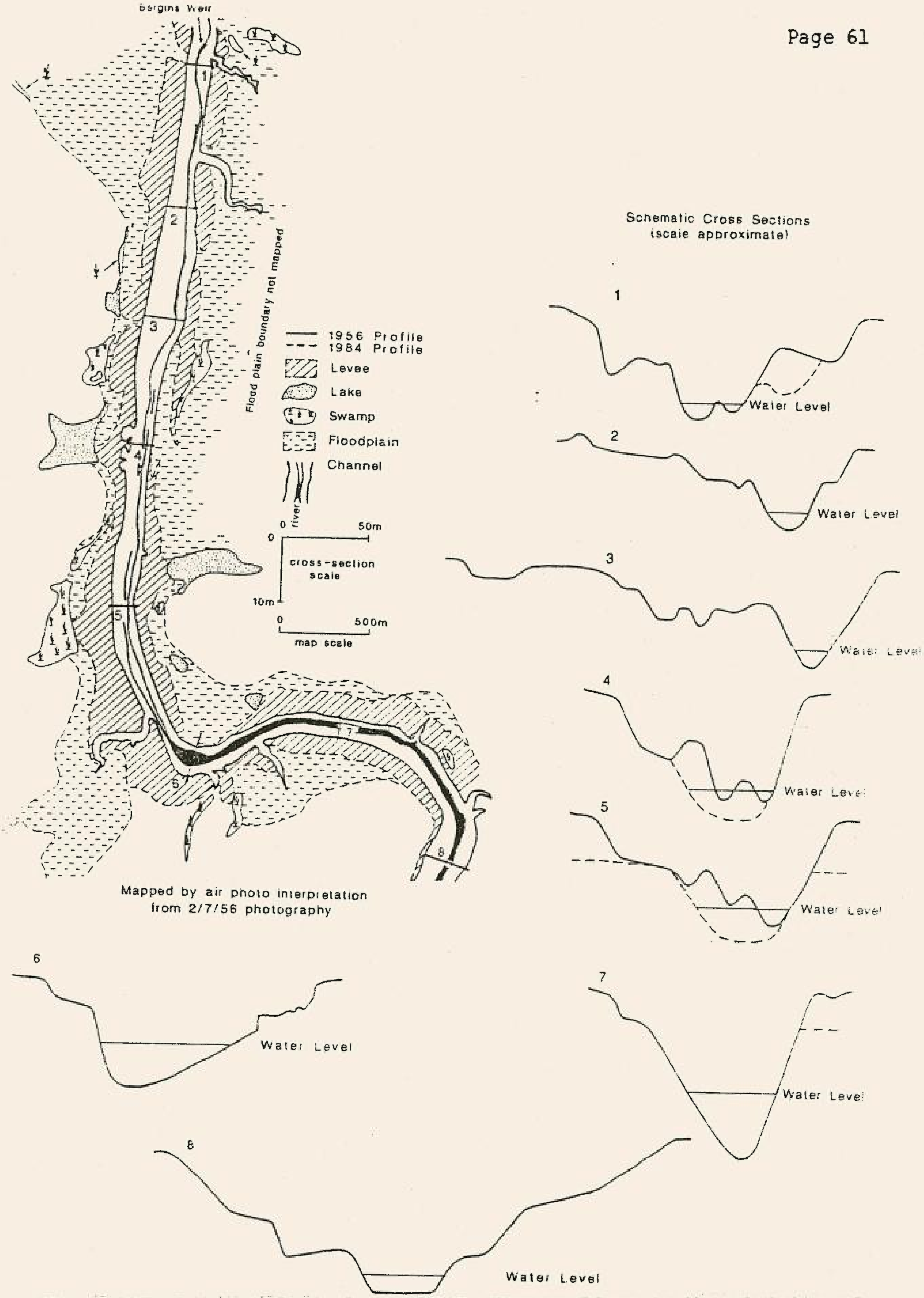


Figure 4.1 Geomorphological map of the Nepean River in the vicinity of Menangle. Constructed from aerial photograph interpretation and field checking. Cross sections (scale approximate) show schematic changes between 1956 and 1984.

Dredging for sand between 1978 and 1983 resulted in approximately 2 km of channel downstream of the Menangle Road bridge being deepened and widened, with the removal of the low ridge. Lowering of the floodplain occurred in the south of this section (Fig 2.5).

Near Bergins weir the floodplain widens rapidly in association with the left hand bend that the river takes downstream of the weir. Floodwater obviously breaks out of the channel and flows across the left hand bank onto the floodplain. There is a floodway that lies along the base of the hillslope of the left hand valley side. This floodway receives water from further upstream, in the approximate area of Barragal Lagoon. There is a well defined levee along the whole of the left hand bank of the Bergins weir section, the elevation of which prior to mining was approximately 73m at the downstream end and 76m in the upstream end of the reach. The levee on the right hand bank is not well developed for the first 400m upstream of the weir. Further upstream it was well developed prior to mining, its height being approximately the same as that of the left hand bank. The levee on the left hand bank appears to be twice as wide as that of the right hand bank.

There are a number of in-channel benches as well as the linear ridges in the reach. The highest bench in the reach between cross sections 3 and 5 (Fig 4.1) is almost to the level of the levee. This is also true on the right bank between cross sections 2 and 3 although not as morphologically distinct. On either side of the floodplain, beyond the levees, are a number of levee-dammed lagoons. These lagoons occupy depressions formed by the damming of smaller tributary streams by the levee. Larger tributaries such as Foot Onslow Creek have maintained their course through the levee to channel bed level. Thick stands of trees line the banks and benches and they occupied some parts of the river bed (on the linear ridges) in the 1956 aerial photographs, although they thin towards the south, possibly as a result of clearing. In the central part of the reach the channel and associated linear ridges are wider than elsewhere and the stream appears to make a small bend to the right before straightening. The morphology of the river has changed considerably since the 1956 aerial photographs were taken; some details of changes are given in the discussion on mining history (Chapter 2).

4.2.2 River reach 2: Menangle Road bridge to railway bridge

The second reach of the river includes stage 6 of the extraction proposal. This stage is on the left hand bank of the river.

This reach of the river incorporates a tight right-angle bend. The river is flowing on bedrock as it passes over the Menangle weir and is hard against bedrock on its left hand bank as it turns the right angle bend and passes Foot Onslow Creek. The right bank is also confined by bedrock for approximately 200m downstream of the Menangle weir. The right-angle bend is marked by a deep pool, which may have been dredged in the past (see Chapter 2) but is consistent with the type of pool often found at such sharp rock-controlled bends. The very nature of the bedrock outcrop and the depth of the pool suggests that the river is transporting through the reach all the sediment that enters underneath the railway bridge and therefore only minor deposition occurs.

The pattern of landforms has been severly altered on the right hand bank making it difficult to assess the exact nature of deposition.

Bedrock does not outcrop on the left hand bank immediately downstream of the railway bridge for a distance of approximately 100m. It may be that the bedrock is buried by alluvium, but the presence of alluvium south and away from the channel suggests that the bedrock is at depth and some distance back from the channel. Alluvium overlies the bedrock on both banks.

There is a well developed levee on the left hand bank but no clear evidence of a levee on the right hand bank. There are two levee dammed lagoons on the left hand bank, both of which are associated with streams draining the higher areas to the south. The channel is very wide in the vicinity of the deep pool at the right angle bend and there are few trees along the banks.

4.2.3 River reach 3: Railway bridge to upstream of F5 Freeway bridge

The third section of river extends from the railway bridge to approximately 200m upstream of the F5 Freeway bridge. This is a large radius curvature in the river, the right hand bank impinges on bedrock for the entire distance around the bend. It is clear that the bedrock is controlling the lateral migration of the river. The opposite bank is composed of alluvium except near the freeway abutment.

Upstream of the Menangle weir and Railway bridge the river is approximately twice as wide as it is in the Bergins weir reach, although if the vegetated in-channel benches and linear ridges are discounted in the Bergins reach both sections of the river have approximately the same low water surface width. The thickest strand of trees is located along the right hand bank, growing on alluvium just above the rock line. There is no evidence of a levee in this reach in 1987 however it is present in the 1954 photograph, which suggests that quarrying has taken place in the interim. This quarrying has drained a small lagoon near the railway line. Two small tributaries in this reach enter the river on the right hand bank and a small tributary enters from the left bank approximately 100m upstream of the railway bridge.

4.2.4 River reach 4: Upstream of 200m from F5 Freeway bridge

The fourth reach is the entrenched straight reach upstream of the F5 Freeway. Bedrock outcrops in this section although the banks are commonly covered with alluvium. There is a well developed alluvial bench on the right hand bank but further upstream this bench can be found on both sides of the river and in some cases alternates between both sides. This stretch of river is the most variable in depth for the whole Nepean River, as seen in the 1985 profile surveyed by the Metropolitan Water Sewage and Drainage Board (now Sydney Water Board).

At the downstream end of this reach the river is approximately 2m deep and the bed is composed of coarse sand. Further upstream the river deepens dramatically in several places, the Black Hole being a notable example.

In the fourth reach the floodplain is narrow and better described as a series of channel and valley benches. The width of the river is approximately the same in this reach as it is in the one immediately downstream. Towards the south the channel narrows in places and in-channel bars are found.

4.3 BANK STABILITY

A reconnaissance survey of the banks was undertaken from a boat for the four sections of river. The stability of banks was mapped using a two-fold classification. The first aspect of the classification is presence or absence of bedrock in the banks. The second aspect of the classification is the degree of bank slumping. Slumping was mapped directly onto the orthophotomaps in three classes: slumps with scars less than 1 m high, slumps with scars between 1 and 3 m high, and slumps with scars greater than 3 m high (Fig 4.2). Bank stability is very high in the place where bedrock outcrops and is presumed to be lowest where the slump scars are the highest and the longest in the downstream direction.

The mapping is at a reconnaissance level so the exact position of slumps and bedrock outcrops has not been determined by detailed survey. There is a small error in using the orthophotomaps to locate the position of features, especialy in an area of dense trees where it is diffiult to distinguish one tree from another.

The areas of most stable banks are located in the second and third reaches of the river, upstream of the Menangle Road bridge. The left hand bank of the river in reach 2 is bedrock and the whole of the right hand bank of the river in reach 3 is bedrock. In reach 4 bedrock crops out intermittently along the bank, and is probably covered with a thin veneer of alluvium elsewhere.

The right hand bank of section 2 and the left hand bank of section 3 are alluvial but there is no evidence of slumping in these areas. Both of these banks are on the inside of meanders, the position traditionally recognised as accretionary in river systems. Any scour or slumping in these areas is probably rapidly repaired by subsequent sedimentation. In addition the banks are relatively well covered with grass which reduces their scour potential.

In reach 1 there are a number of landslide (probably slump) scars along the river. The exact age of these scars is unknown, the 1956 aerial photgraphs show many examples of bank failure but these are not conspicuous in the 1945 aerial photographs; it is unlikely that they relate to one short period of mass movement along the whole of reach 1. The largest and the greatest length of bank affected is in the northern area of reach 1, particularly on the right hand bank where flow has been deflected (see section 4.2.1). The highest mass movement scars are associated with the highest banks simply because these banks have the potential for the highest failures. There are a number of mass movement scars along the left hand bank of the southern end of reach 1. These are small simply because the previous mining had reduced the height of the bank to 2 to 3 metres above low flow level. On the opposite side of the channel some of the mass movement scars are larger because the bank is higher, not having been mined.

4.2

Figure 4.2 Bank stability and floodplain stratigraphy. Based on aerial photography interpretation and field mapping. See text for discussion of stratigraphic sections. Bed sampling sites also shown.

(SEE FOLIO)

In the levee near Barragal Lagoon there are three large bank failures. These differ from other types in that they do not involve the full height of the bank but extend some distance in from the bank (up to 80m). The volume of material removed is large. These appear to be shallow (3-6m) fluid failures where a large body of levee material has moved laterally into the channel through a relatively small opening. These failures only occur in one locality and have the form of a quarry. This has been discounted however, as there are no signs of access roads in the 1945 aerial photographs where the features appear relatively new. Two small flow type mass movement are to be found on the right hand bank approximately 500m downstream of the Menangle Road bridge. These are associated with gullies, but they suggest that under some conditions the banks can fail as flows rather than as slumps. these flows may be associated with particular types of material or with unusual groundwater conditions during floods.

There does not appear to be a consistent pattern in the location of the mass movement scars. Near the Menangle Road bridge the scars are on the outside of a gentle curve in the river and may be the result of undermining of the bank by impinging flow. But 400m further downstream the undercutting is on both sides of the bank, with slightly more on the inside of a gentle curve. A number of scars are associated with the outside of channel bends, and the hydraulics of transverse currents associated with such bends may be a factor in the initiation of mass movement, but other factors must be important, as discussed in the following.

4.3.1 Causes of bank failure

There are several possible causes of mass movement. Channel deepening would create bank instability. If a bed is degraded and the degradation extends across the whole bed of the channel then some of the basal support of the channel banks is removed. Furthermore, if the bank is underlain by non-cohesive sands that are easily washed out when exposed by the degradation then even more basal sapping of the banks will take place. A higher bank with less support at its base will be a less stable bank.

Another possible cause of bank collapse could be increased pore water pressures in the bank material. Increased rainfall and higher flows will increase the height of the groundwater table and will also increase the pore water pressure in the floodplain and bank material. Soils with high pore water pressures are more susceptible to bank collapse than soils with low pore water pressures.

Oversteepening of the bank by loading of alluvium deposited at the top of the bank during floods could also lead to bank instability. Over a period of time the additional height and weight of sediment of the levee may be sufficient to cause mass movement.

Another possible cause of the mass movement is the increase in shear stress on the bed and banks of the river by the frequent floods of the 1945 to 1987 period. The drier 1900 to 1944 period may have been one in which vegetation was able to establish itself on the bed and banks and hence reduce the effectiveness of scour on the banks. However, a succession of floods is known to promote scour in some river systems, each successive flood weakening the banks and destroying more of the vegetation (the MacDonald Valley catastrophic scour of the 1950's was triggered by such a succession of events; Henry, 1978 and pers comm.). The present period of bank collapse may be the result of the cumulative effect of a number of floods.

Mining may be the cause of bank collapse in the widened section of the river in the Bergins weir reach. The river has been deepended in this area and the exposure of sands which may continue underneath the banks could lead to bank collapse through basal sapping. However, it is difficult to see how the mining could be invoked to explain the incidence of bank collapse in the Bergins reach downstream of the dredged section especially since bank collapse was extensive before mining.

It is also possible that the true cause of bank collapse is a combination of several of the individual explanations offered above. At this stage there is no way of identifying a unique cause.

The bank collapse may be a completely random phenomenon or so complexly related to its causes that it can be considered random. If this is so then the bank collapse may be a recurring feature of the area. There are many old mass movement scars in the unmined channel banks; these are now well vegetated but their degraded crowns may still be seen.

4.4 CHANGES IN CHANNEL MORPHOLOGY

The changes in channel and floodplain morphology are reviewed as are some of the possible explanations for these changes. Changes in channel morphology are a result of either human or natural processes. It is difficult to isolate the primary causes of change in the river geometry, changes often being the result of several factors acting together in complex associations.

Three aspects of river change will be examined; the change in the long profile of the Nepean River; the changes in its cross sectional geometry; and thirdly, the changes as a result of mining activity on the floodplain and in the channel.

4.4.1 Long profile changes

Long profile or thalweg changes throughout the whole of the Hawkesbury-Nepean River system have been recognised for a number of years. A number of surveys of the Hawkesbury-Nepean long profile have been conducted in the last 150 years; for this study an important survey was conducted in 1911 by the NSW Department of Public Works for a study of weirs of the Upper Nepean River. This 1911 survey is a bench mark for assessing change, although it must be remembered that it was completed some 100 years after the first settlement of the area and so does not include all the long profile changes associated with the first wave of European settlement.

Examination of the changes between 1911 and 1982 in the Nepean River by Warner (1983) shows that there has been an almost universal lowering of the bed of the Nepean River along the whole of its profile upstream of Penrith weir. The average increase in depth is of the order of 3 to 5 metres and is much greater for some reaches.

Comparison of the 1911 survey and the surveys of the river in the Menangle area done in 1985 by the Metropolitan Water Sewage and Drainage Board (plan WN 625097, file no. 59/99290B) reveals the detail of the changes. In addition, some of the short term changes in the thalweg are also evident from later surveys undertaken by surveyors associated with Menangle Soil and Sand P/L (Fig 4.3). Warners' observations are essentially correct. There is a considerable increase in the depth of the river in the reach between Bergins weir and upstream of the F5 Freeway bridge.

The 1911 survey shows no accumulation of sediment against the weir walls. Water depth declines upstream for Bergins weir but is essentially constant for Menangle weir. However, a point to note about Menangle weir is that few soundings were taken for the first 1 km upstream of the weir, and the deep holes that are evident in the 1987 and 1985 surveys may have been missed.

The 1980-1982 survey for Bergins weir shows considerable variation in the depth of the river, with obvious signs of bars separated by pools. The 1985 survey shows a more uniform depth, consistent with dredging in stages 2 and 3, the average depth of increase between 1911 and 1985 is approximately 3 metres. However, a large bar has also disappeared in the upstream end of stage 3. As this bar is outside of the dredged zone it must have been removed by natural processes. The 1987 profile shows no major change with the 1985 profile, suggesting no major sedimentation in the river in the area of dredging. Thus, if sediment is being delivered to the reach it is moving through and is not being deposited.

The Menangle weir pond shows a similar pattern to that of Bergins weir. There has been lowering of the bed by several metres since 1911, in some places 10 to 15 metres. Between 1985 and 1987 there are substantial differences in depth. The pool at 5.5km appears to have deepended by 5m and moved upstream whilst a bar appears to be developed at 5km. Thus, whilst there is some movement of sediment over the bed and change in form, the most recent data, which is only over a two year period, suggests no change in the volume of sediment stored, only a change in the position of its storage.

Mining is an obvious cause of some of the change, but the clear continuity of the incision over the whole reach of the Nepean River forces one to seek a more universal cause. Mining may cause local increases in depth, which may or may not propogate upstream and downstream, but it is unlikely that the magnitude of the changes could be accounted for by the mining.

It is interesting to note that there does not appear to be considerable quantities of sediment accumulating behind the weirs. There are verbal reports of sediment accumulating behind the weirs, but these cannot be substantiated for Bergins and Menangle weir. Sedimentation probably does occur at low flow stages, and sedimentation may have been common in the relatively dry 1900 to 1944 period, but does not appear to be the case for the present wet period.

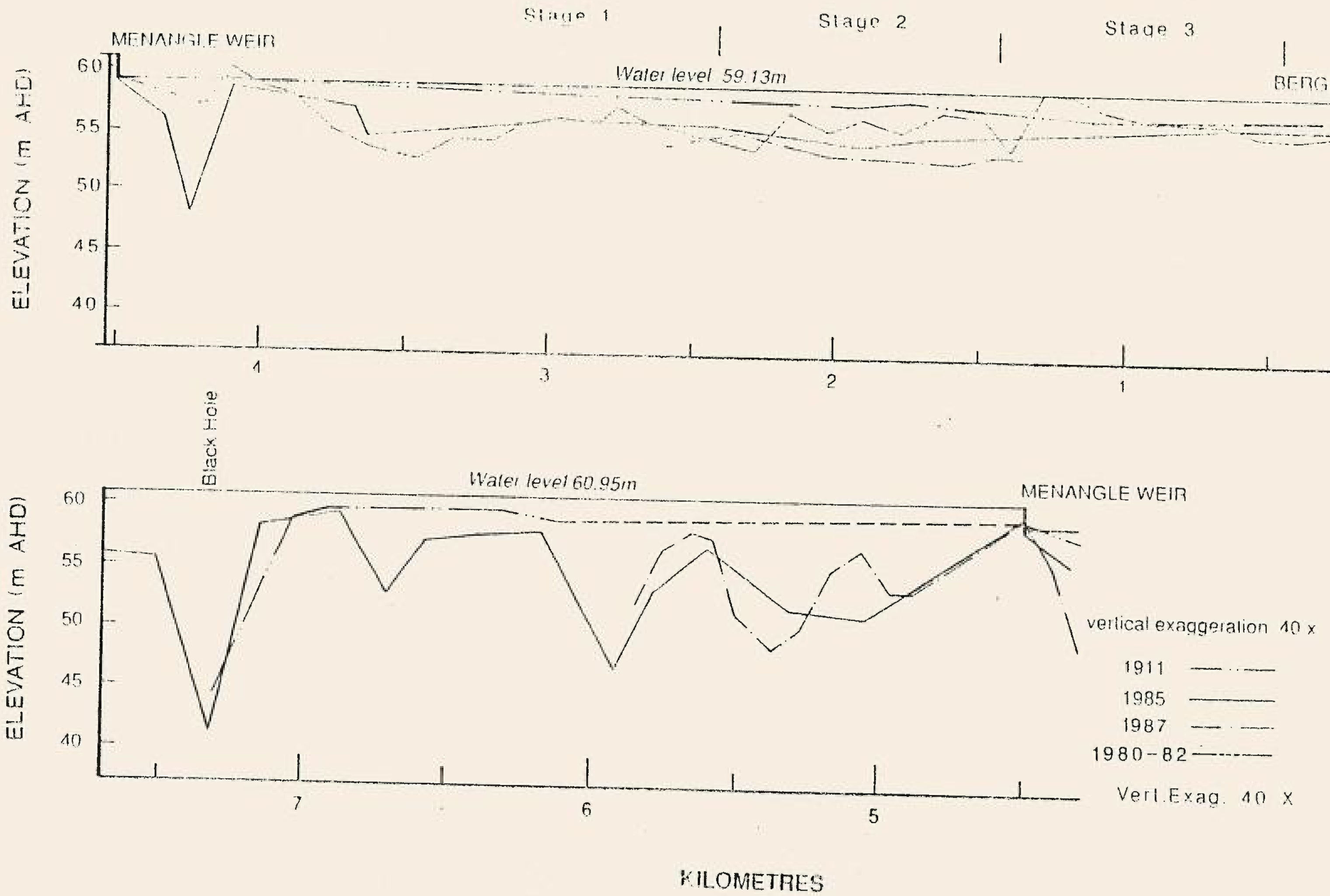


Figure 4.3 Longitudinal profile (thalweg) of the Nepean River at Menangle, showing changes over the period 1911 to 1987

4.4.2 Causes of long profile changes

Several natural and human processes may be involved in the general incision along the Nepean River.

Firstly, the construction of the major dams (Cataract, Cordeaux, Avon and Nepean) would have acted as sediment traps. The trap efficiency is unknown but there is general evidence from the literature (Petts, 1979; Taylor, 1978) that large dams trap enough sediment to cause downstream incision as the river adjusts to a reduced sediment load. Scholer (1974) and Bishop (1985) have both calculated sediment storage behind Warragamba Dam and shown it to be large.

Secondly, human activity in the catchment other than dam construction can alter the runoff/sediment load ratio of a stream (high ratios are typical of degrading or incising systems, low ratios are typical of aggrading or depositing systems). Clearing of large areas increases the erodibility of surface material and hence the erosion rate. Changing areas from one vegetation community to another, (eg. replacing forests with grasslands) may reduce the sediment loss. However, the sediment delivery ratios are largely unknown for the Upper Nepean catchment under various land use practices, so it cannot be definitely stated that the changed land use will have increased or decreased the quantity of sediment reaching the channel. In fact, the lag of the catchment response may be so long that insufficient time has passed for the effects to be felt.

Thirdly, increased discharges during the 1945-1987 wet period will have increased the capacity of the river to carry sediment, and if the stream did not have sediment available from the hillslope or channel banks then increased discharge would have meant increased bed incision. Comparison of the 1945 and 1956 aerial photographs indicates a considerable change in the morphology of the river in the 11 year period. There are far less trees in the river in the 1956 photographs and the banks show more mass movement scars. There may have been an active program of tree removal between 1945 and 1956, but the general evidence would support a period of rapid river degradation as a result of the floods of the late 1940's and early 1950's. It was this same sequence of floods that produced major changes in the MacDonald River (Henry, 1977).

It is my opinion that the incision is a result of a number of factors; the effect of the dams, the increased runoff in the wet period and possibly (although I am less convinced of this) land use changes in the catchment. Superimposed on these changes are the effect of extraction from within the river.

4.4.3 Cross-sectional changes

Changes in channel cross-sections are related to the same set of processes as changes in the channel thalweg. Cross-sections taken from a number of surveys along the Bergins weir section of the river allow comparisons of cross-sectional changes (Fig 4.4). The cross sections show increased deepening and widening of the river.

Re-surveyed cross-sections are only available in the dredged reach of

Bergins weir so only the effect of the dredging is clearly evident, although the previous discussion on the longitudinal profile changes suggests other causes as important.

Deepening in Stage 2 of the extraction was approximately 5 metres and width increased by 20 metres at cross section 22 (Fig 4.4). A considerable height of the left hand floodplain and bank has been removed, down to 3 metres above low water mark. The deepening at stage 2, cross section 11 was 1 metre and at cross section 3 it was 3 metres. Channel width increased by 10 to 20 metres at both sites. The left hand bank was largely untouched at cross section 11 but in cross section 3 it has be lowered by 5 metres.

In Stage 1 the deepening appears to have been minor, as does the change in width. This is due to the fact that dredging of the section was completed before 1981. Hence the two cross sections suggest a small amount of deepening of the section. Five metres of the top of the left hand bank has been removed (Fig 4.4).

4.4.4 Changes as a result of quarrying

Substantial changes in the river and floodplain have been produced by mining for sand, soil, and loam within the channel and on the floodplain. Many of these changes took place after 1945 and hence are recorded on aerial photographs. However, there is considerable evidence for and debate about mining prior to this period. Some of the changes that are thought to be natural may well be human.

The history of quarrying and dredging was reviewed in Chapter 2. In this section the effect of dredging and quarrying on channel and floodplain geometry will be specifically discussed.

The floodplain quarrying has resulted in a substantial lowering of the floodplain (Figs 2.5 and 4.4), increasing the frequency of inundation of the areas lowered. This lowering has been most extensive in the reaches of river downstream of the Menangle Road bridge, although there has probably been quarrying and floodplain lowering on the right hand bank of the river between the F5 Freeway bridge and the railway bridge. Lowering has been of the order of 2 to 5 metres.

Within the channel dredging has removed the benches and in-channel ridges. These changes have increased the cross sectional area of the channel by at least 50 percent in some areas (Fig 4.4). The bank of the river has also been lowered by several metres, particularly on the left hand bank downstream of the road bridge. The removal of the bars and ridges with their stands of trees has reduced the resistance to flow through the river.

Quarrying has removed the levee and associated vegetation for a substantial length of the river on the left hand bank. There is now no barrier to high velocity flows moving across the floodplain. Lowering of the floodplain by up to 6 metres means that floods are more frequent for the quarried section of floodplain.

4.4

Figure 4.4 Cross sectional changes in the Nepean River at Menangle. Map shows location of cross sections and several typical cross sections.

(SEE FOLIO)

4.5 BED SEDIMENTS

The bed sediments of the river over three reaches were retrieved with a grab sampler. No samples were taken from the second reach between the railway and the road bridges. All samples were air dried and then a number of these sieved. No other pretreatment occurred except for the samples near Bergins weir, which will be examined in some detail.

The sediment sampling sites (Fig 4.2) were located at random intervals along the channel. At each site the boat was allowed to drift whilst the samples were collected, so the samples represent a composite of the bed material in the general location of each site and are not specific to one small section of the river bed. Notes were made of the depth of river, sediment type and the degree of turbidity when the sample was released into the sampling bag (Table 4.1)

Except for river sites 1 and 2 the river bed appears to be composed of medium sand with minor amounts of gravels (Fig 4.5). There are two sites at which sandstone fragments were found, sites 13 and 15. It is possible that these are not bedrock but rather represent fragments derived from the banks or from further upstream. For site 15 it is possible that the samples are derived from bedrock cropping out in the river bed. Site 15 is within 200m of the location where bedrock outcrops at the Menangle weir. In-channel drilling or seismic profiling would be required to confirm the depth of sediment at site 15.

The only place at which clay was found was at site 13, where the clay was in the form of mud balls. These are features typically associated with bank collapse; they do not last for long in an active bedload stream (unless buried) because they are easily abraded. No great significance can be attached to them in terms of the sediment load of the river other than to show that on occasions when the bank collapses the finer material can behave as coarse bedload and be transported along the bed until it fragments. In general there is no evidence of clay deposition on the bed or in the bed sediments of the Nepean River in this reach.

Exceptional sites for bed sediment are sites 1 and 2, upstream of Bergins weir. The material brought to the surface in the grab sampler was a thick, black suspension in which there were coarse particles of quartz sand and coal. This ooze was extremely sticky, it required some effort to wash off hands and when poured into the water behaved like a high density turbidity current, dispersing only to a minor extent and rapidly flowing to the bed of the river. It is believed that this material was washed into the river in November 1986 when a tailings wall for a settling pond collapsed at the Glenlee Coal Washery and released a considerable quantity of material into the river. This material is still present in the bed of the river and would appear to be forming a dense black blanket over the bed of the river. The small rise of stage observed during the 22.8.87 survey did not appear to mobilise this material, even though flow velocities near the bed were of the order of 0.22m/sec as measured by an Ott current meter.

TABLE 4.1

Location and description of river bed smaple sites
(refer to Fig 4.2)

River site 1.	100m upstream from Bergins weir. 3m depth. Coal fragments (many) in sampler. Water in dredge very black. Black material is sticky and when poured into the water acts as a density current and does not rapidly disperse.
River site 2.	30m upstream of creek and adjacent to MWSDB sampling site. Gauge reading 1.67m on 22.8.87. Water depth between 4 and 4.5m. Two samples retrieved. Both contained coal fragments and sand. Water black and did not settle out in entire period of transport in the boat nor when left sitting on the laboratory bench for 2 days.
River site 3.	Opposite peg labelled Q7. Water depth 4.5m. Clear water. Coarse sands and some organic fragments.
River site 4.	Opposite peg Q5. Water depth 4 to 4.8m. Organic fragments and clean sand, coarse.
River site 5.	Downstream of dredged section. Depth 4m. Water slightly turbid. organic debris in amongst coarse sand.
River site 6.	Depth 3m. In line with traverse 11, traverse through piezometers. Slightly turbid, organic fragments in amongst coarse sand. Majority of turbidity appears to be a result of suspension of small filaments of organic material and not clay.
River site 7.	20m upstream from creek entering on right hand bank. Depth 4.5m. sand with organics, some large pieces of wood. Water turbid when brought to surface, mostly due to organic fragments.
River site 8.	Near white peg on left hand bank and 100m downstream of road bridge. Depth 2m. Clear, coarse sands with organic fragments. Bridge gauge reading 1.45m on 22.8.87
River site 10.	Opposite excavation site approximately 400m upstream of F5 Freeway bridge. Depth 2.2m. Clean sand but water turbid when brought to surface. Charcoal and shells in sample.
River site 11.	200m upstream from F5 Freeway bridge and opposite a survey peg. Depth 2.5m. Material similar to site 10. No sample retained. Sandstone cropping out on right hand bank from this point downstream. Road bridge and further downstream the sandstone banks at least 4 to 5 m high
River site 12.	50m upstream of F5 Freeway bridge. Water 9.5m deep. Clean sand with little turbidity in the sampler.
River site 13.	Opposite sand bank on left bank of river. 3.2m deep. Large sandstone fragments and poorly sorted sand and gravels. Some mudballs. Suggests recent and nearby source for material.
River site 14.	50m upstream from creek entering on right hand bank. 4.5m deep. Sample sandy but very turbid in grab sampler. Some charcoal in sample.
River site 15.	20 m upstream from creek entering on left hand bank, 100m upstream of railroad bridge. 5.5m deep. Turbid. coarse sand and sandstone fragments. Sampler hitting solid material at depth (possibly bedrock fragments, logs, etc.).

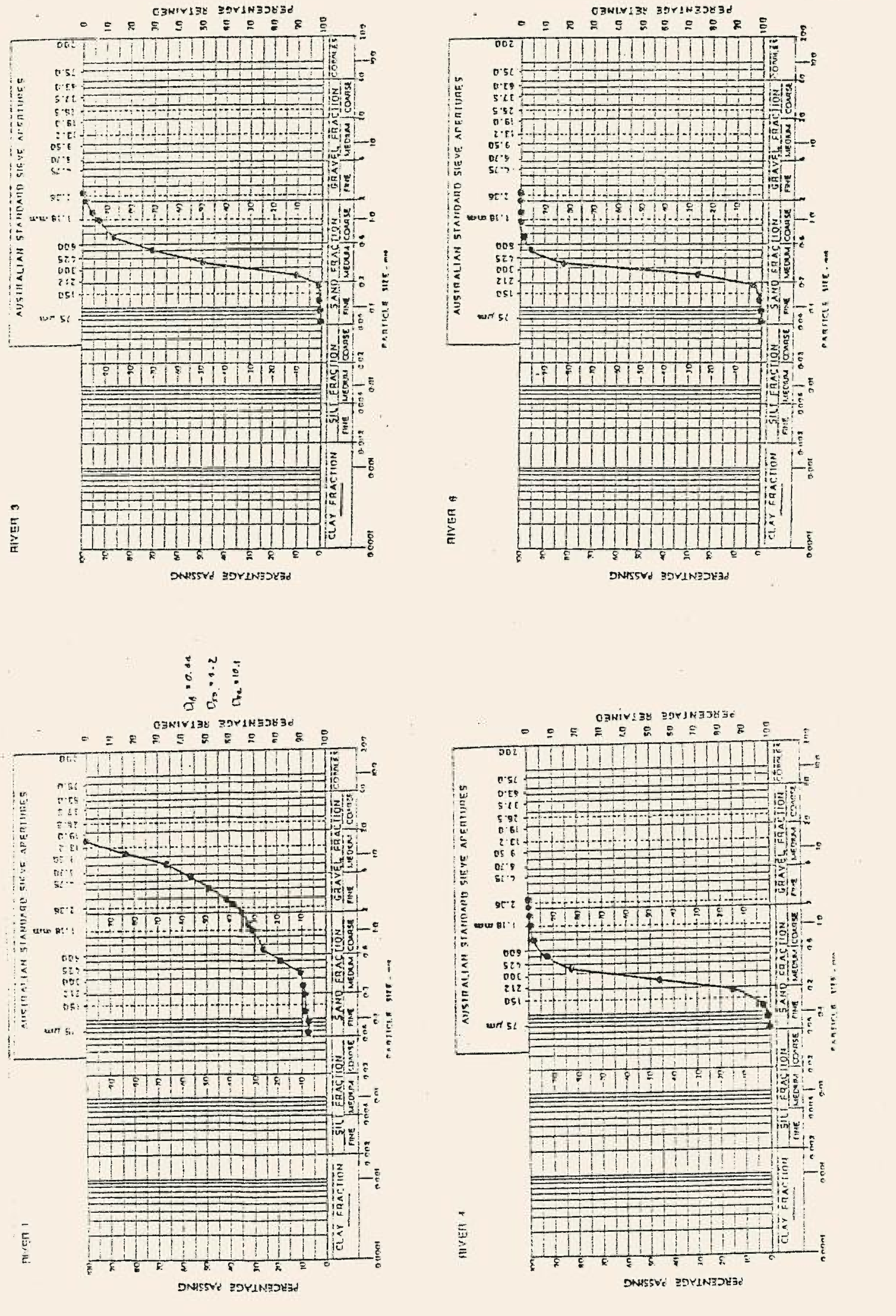
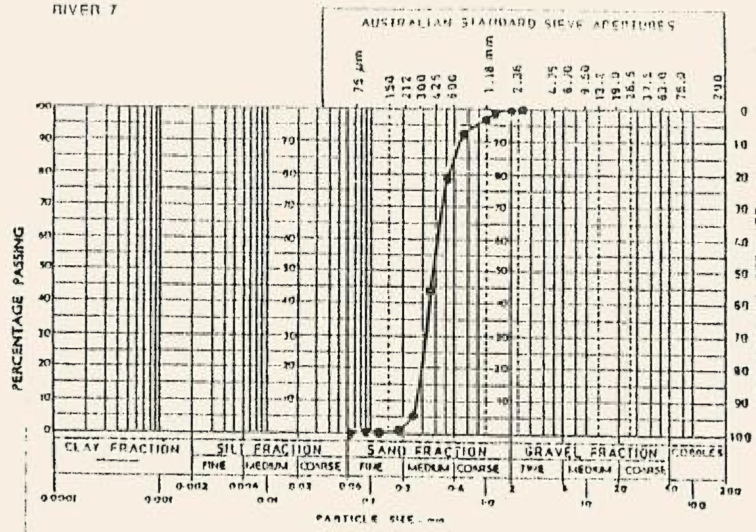
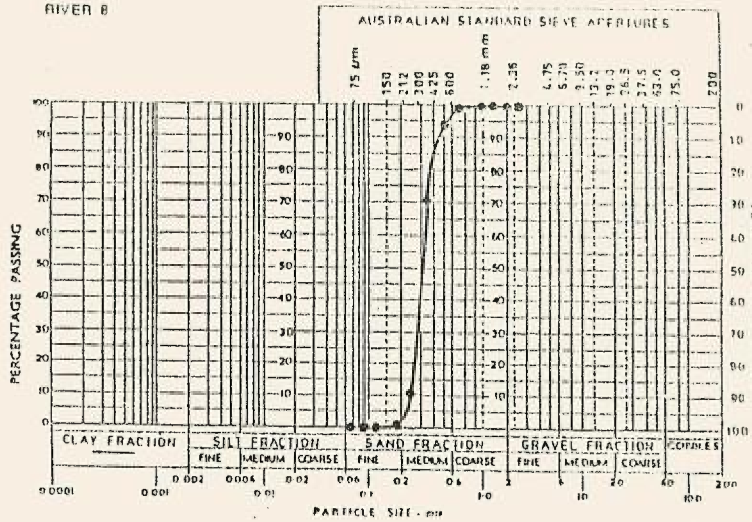


Figure 4.5 textural curves for river bed and bank sediments obtained by grab sampler

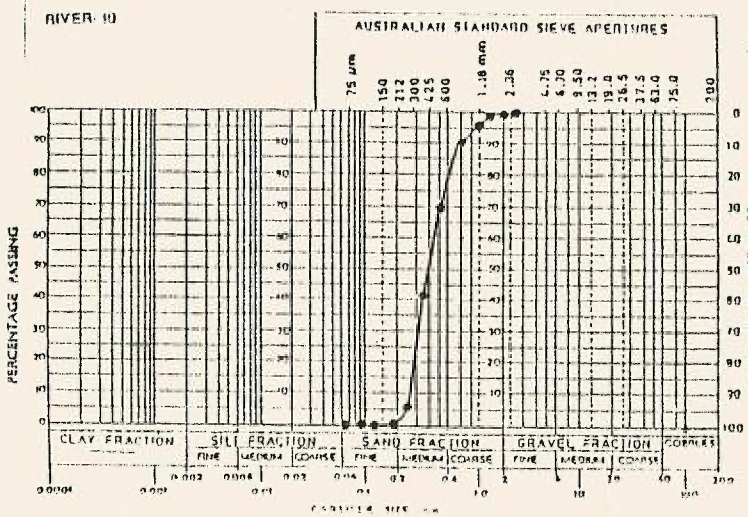
RIVER 7



RIVER 8



RIVER 10



RIVER 12

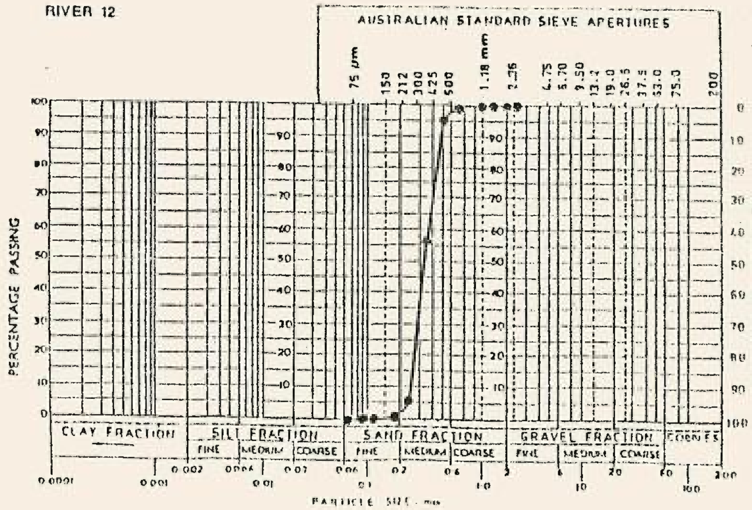
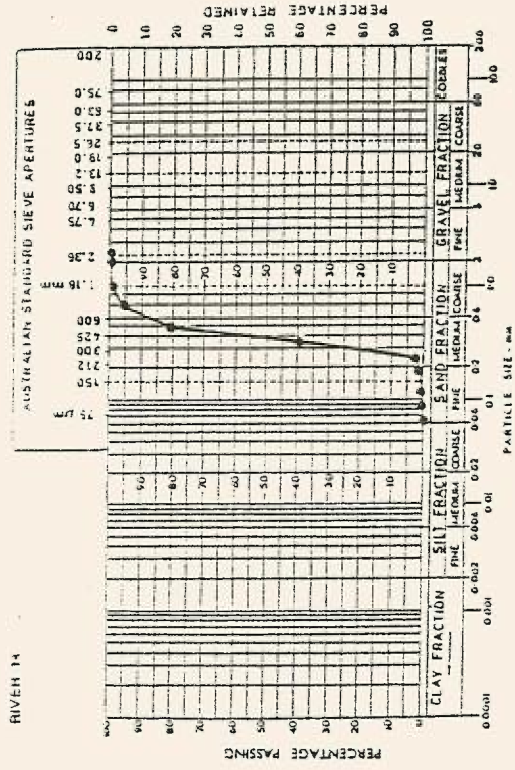
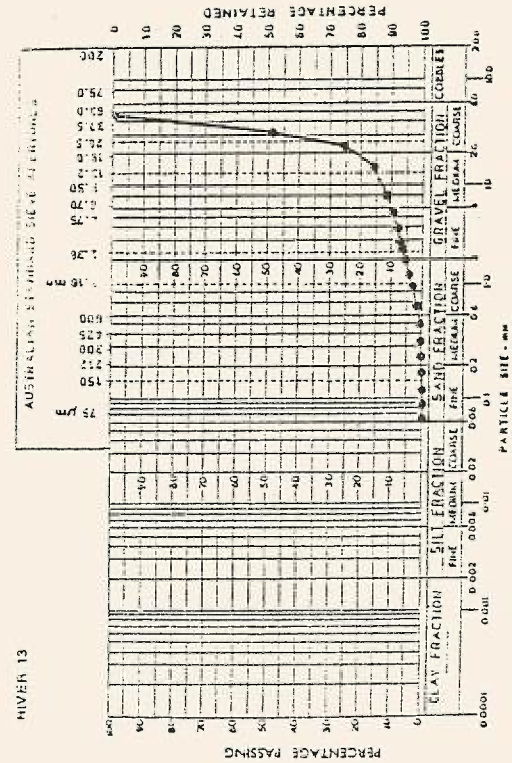


Figure 4.5 (cont)





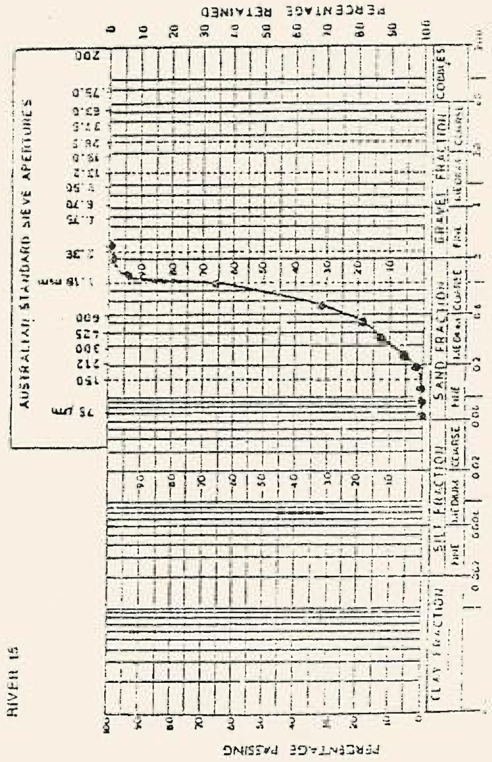


Figure 4.5 (cont)

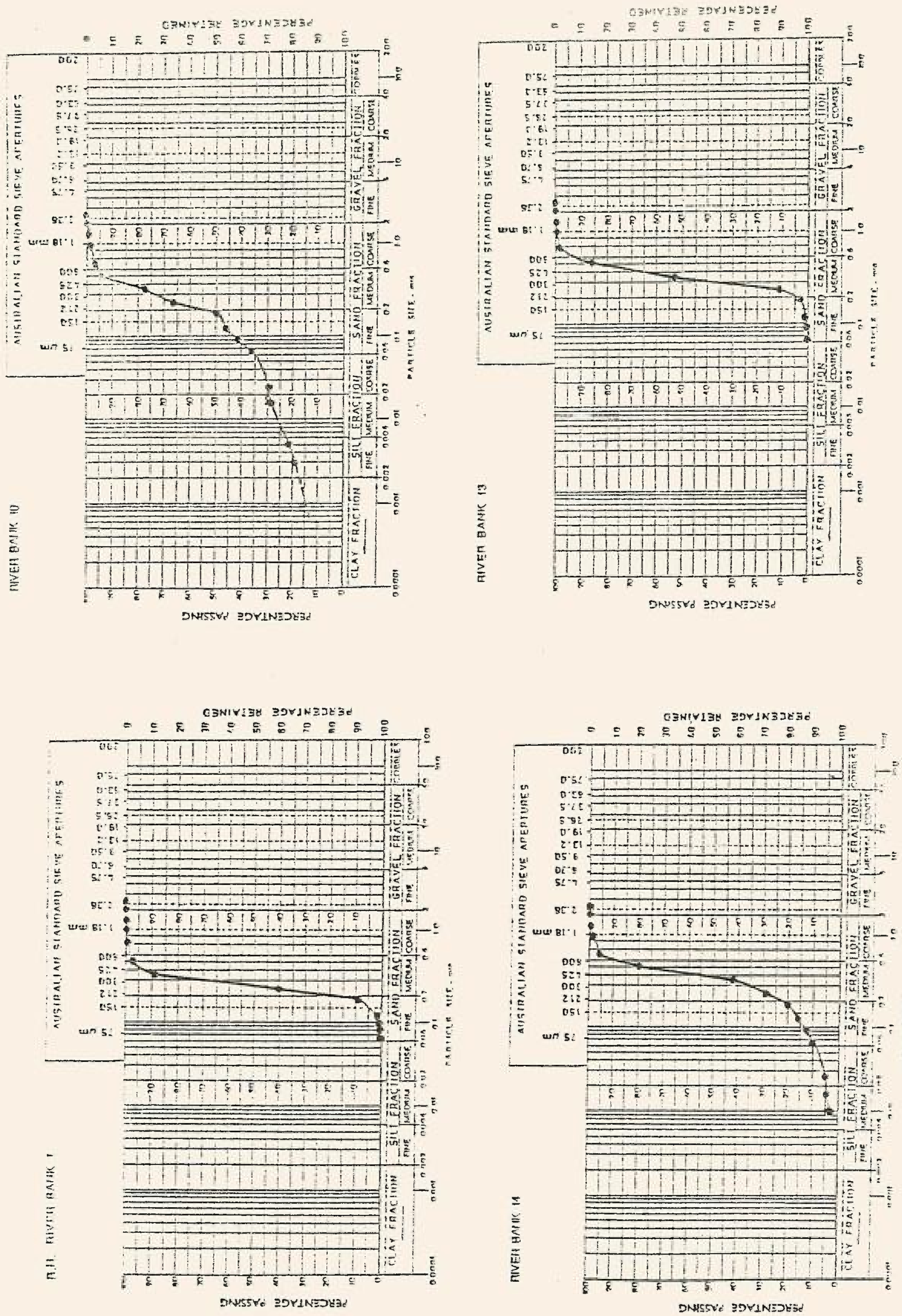


Figure 4.5 (cont)

There is no evidence that the mining operation or previous dredging of the upstream section of the Bergins weir pond has had an effect on the bed sediment composition of the Nepean River (Fig 4.6, Table 4.2). The bed sediments have similar median and 16 and 84 percentile values throughout the whole reach. No differences are evident in mineralogy or organic matter content as seen in a hand sample.

The downstream trend in median grain size of bed material (D50) is constant except for sites 13,15, and 1. Sites 13 and 15 include rock fragments from the bedrock of the right hand bank. Site 1 includes the coal fragments. There is no difference in grain size between the material in the dredged reach (sites 6 to 8) and the samples in the undredged sites. The D16 and D84 values, the diameters for which 16 percent and 84 percent of the material is finer, are also similar downstream. For the D16 there is a range in diameters between 0.1 and 0.3 mm and for D84 between 0.3 and 0.6 mm.

TABLE 4.2

D16,D50 and D84 of bed and bank samples ordered in downstream direction

Sample	D16	D50	D84
10	0.28	0.39	0.64
10 bank	0.001	0.20	0.43
12	0.27	0.34	0.46
13	14.00	33.00	40.00
13 bank	0.27	0.34	0.50
14	0.28	0.38	0.53
14 bank	0.12	0.39	0.56
15	0.43	1.00	1.30
8	0.26	0.32	0.39
7	0.28	0.38	0.60
6	0.23	0.28	0.37
4	0.18	0.27	0.37
3	0.26	0.37	0.66
1	0.43	4.20	11.00
1 bank	0.19	0.27	0.33

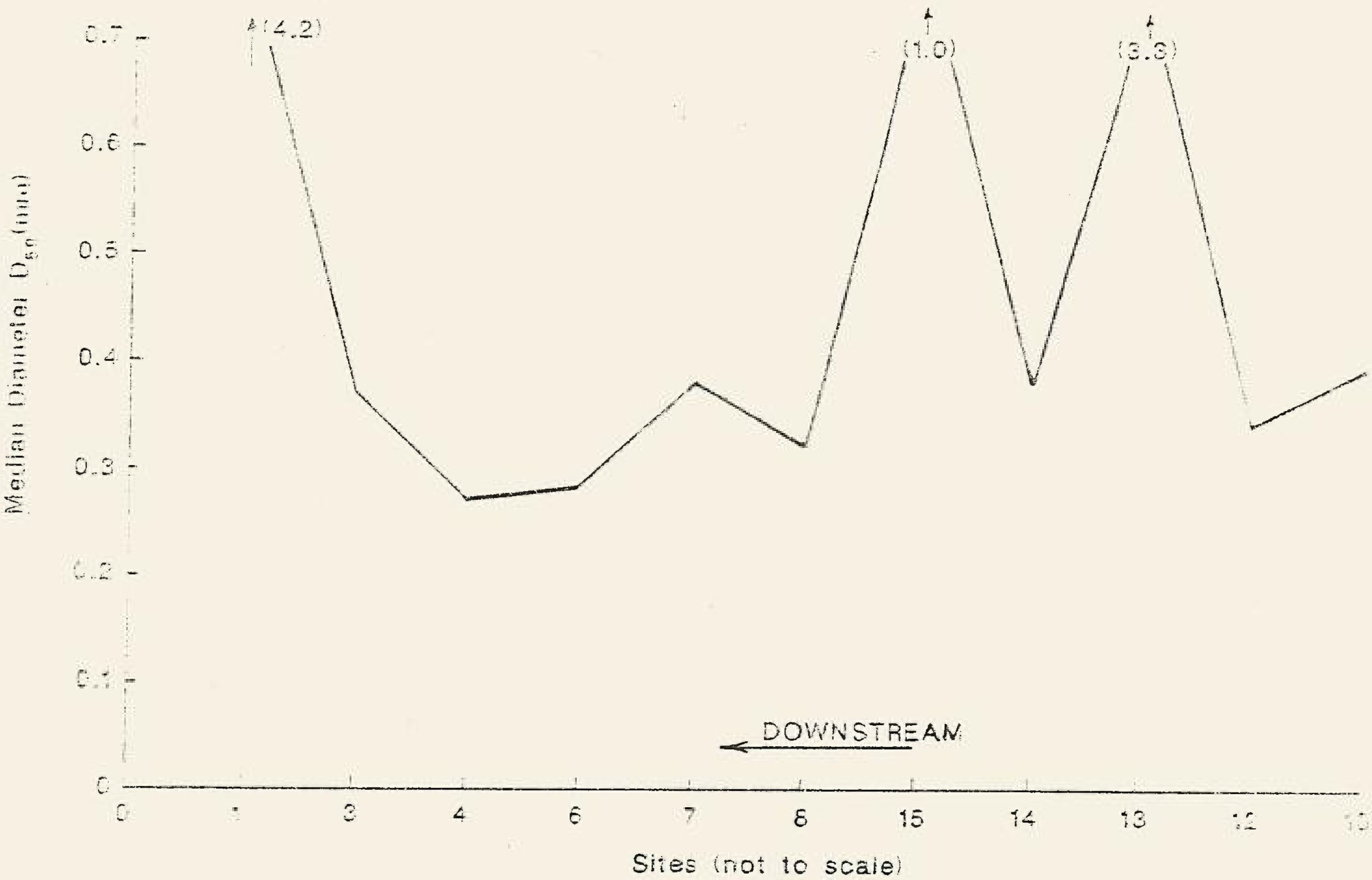


Figure 4.6 Trends in bed sediment grain size along the Nepean river

The narrow range in particle size for the majority of bed sites is exceptional. It suggests a bed material source where there are no significant coarse fractions being produced. It also suggests that the fines, ie. particles less than 0.1mm in diameter are either not present in the sediment load or are being transported through the reach and not deposited in the stream bed. The presence of medium sand may suggest armouring of the bed. That is, the fine material is winnowed out by small flows leaving behind coarse fragments. It will be shown in section 4.8 that the river is competent to move the sediment.

Several bank samples were collected in association with the bed sediment sampling. Sites 1, 13 and 14 were sand bars on the river banks. They have the same textural characteristics as the bed sediments (Table 4.2, Fig 4.5). Site 10 was a cohesive bank sample: it had a high percentage of clay within it. This pattern of sandy banks and cohesive banks is common along the river, with the banks being dominantly sandy.

4.6 FLOODPLAIN STRATIGRAPHY

Floodplain stratigraphy needs to be investigated if the extent of the resource and the manner in which it was emplaced by the river is to be understood.

There are limited data available on floodplain stratigraphy. Some sections are exposed in mass movement scars on the river bank, in gullies that cut through the levee and in exposed excavation pits. The majority of the drilling has been resource oriented and so does not show the finer detail of the stratigraphy. Some limited augering was undertaken as part of this study but cannot be classified as exhaustive. This evidence has created the framework for establishment of several working hypotheses regarding stratigraphic history. Further work is needed to test these ideas.

There are four major sources of information on the stratigraphy of the floodplain. The first is some stratigraphic analysis undertaken by Pioneer Quarries. The second is some drilling carried out for foundations investigations by the Department of Main Roads, the third is a series of Gemco auger holes along the levee of Bergins weir reach, and the fourth is drilling and resource mapping data provided by K.Steggles for Menangle Sand and Soil P/L.

Pioneer Quarries Sydney Pty Ltd Drawings no.PQS218 and PQS219, dated 5.11.73 provide some detail on the stratigraphy of the floodplain adjacent to the river downstream of the Menangle Paceway. Four stratigraphic cross-sections from the river bank to the eastern side of the levee and one long section along the levee are provided. Two of these sections, C and A, are transferred to Fig 4.2. The descriptions of materials in the sections are not clear, the terms being colloquial rather than scientific. The descriptors they use are listed below together with an interpretation of their meaning.

Black top soil
red top soil
loam
mortar sand
fine sand
coarse sand
coarse sand with pea gravel
clayish soil
clay

Red and black top soil presumably refer to loams and loamy sands with these colours. Mortar sand is probably a clayey sand. Clayish soil is either clayey loams or weathered clay (Wianamatta Group Shale) and clay could be Wianamatta Group Shale.

Between the railway bridge and the F5 Freeway bridge two stratigraphic sections are used to define the sedimentology of the subsurface deposit. The first is provided from a Department of Main Roads plan (regn. no.6005 076 BC0133) 'Bore details and pile layout'. The cross section for the northbound carriageway is used. This section distinguishes among sand, silty sand and sandstone. It is probable that a considerable amount of detail has been lost in these sections by the coarse grouping of units. Nevertheless the bedrock contact is well established. The second is a section provided by K.Steggles on a cross section of line 4 within Lot 202 in Dp 590247, drawn by John Daly and Associates, surveyors, plan reference 87/197. This shows the material as river sand, sandstone bedrock, floodplain soil, and bank sand.

Associated with a plan by Blue Metal Industries Ltd, File no.MS 213 (date unknown, but probably drawn in the early 1970's) of a number of sections across the Nepean River between Bergins weir and Menangle Road bridge is an abbreviated table of results of Gemco drilling (Table 4.3). The reference mark is water level. It appears that the drilling was mostly carried out on the levee on the right hand bank (Fig 4.7) although some drilling was carried out in the river bed. The general trend shows either sandstone or clay at approximately 35 to 50 feet (10 to 15 metres) below water level (presumably river low flow). These sections are not transposed to Fig 4.2 because their exact location is uncertain.

The fourth source of information is from two reports by K.R.Steggles and Associates Pty Ltd, one dated 26.5.1983 ('Geological investigations and mining plan - Menangle River Sand and Soil Supplies Pty Ltd Soil deposit at Menangle NSW') and the other dated 9.5.1985 ('Geological investigations and mining plan Menangle River Sand and Soil Supplies Pty Ltd. Stage 2 soil and sand deposit, Menangle NSW'). The Steggles reports detail the stratigraphy on the left hand floodplain of the Bergins weir reach of river. The details of the survey are not presented here, but one of the sections, 17N, is illustrated with a reinterpretation (Fig 4.2).

TABLE 4.3

Reports of Gemco drilling along the Bergins weir section of the Nepean River

HOLE	TOTAL DEPTH OF DRILL [ft]	DEPTH BELOW WATER TO BASE [ft]	TYPE OF BASE
1	70	43	Decomposed sandstone
2	70	32	Sandy clay
3	70	30	Sand
4	34	--	Clay
5	70	24	Clay
6	28	--	Clay at 10ft
7	40	--	Sandy clay at 20ft
8	70	32	Sandy clay at 62ft
9	46	6	Clay at 36ft
10	34	+6	Red clay at 24ft NOTE:Clay encountered on Bank 6ft above water. However,cased hole in river itself went to 22ft below water at this position in sand-no base reached.
11	70	15	Clay at 66ft
12	70	25	Sand. Cased hole in river bed to 27ft below water.
13	70	20	Sand-no base reached.
14	70	20	Sand-no base reached.
15	36	+18	Sandstone. NOTE:Cased hole in river bed at this location went to 23ft below water.
16	93	50	Sandstone
17	86	46	Sandstone at 83ft
18	78	25	Shale and clay at 65ft
19	34	+22	Clay at 20ft NOTE:River tests at this location indicate sand in river bed to 18ft
20	17	10	Sandstone
21	41	--	Clay at 8ft. NOTE:Sand evident in river clay at 44ft. Similar to hole 20.

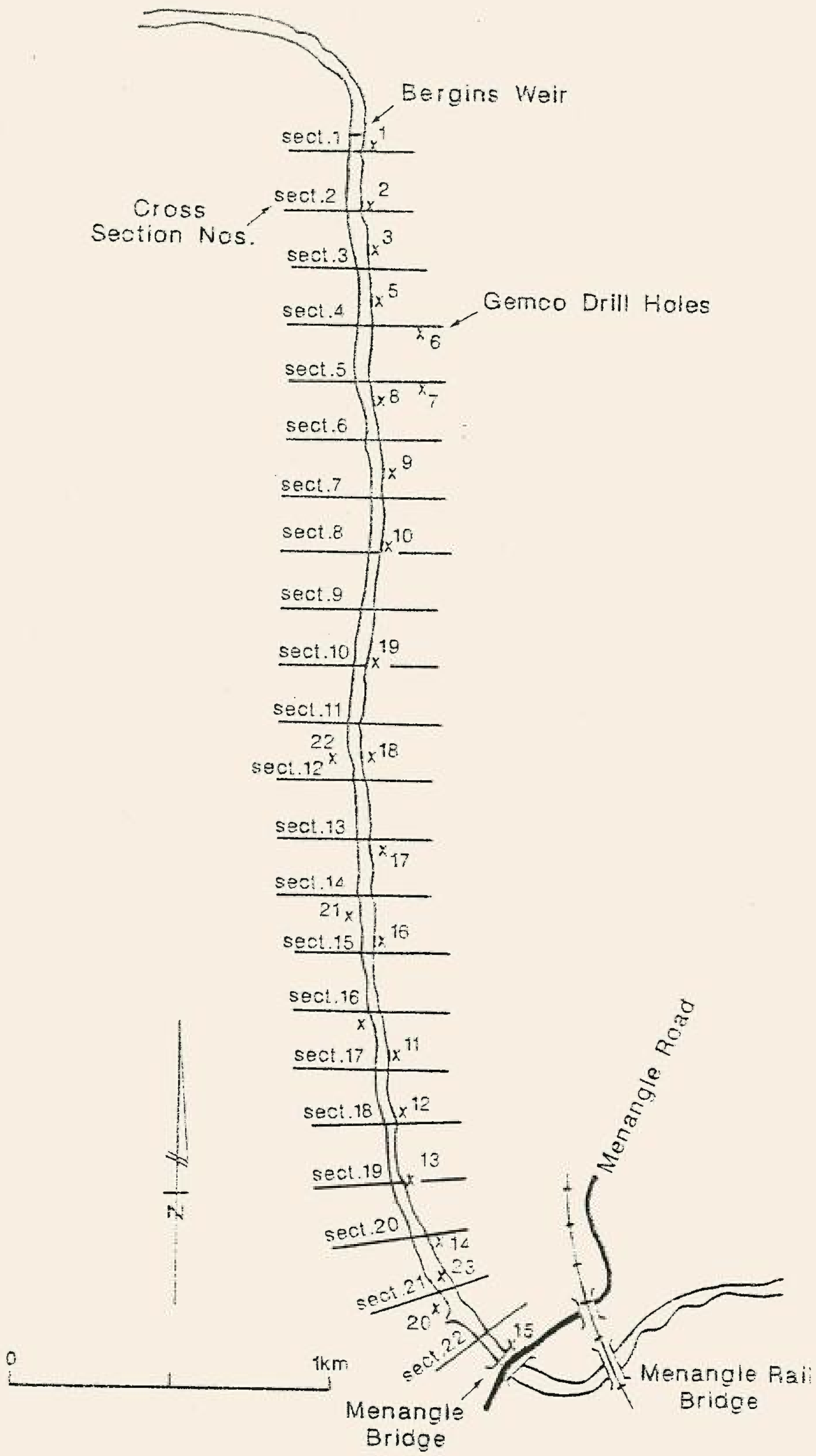


Figure 4.7 Location of cross sections and Gemco drilling of Blue metal Industries

A number of auger holes were drilled across the floodplain in the line of the piezometers in the Bergins weir reach. Detailed descriptions of the materials using the Northcote Key (Northcote, 1971) and Gardiner and Dackombe (1983) define the stratigraphy to the depths of augering.

Samples were obtained by hand augering: holes were drilled to bedrock (weathered) or to the water table. Colour was determined by comparison with the soil colour charts of Oyama and Takehara (1967). Field texture and the nature of the lower boundary were determined according to Northcote (1971). The latter is imprecise owing to the disruption imposed by augering. The texture classification has been modified to indicate the presence of fine sand in light, medium, and heavy clays. The value of pH was measured using the Raupach pH kit. Other descriptions were made according to the methods of Gardiner and Dackombe (1983, Ch6).

4.6.1 Results of stratigraphic investigation using augers

The cross-section (Fig 4.8) shows four distinct sediment types. Each exists within a distinct hydraulic environment and this is reflected in different particle size distributions and sedimentary structures. The sampling was by hand augering which has destroyed much of the original layering. The following description relies mainly on texture and colour differences.

i) Lagoonal muds and clays - these are primarily still water environment fine sandy medium clays and heavy clays and were sampled in Profile 5 (Fig 4.8, Table 4.4). There is no conspicuous bedding and colour changes are gradual from dark brown at the surface to mottled blue gleyed clays at depth (>3m). The gley colours indicate a permanently moist environment.

ii) Floodplain sandy clay loams - the materials in Profiles 1, 2 and 3 (Table 4.4, Fig 4.8) are remarkably consistent in colour and texture. The materials are classified mainly as fine sandy clay loams, which is consistent with the deposition of the finer overbank materials further from the channel where flood flow velocities are likely to be low. The materials are uniformly dark in colour as a result of high organic content. It is presumed that the materials were laid down in layers that persisted at the land surface for a period sufficient for organic material to be incorporated through the thickness of each layer. At depth (below 1-2 m) the materials become mottled indicating a fluctuating watertable.

The lagoonal and floodplain sediments probably interdigitate.

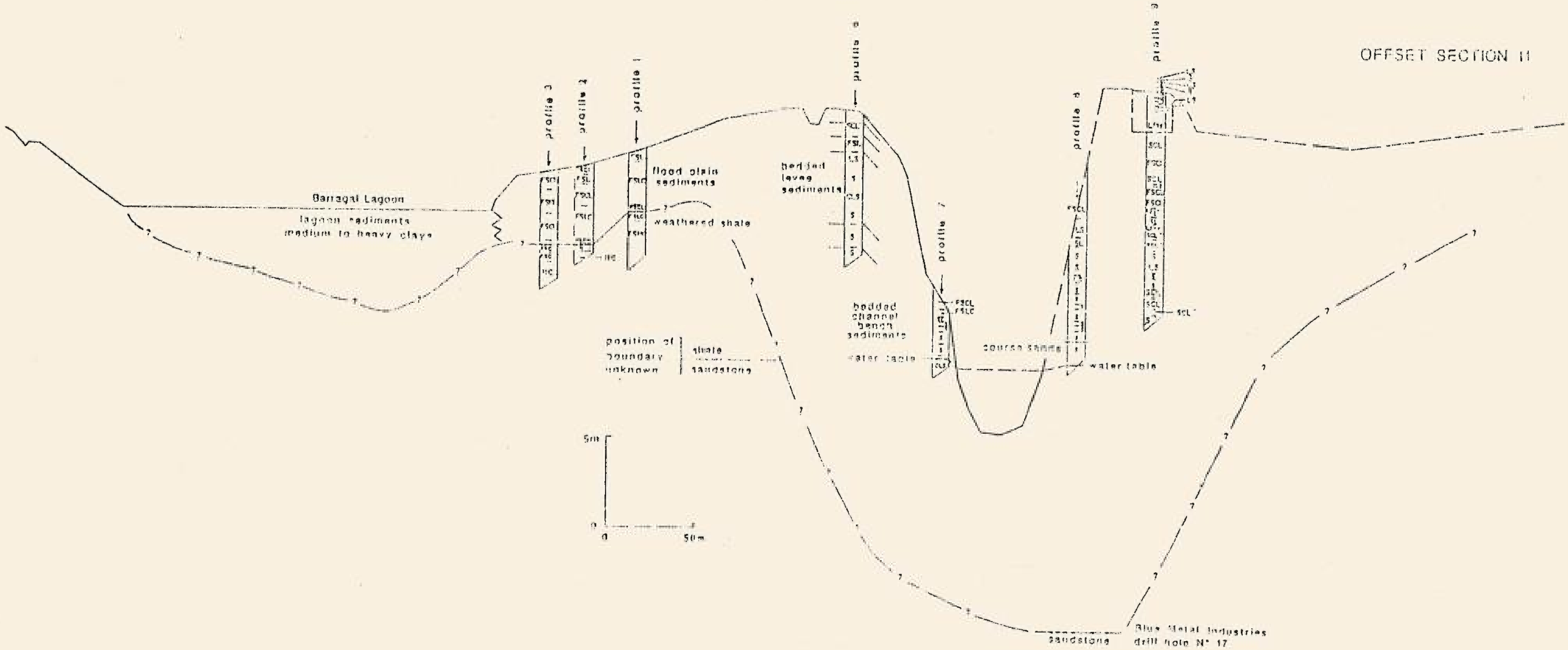


Figure 4.8 Stratigraphic section across river based on auger drilling. This section is located in line with the piezometers, they being hole 1,2 and 3 on this section.

TABLE 4.4A

Material description for auger sample: profile 1

Located 80m east of Barragal Lagoon on lower flanks of the levee. Smooth undulating micro relief, amplitude .3-.5m, wavelength 1-4m. Pasture grass - 100% cover. No surface scour.

Depth (m)	Description
0.0-0.5	Sample 0.1m. Brownish black 5YR 2/2, fine sandy loam, apedal massive, weak, many very fine and fine roots, pH 6. Boundary diffuse.
0.5-2.8	Sample 0.8m. Dull reddish brown 5YR 4/3 fine sandy light clay, apedal massive, weak, few fine roots, pH 6.5. Sample 1.8m. Greyish brown 5YR 4/2, fine sandy light clay, apedal massive, few very fine roots, pH 6. Boundary gradual.
2.8-3.2	Sample 2.9m. Brown 7.5YR 4/4, fine sandy clay loam (somewhat sandier than above), apedal massive, no roots, pH 6.5. Boundary gradual.
3.2-3.8	Sample 3.3m. Reddish brown 5YR 4/6 with small (5mm) spheroidal mottles, fine sandy clay, moderately cohesive, no roots, apedal massive, pH 5.5. Boundary diffuse.
3.8-6.0 plus	Sample 3.9. Reddish brown 2.5YR 4/8, fine sandy heavy clay, apedal massive, no roots, pH 5.5. Mottling as above. Note: black coatings (assumed to be Manganese) on faces. The material appears identical to exposure of weathered bedrock (B horizon) in shale quarry on adjacent ridge.

TABLE 4.4B

Material description for auger sample: profile 2

Located low on levee 50m from Barragal Lagoon. Smooth undulating micro-relief, 1m wavelenth, 0.2m amplitude. Pasture grass- 100% cover. No surface scour.

Depth(m)	Description
0.0-0.4	Sample 0.2m. Brownish black 10YR 2/3, fine sandy clay loam, apedal massive, weakly pedal at surface, moderately weak, common fine and very fine roots, pH 6.5. Boundary gradual.
0.4-0.9	Sample 0.6m. Black 2.5Y 2/1, fine sandy loam, apedal massive, moderately weak, few fine and very fine roots, pH 6.5. Boundary gradual.
0.9-2.2	Sample 1.5m. Very dark brown 7.5YR 2/3, fine sandy clay loam, few very fine roots, apedal massive, moderately weak, pH 6.5. Boundary diffuse.
2.2-3.9	Sample 3.5m. Mottled, 50% brownish black 7.5YR 2/2. 30% dark reddish brown 5YR 3/3, 20% yellowish grey 2.5Y 3/1, fine sandy clay loam. no roots apedal massive, moderately weak, pH 6.5. Boundry diffuse.
3.9-4.2	Sample 4.0. Brownish black 7.5YR 2/3, fine sandy light clay, apedal massive, moderately weak, no roots, pH 8. Boundary diffuse.
4.2-4.6	Sample 4.4. Mottled, 70% reddish brown 5YR 4/6, 30% greyish brown 7.5YR 4/6, fine sandy light clay, no roots, moderately firm, apedal massive, abundent black nodules to 5mm (assumed to be Mn), pH7.5. Boundary gradual.
4.6-5.0 plus	Sample 4.8m. Mottled, 90% dark reddish brown 2.5YR 3/6, 10% brownish grey 7.5YR 4/1, heavy clay, apedal massive, very strong (deformed plasticly underfoot, no roots, pH 8.0. Weathered shale (see profile 1).

TABLE 4.4C

Material description for auger sample: profile 3

Located 30m from Barragal lagoon at base of levee. Smooth undulating surface, wavelength 1-4m, amplitude .5m. Pasture grass, 100% cover, no obvious scour.

Depth(m)	Description
0.0-1.0	Sample 0.5m. Black 7.5YR 2/1, fine sandy clay loam, apedal massive, weakly pedal at the surface, moderately weak, common fine and very fine roots at the surface, few below 0.1m, pH 6.0. Boundary gradual.
1.0-2.3	Sample 1.3. Mottled, 70% dark brown 7.5YR 3/4, 30% dull reddish brown 5YR 4/4, fine sandy clay loam, apedal massive, moderately weak, few fine roots throught, pH 6.0. Boundary diffuse.
2.3-4.0	Sample 2.9. Mottled, 70% dark brown 7.5YR 3/3, 20% dark reddish brown 5YR 3/4, 10% dark reddish brown 5YR 3/6, fine sandy clay loam, no roots, apedal massive, moderately firm, pH 6.5. Boundary gradual.
4.0-4.4	Mottled, 80% dark brown 7.5YR 3/3, 20% dark reddish brown 5YR 3/4, fine sandy light clay, no roots, apedal massive, moderately firm, pH 6.5. Boundary diffuse.
4.4-4.9	Mottled, 40% dark reddish brown 2.5YR 3/6, 30% dark reddish brown 5YR3/3, 30% reddish grey 2.5YR 4/1, fine sandy medium clay, apedal massive, moderately firm, no roots, pH 7.5. Boundary diffuse.
4.9-6.0 plus	Sample 5.3m. Mottled, 60% reddish brown 2.5YR 4/8, 30% dark reddish brown 5YR 3/3, 10% black nodules (assumed to be Mn), heavy clay, apedal massive, moderately firm, no roots, pH 8.0. Weathered shale (see profile 1).

TABLE 4.4D

Material description for auger sample: profile 4

Site approximately 80m southeast of Barragal Lagoon in depression used as a settling pond. Approximately 10m southeast of excavated pond, adjacent to base of hillslope. Smooth undulating microrelief, broken by mounds 0.2m high and 0.2-1.0m across. Pasture grass, 90% cover.

Depth(m)	Description
0.0-0.4	Sample 0.2m. Dark brown 7.5YR 3/3, heavy clay (no sand), apedal massive, very firm, few fine and very fine roots, pH 6.0. Settling pond sediment. Boundary clear.
0.4-0.8	Sample 0.5. Dull reddish brown 7.5YR 4/4, fine sandy clay loam, few fine roots. apedal massive, moderately weak, pH 5.5. Boundary diffuse.
0.8-1.3	Sample 1.2. Reddish brown 5YR 4/6, fine sandy clay loam. apedal massive, very weak, no roots. pH 6.5. Boundary diffuse.
1.3-1.7	Sample 1.6. Dull brown 7.5YR 6/3 with abundent black nodules (assumed to be Mn), fine sandy clay loam, no roots, apedal massive, pH 5.5.
1.7-2.0	Sample 1.8. Bluish grey 5PB 5/1 with bright reddish brown 5YR 5/8 and yellow orange 10YR 7/8 mottles, gleyed heavy clay, no roots, apedal massive, pH 6.0. Weathered shale (see profile 1). Boundary gradual.
2.0-2.8 plus	Sample 2.6. Dull yellowish brown 10YR 5/3 with bright brown 7.5YR 5/8 mottles, no roots apedal massive, moderately strong, pH 7. Weathered shale (see profile 1).

TABLE 4.4E

Material description for auger sample: profile 5

Adjacent to the northeast outlet to Barragal Lagoon inside fenced area. Site appears mechanically modified. Smooth microrelief. Pasture grass, 100% cover, with recently planted trees at 10m spacing.

Depth(m)	Description
0.0-10.0 plus	Sample 0.5m. Very dark reddish brown 5YR 2/3, fine sandy clay loam, apedal massive, moderately strong, no roots, pH 6.5. Boundary diffuse. Sample 2.5m. 30% bright brown 7.5YR 5/8, 70% dark brown 7.5YR 3/3, fine sandy medium clay, apedal massive, moderately strong, no roots, pH 6.5. Boundary diffuse. Sample 5.5m. 40% dark bluish gray 5B 4/1, 60% bright brown 7.5YR 5/8, fine sandy medium clay, apedal massive, moderately strong, no roots, pH 7.5. Boundary diffuse. Sample 7.5m. 50% dark bluish gray 5B 4/1, 50% dull yellowish brown 10YR 5/4, fine sandy heavy clay, apedal massive, very strong, no roots, pH 8.0. Boundary diffuse. Sample 9.5m. 50% bluish gray 5B 6/1, 50% bright yellowish brown 10YR 6/8, nodules (assumed to be Mn), fine sandy heavy clay, apedal massive, moderately strong, no roots, pH 8.5.

TABLE 4.4F

Material description for auger sample: profile 6

On levee crest immediately adjacent to channel bank, 5m south of large shallow bank in line with profiles 1,2 and 3. Site is approximately 2m below the level of the levee crest on 5 degree slope. Smooth microrelief, no obvious scour at site.

Depth (m)	Description
0.0-1.3	Sample 0.5m. Dark brown 10YR 3/3, light sandy clay loam, apedal massive, very weak, few very fine roots, pH 6.0. Boundary gradual.
1.3-2.1	Sample 1.8m. Brownish black 10YR 2/3, fine sandy loam, apedal massive, moderately firm, no roots, pH 6. Boundary gradual.
2.1-6.0	Sample 2.5m. Very dark brown 7.5YR 2/3, loamy sand, apedal massive, very weak, no roots, pH 6.0. Boundary gradual.
	Sample 3.5m. Brownish black 10YR 2/3, sand, apedal massive, moderately weak, pH 6.5. Boundary gradual.
	Sample 4.5m. Dark brown 10YR 3/4, clayey sand, apedal massive, moderately firm, no roots, pH 6.5. Boundary gradual.
	Sample 5.5m. Dark brown 10YR 3/3, sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
6.0-7.2	Sample 6.5m. Brown 10YR 4/4, sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
7.2-8.0 plus	Sample 7.5m. Brown 10YR 4/4, sand, apedal granular, loose, no roots, pH 6.5.

TABLE 4.4G

Material description for auger sample: profile 7

On in channel bench 3-4m above water level. Smooth undulating microrelief, amplitude 0.2-0.5m, wavelength 1-3m. Mix of planted Acacia and Eucalyptus species to 6m high, spacing 2-4m. Pasture grass, 100% cover. No obvious recent scour.

Depth (m)	Description
0.0-0.5	Sample 0.2m. Brownish black 10YR 2/3, fine sandy clay loam, apedal massive, very weak, common very fine roots, pH 6.0. Boundary clear.
0.5-0.9	Sample 0.7m. Dark brown 10YR 3/3, fine sandy light clay, apedal massive, moderately firm, few very fine roots, pH 6.0. Boundary clear.
0.9-1.2	Sample 1.0m. Dark brown 10YR 3/3, sandy clay, apedal massive, moderately weak, few very fine roots, pH 6.0. Boundary clear.
1.2-1.4	Sample 1.3m. Dark brown 10YR 3/4, sand, apedal granular, loose, no roots, pH 6.0. Boundary clear.
1.4-1.7	Sample 1.5m. Dark brown 10YR 3/4, sand, apedal granular, loose, no roots, pH 5.5. Boundary clear.
1.7-2.4	Sample 1.9m. Dark brown 10YR 3/3, sand, apedal granular, very weak, no roots, pH 5.5. Boundary clear.
2.4-3.0	Sample 2.7m. Very dark brown 7.5YR 2/3, sand, apedal massive, very weak, no roots, pH 6.0. Boundary clear.
3.0-4.0 plus	Sample 3.2m. Dark brown 10YR 3/3, clayey sand, apedal massive, moderately weak, no roots, pH 5.5. Water table at 3m.

TABLE 4.4H

Material description for auger sample: profile 8

On channel bank approximately 50m northeast of Profile 9, 8-10m above water level. Bank thickly vegetated with tall (greater than 30m) Eucalypt spp. and Casuarina spp. Microrelief crenulate (possible microterraces, channel benches and/or slumps). Materials appear layered in auger sample.

Depth (m)	Description
0.0-0.5	Sample 0.1m. Dark brown 10YR 3/3, fine sandy clay loam, apedal massive, moderately weak, common very fine and fine roots, pH 6.0. Boundary abrupt.
0.5-1.5	Sample 1.1m. Dark brown 7.5YR 3/3, loamy sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
1.5-2.0	Sample 1.8m. Brownish black 10YR 2/2, sandy loam, apedal granular, loose, no roots, pH 6.0. Boundary gradual.
2.0-3.5	Sample 2.5m. Dark brown 10YR 3/3, sand, apedal granular, loose, no roots, ph 6.0. Boundary gradual. Sample 3.2m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, gradual boundary, pH 6.0 Boundary gradual.
3.5-4.0	Sample 3.8m. Brownish black 10YR 2/2, loamy sand, apedal granular, loose, no roots, pH 6.0. Boundary gradual.
4.0-4.5	Sample 4.3m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
4.5-5.1	Sample 4.8m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, pH 6.5. Boundry clear.
5.1-5.3	Sample 5.2m. Dark brown 10YR 3/3, sand, apedal granular, loose, no roots, pH 5.5. Boundary clear.
5.3-6.0	Sample 5.8m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, pH 6.5. Boundary clear.
6.0-6.2	Sample 6.1m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, charcoal fragments, pH 6.5. Boundary clear.
6.2-6.5	Sample 6.4m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, pH 6.0. Boundary clear.
6.5-7.1	Sample 6.8m. Dark brown 10YR 3/4, sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
7.1-8.5	Bedded sands, grain size coarser than above with less clay. Sample 7.5m. Dark brown 10YR 3/4, sand, apedal granular, loose, no roots, pH 6.5. Sample 7.9m. Brown 10YR 4/4., sand, apedal granular, loose, no roots, pH 6.5. Sample 8.2m. Dark brown 10YR 3/3, sand, very little clay, apedal granular, loose, no roots, pH 6.0. Wter table at 8.5m

TABLE 4.4I

Material description for auger sample: profile 9

On right bank levee in small quarry (approximately 2m deep) opposite trotting track. Levee surface has smooth microrelief and 100% pasture cover. Quarry floor is smooth and approximately horizontal, both floor and walls bare of vegetation. Exposure shows 0.1-0.3m sharply bounded stata draped over levee in upper 1m then massively bedded material to quarry floor at 2.3m. Upper 2.3m samples taken from exposure, lower samples obtained by hand auger.

Depth (m)	Description
0.0-0.2	Sample 0.1m. Dark brown 10YR 3/3, loamy sand, apedal granular, loose, many fine and very fine roots, pH 5.5. Boundary abrupt.
0.2-0.4	Sample 0.3m. Dark olive 2.5Y 3/3, sand, apedal granular, few very fine roots, charcoal, pH 5.5. Boundary clear.
0.4-0.65	Sample 0.6m. Brownish black 10YR 2/3, loamy sand, apedal granular, loose, few very fine roots, pH 6.0 Boundary clear.
0.65-0.75	Sample 0.7m. Reddish brown 2.5YR 4/8, sand, apedal granular, loose, few very fine roots, charcoal, pH 6.0. Boundary clear.
0.75-0.9	Sample 0.8m. Brownish black 10YR 2/3, loamy sand, apedal granular, loose, few very fine roots, pH 6.5. Boundary clear.
	Sample 0.85m. Dark brown 7.5YR 3/4, sand, apedal granular, loose, few very fine roots, pH 6.5. Boundary abrupt.
0.9-4.8	Sample 1.85m. Very dark brown 7.5YR 2/3, darker, more organic material, charcoal, loam fine sandy, apedal granular, loose, common very fine roots, pH 6.5.
	Sample 2.8m. Brownish black 10YR 2/3, sandy clay loam, apedal massive, very weak, no roots, pH 6.5. Boundary gradual.
	Sample 3.8m. Brownish black 10YR 2/3, fine sandy loam clay, apedal massive, moderately weak, few very fine roots, pH 6.5. Boundary gradual.
	Sample 4.6m. Brownish black 10YR 2/3, sandy clay loam, apedal massive, moderately weak, no roots, pH 6.5. Boundary gradual.
4.8-4.9	Sample 4.85m. Dark brown 10YR 3/3, sand, apedal massive, very weak, no roots, pH 6.5. Boundary gradual.
4.9-6.1	Sample 5.0m. Brownish black 10YR 2/3, fine sandy clay loam, apedal massive, moderately weak, no roots, pH 6.5. Boundary gradual.
	Sample 5.8m. Brownish black 10YR 2/3, fine sandy clay loam, apedal massive, moderately weak, no roots, pH 6.5. Boundary gradual.
6.1-6.6	Sample 6.2m. Dark brown 10YR 3/4, loam fine sandy, apedal massive, moderately weak, no roots, pH 6.5. Boundary gradual.
	Sample 6.4m. Brownish black 10YR 2/3, loamy sand, apedal massive,

TABLE 4.4I (cont)

Material description for auger sample: profile 9

	very weak, no roots, pH 6.5. Boundary gradual.
6.6-7.0	Sample 6.8m. Dark brown 10YR 3/3, sandy loam, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
7.0-7.8	Sample 7.1m. Dark brown 10YR 3/3, loam fine sandy, apedal massive, moderately weak, no roots, pH 7.0. Boundary gradual. Sample 7.7m. Dark brown 10YR 3/3, light sandy clay loam, apedal massive, very weak, no roots, pH 6.0 Boundary gradual.
7.8-8.4	Sample 8.0m. Brownish black 10YR 2/3, light sandy clay loam, apedal massive, very weak, no roots, pH 6.5. Boundary gradual. Sample 8.3m. Brownish black 10YR 2/3,light sandy clay loam, apedal massive, very weak, no roots, pH 6.0. Boundary gradual.
8.4-9.6	Sample 8.6m. Dark brown 10YR 3/3, sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual. Sample 9.4m. Brownish black 10YR 2/3, loamy sand, apedal massive, very weak, no roots, pH 6.5.
9.6-9.9	Sample 9.8m. Dark brown 10YR 3/4, sand, apedal granular, loose, no roots, pH 6.0. Boundary gradual.
9.9-10.4	Sample 10.2m. Brownish black 10YR 2/3, sand, apedal granular, loose, no roots, pH 6.5. Boundary gradual.
10.4-10.9	Sample 10.6m. Brownish black 10YR 2/3, sandy clay loam, apedal massive, moderately weak, no roots, pH 6.0. Boundary gradual.
10.9-11.5	Sample 11.1m. Dark brown 10YR 3/3, light sandy clay loam, apedal massive, moderately weak, no roots, pH 6.0. Boundary gradual.
11.5-11.8	Sample 11.6m. Dark brown 10YR 3/3, light sandy clay loam, apedal massive, moderately weak, no roots, pH 6.0. Boundary gradual.
11.8-12.3 plus	Sample 12.1m. Dark brown 10 YR 3/4, sand, apedal granular, loose, no roots, pH 6.5.

iii) Bedded levee sands, sandy loams and loamy sands. These were sampled on both the left and right banks (Profiles 6 and 9; Fig 4.8, Table 4.4). The right bank materials are finer grained consisting of interbedded sands and sandy loams. Bedding was observed in the quarry exposure as a sequence of sharply bounded sandy drapes of 0.10-0.30 m thick over the pre-existing levee form. In addition two layers (0.20-0.40 m and 0.65-0.75 m) showed signs of having been burned, with conspicuous charcoal at the surface and a lighter more orange colour. In the western face of the quarry a buried stump indicated 1 m of levee aggradation (and probably more) since establishment of the tree. There is no way of knowing how long ago the tree died nor its age at death. However a 1.5 m diameter eucalypt indicates an age in the order of 100 years. Decay rates are likely to be rapid in a moist buried environment.

The left bank levee materials are significantly coarser grained being mainly sands below 2 m. Any bedding was destroyed in the auger sample, however is expected to drape the pre-existing surface. Colour was more variable with materials below 4 m being significantly lighter. This may indicate rapid deposition of thicker sand sheets. The sands are interpreted as coarse overbank sediments deposited as floodwaters lose competence when leaving the channel. The finer grained surface materials (down to 2 m) may indicate a fining upwards sequence of slow flow velocities on the levee as the levee grows in height above the channel bed or a change in sediment load of the stream. No investigation was made of the relationship between the left bank levee sand and the floodplain sediments of Profiles 1, 2 and 3. There are no breaks in surface morphology and if the subsurface strata reflects this pattern then the relationship is likely to be a gradual facies change from the coarser levee sands to the finer sands and clays of the floodplain. A distinct cut and fill break is also possible as is a combination of the two models.

iv) Channel bank and bench sands and loamy sands - these were investigated on the right and left banks in Profiles 8 and 7 (Table 4.4, Fig 4.8). Both auger profiles showed similar characteristics of sands overlain by 1-2 m of loams. This can be interpretated as either a fining upwards sequence resulting from increasing elevation from the bed or a change in the sediment load of the stream. Coarser sands at the base of profile 8 are interpreted as channel bed materials. The surface materials are more cohesive than the sandy material and offer a more stable surface to the channel bank. The left bank material is interpreted as being sub-horizontally bedded in-channel bench sediments having a cut and fill relationship with the levee sediments. The right bank sediments may also have a similar cut and fill history however there is no bench morphology in the modern environment nor can one be detected in the 1956 aerial photographs. A second hypothesis must also be accepted of steeply inclined bank sediments that grade laterally into the levee sediments in Profile 9.

In order to determine the rate of accumulation and turnover of these materials, detailed stratigraphic study including dating is required.

4.7 MODELS OF LATE QUATERNARY AND HOLOCENE SEDIMENTATION

The four morphologic zones of the river appear to have different patterns and histories of sedimentation. Several models will be presented herein to account for the stratigraphy of the valley floor. There was insufficient time during this study for a detailed survey of all aspects of the stratigraphy of the valley floor in this area. Reliance has been placed on data gathered by others for most of the drill information; these drilling programs were oriented towards establishing a resource base and much of the finer detail required for good stratigraphic interpretation is obscured by the retrieval method. Some augering was undertaken, grab samples have been obtained from the river bed and banks, and sections in gullies, exposed banks and pits have been examined.

Within the time frame of this study it was not possible to use C14 dating. Such dating should be the subject of a future study, as outlined in chapter 9, because it will allow an estimate of the rate of turnover of the deposit to be defined. Such dating cannot be done in a hurry. Good stratigraphic mapping needs to preceed it otherwise the dates may reveal nothing, as a recent criticism of dating in Eastern Australia has revealed (Young, Nanson and Bryant, 1986).

There are two models for the alluvial history of the river between Bergins weir and Menangle Road bridge. Both models begin with a river that has at some time excavated to bedrock over a width of 700 to 1200 metres, and possibly even wider. The bedrock in this section is Wianamatta Group shale overlying Hawkesbury Group sandstone (Chapter 2). At a later date the Elderslie Sands were layed down and subsequently trenched. At this point the author is not willing to assume a uniform history for the Elderslie deposit/deposits. There appears to be a considerable variation in the material and it may in fact represent a complex history of aggradation, degradation and reworking and include a variety of facies. The modern alluvium with which the following models are concerned both overlies and is inset into the Elderslie sands.

4.7.1 Lateral migration model

The first of the models is relatively simple. It is assumed that the river is laterally migrating. There are a number of bends within the river in this section (Fig 4.9), albeit small, and the bank stability and stratigraphy map (Fig 4.2) shows that there are a number of sites where undercutting and bank retreat are taking place. Many of these bank collapses may be recent, dating from the 1978 flood, but they are by no means unusual in such a river system. The slow migration of the river would allow in-channel benches to develop and these could easily grow into large ridges parallel to the stream with vegetation fixing surface sediment. Sediment would continue to be deposited on the floodplain during the large floods that overtop the bank (71mAHD+) and levees on the margin continue to grow (Fig 4.9). The fact that the parallel ridges within the major channel complex are lower than the major levee may mean that the migration has been relatively rapid in terms of sediment supply or that the river has incised since it started to migrate.

The model accounts for the large deposit of coarse sand that underlies the banks and appears to extend some distance away from the channel in both directions. The complex pattern of lenses and draped beds of fine sand, organic rich sands, loams and even the occasional clay deposit is also accounted for by the model.

The problem with the simple lateral migration model is that the ridges appear to be dominantly located on one side of the river (left hand bank) in the 1956 photographs. This may be a chance occurrence, but it seems suspicious, and one cannot invoke tectonic tilting of the region to explain an eastwards side-slip since as there is no evidence of Holocene tectonic activity (other than a few small earthquakes the cause of which is the subject of debate)

4.7.2 Catastrophic model

The second model is a catastrophic model (Fig 4.10), invoking more recent ideas on channel and floodplain development in several streams in Eastern Australia. In this model it is assumed that the river underwent a series of large floods at some time in the recent past. The result of these floods was a considerable increase in the width of the channel, with possible excavation down to bedrock. At the same time massive overbank deposition would have occurred, resulting in the construction of high levees consisting of thick lenses of relatively clean fine sand, interspersed with organic rich sands and finer sediments deposited by the smaller floods or representing quiescent periods when soil forming processes have had the opportunity to operate and modify the deposit. In fact, there may have been several catastrophic sequences with subsequent infilling and rebuilding. Following the major excavation of the channel the small flood regime, operating in a channel that is too large, deposited sediment on the margin of the channel. The channel became narrower as a result of bench construction. It may also have become deeper as a result of concentration of the flows.

A problem with this model is that if the channel was scoured by a series of low frequency floods why is the present channel not undergoing enlargement considering the high frequency of large floods in the last four decades? Possible answers to this question are that the stream had not recovered completely from the previous catastrophic event and that there is sufficient capacity for the more frequent floods to be handled. Secondly, there is evidence of bank collapse after 1945 along sections of the river and this may indicate adjustment to higher frequency floods. Thirdly, the wet period of the last four decades has not produced the sequence of floods required to initiate catastrophic scour in the Nepean River in this area.

4.9

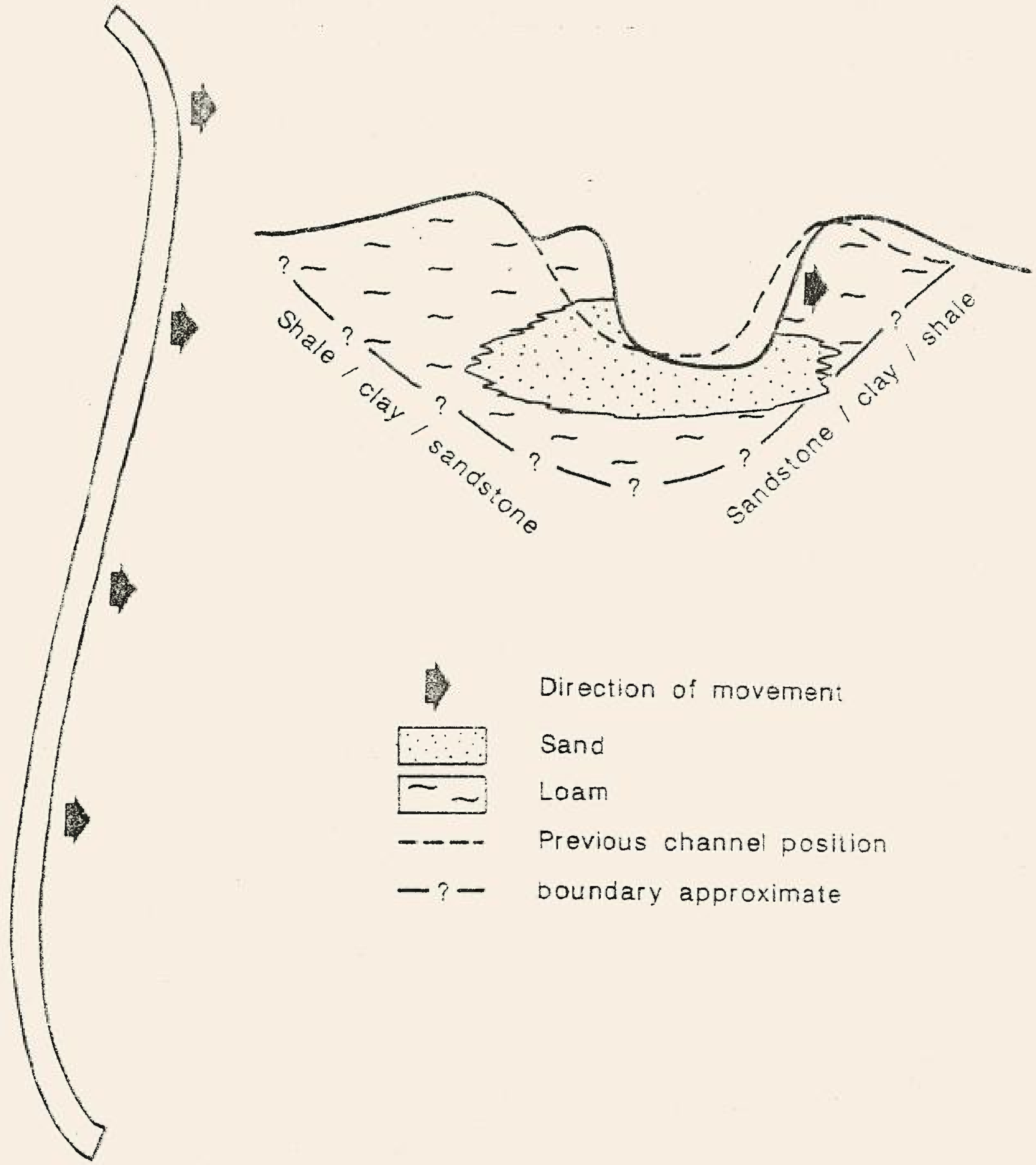


Figure 4.9 Lateral migration model

4.7.3 Model for sedimentation in Reaches 2 and 3

The Nepean River in reaches 2 and 3, i.e between the Menangle Road bridge and upstream of the F5 Freeway bridge, consists of two curved reaches. Sedimentation in these reaches appears to take place as a result of transverse currents flowing from the river across the flood-plain on the inside of the meander bend and low velocities of flow across the meander cores. The reduction of velocity in the meander core and the transfer of sediment by the currents to the core results in deposition (Fig 4.11). The deposition on the outside of the meander bend is probably a result of energy dissipation in the vegetation that lines the outside of the bend. This loss of energy, with a consequent decrease in stream velocities means that the flow over the bank does not have either the competence or the capacity to transport the sediment that it brought into the overbank section. Material is deposited out of the flow where it is stabilised by subsequent vegetation growth.

4.7.4 Model for sedimentation in reach 4

The fourth reach, that section of the river confined by the bedrock walls upstream of the F5 Freeway, is dominated by in-channel benches on either side of the river. These probably come into being as the thick stands of trees and other vegetation reduce the flow velocities near the walls of the narrow valley. Debris accumulation, such as fallen logs, may also promote sedimentation and bar formation in the channel during low flows. It is highly likely that these bars will be removed during the large flows.

4.7.5 Implications for mining

The most favoured of the geomorphic models for this deposit is the catastrophic model. If this model is correct then a relatively wide channel with a narrow floodplain is not atypical of the area within the recent geologic past. The river is adding sediment to the channel, that is, the river has been in an aggradational phase in the recent geologic past. Widening and deepening of the river by dredging could be seen as returning the river to a state it was recently in. However, the complication with the application of this model to the present day is that it is not known whether the stream continues to be in an aggradational phase; in fact the evidence is in favour of a period of degradation since 1945.

For reaches 2 and 3 the channel planimetric shape is such that the inside bends of the rivers are natural accumulation points. Material removed from these areas would probably be replaced over a period of time by subsequent flood flows. The outside of the bends are armoured by bedrock and unlikely to fail as a result of river deepening during and after a dredging operation.

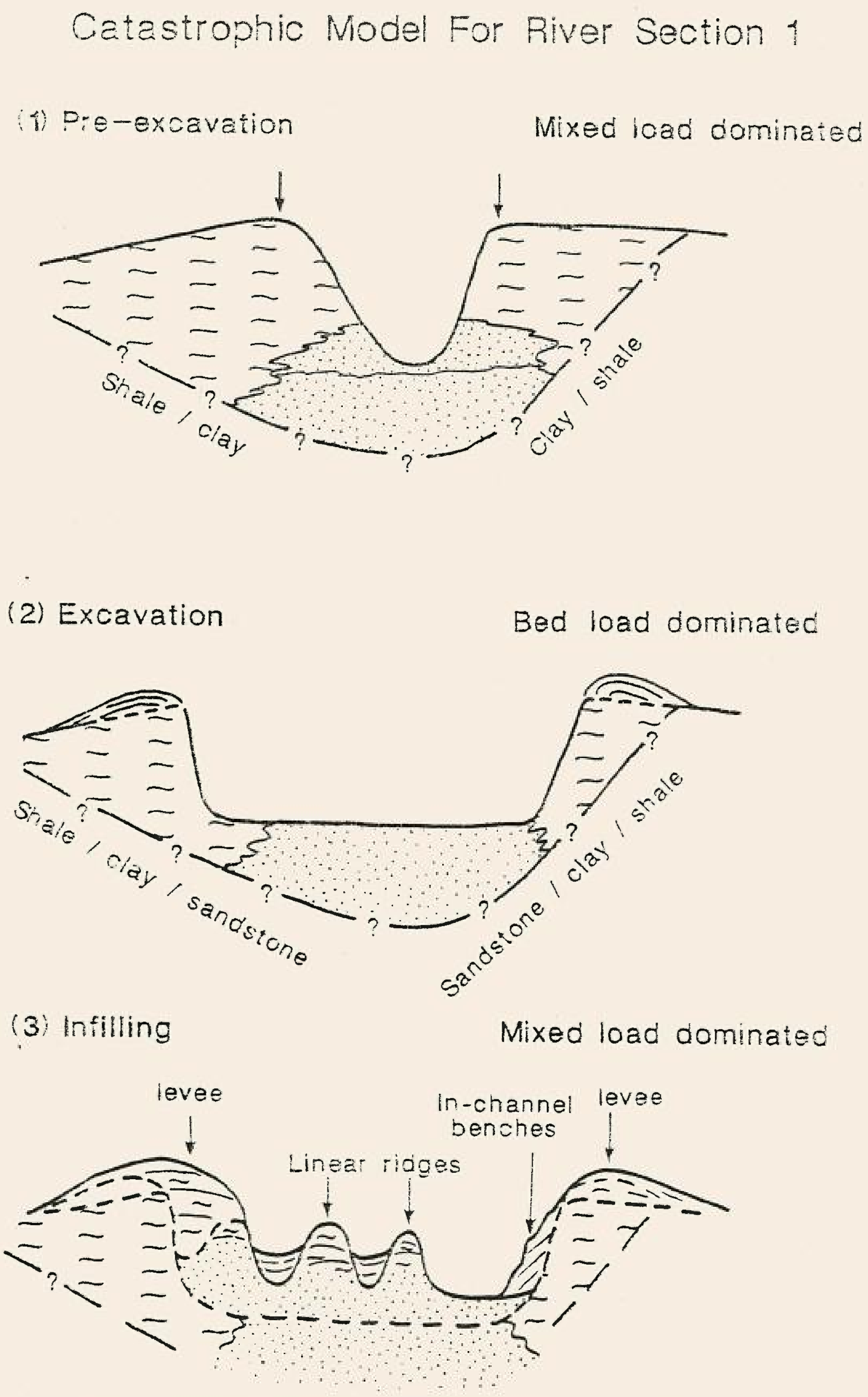


Figure 4.10 Catastrophic model of floodplain formation

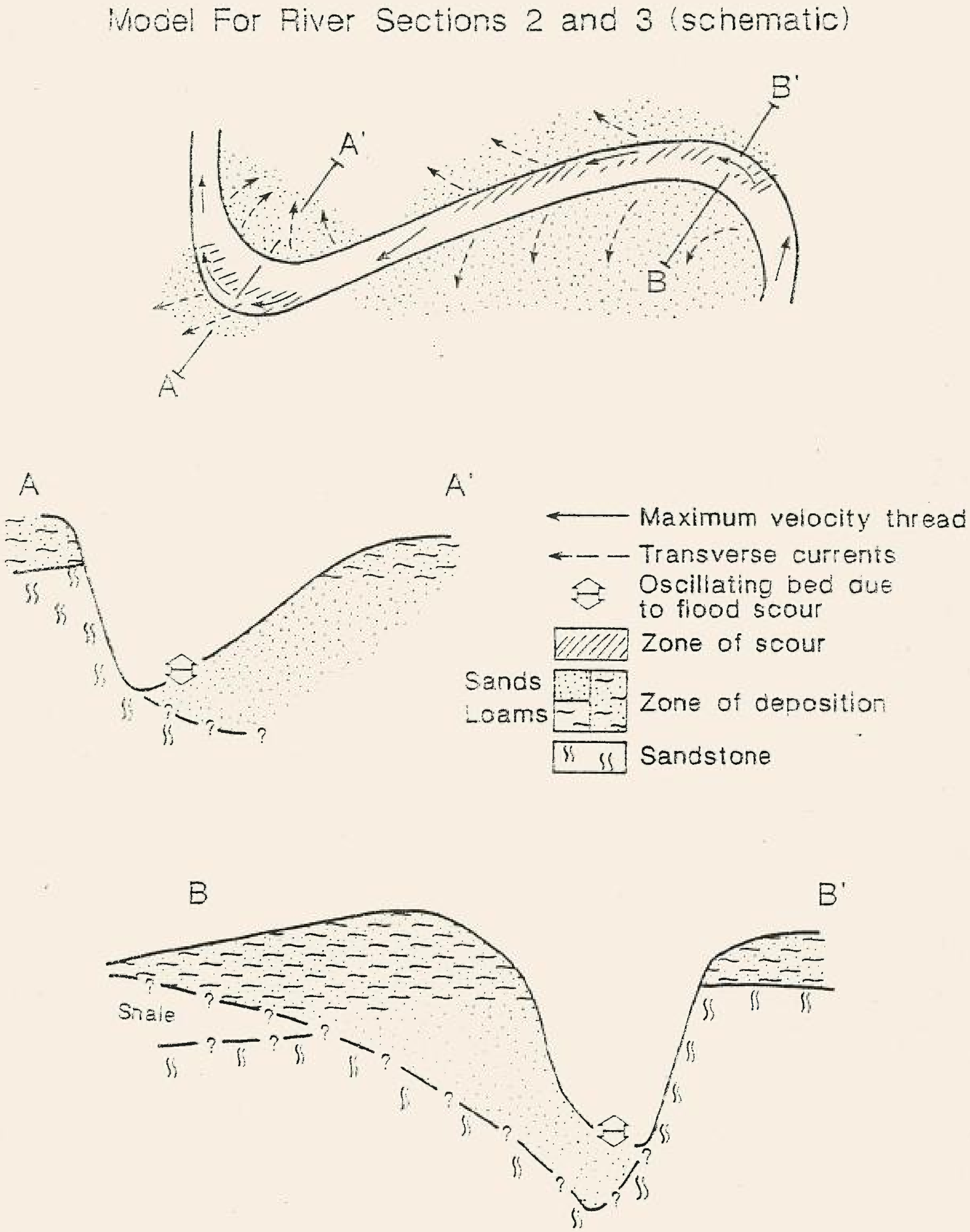


Figure 4.11 Model for sedimentation in sections 2 and 3 of the Nepean River at Menangle

It is less certain what the impact of mining would be on the canyon reach of the Nepean River. There is no way to assess the stability of the river following excavation of the in-channel benches, although the lowering of benches and small floodplain segments would increase shear stress on the remaining bench as a result of increased depth of flow. In such a narrow channel the increased shear stress could be considerable with a high risk of erosion and sediment mobilisation.

4.8 SEDIMENT TRANSPORT

In this section the nature and magnitude of sediment transport in the Nepean River at Menangle will be reviewed.

4.8.1 Long term sediment load

There is a scarcity of data on the sediment loads of eastern Australian rivers. However, a review of sediment yields of catchments in Australia has shown that for the eastern states the sediment yields are of the order of 10 to 30 tonnes/sq.km/yr (Olive and Walker, 1982). These values are probably maxima for they relate to studies on small catchments and they incorporate land use practices that often lead to high sediment yields.

For the Nepean River at Menangle with a catchment area of approximately 1300 sq km the maximum average annual sediment load being carried by the river (using the yield values above) is of the order of 30 000 to 50 000 tonnes, substantially less than the quantities it is proposed to mine from the floodplain and the river.

Bishop (1984) in his work within the Hawkesbury-Nepean, Shoalhaven and other catchments derived erosion rates of 0.02mm/year. In many cases the rate were lower. Assuming a density of the sandstone of 2 tonnes/cubic metre and that 50% of the erosion produces particulate material the annual sediment production by the breakdown of rocks is of the order of 26 000 tonnes.

4.8.2 Estimates of bed material load transport

Estimation of sediment loads, both long term and short term, is notoriously prone to error. The available models are subject to considerable error when applied to river systems other than the ones on which they were developed. There is every evidence that for river systems that are not stable the errors are even greater. For this reason the following analysis of sediment loads should be considered as giving an indication of the magnitudes of seidment loads and the changes that may be expected as the river morphology undergoes change with the proposed extraction.

Bedload material load is estimated using the available hydraulic information and the grain size analysis of the bed sediments. The Bagnold sediment transport equation (Bagnold, 1966) is used. It is assumed that the mean size of the material in the bed is 0.3mm, the size indicated from the grab samples. No allowance is made for variations in particle size as the flood wave passes. Sediment loads are calculated for 3 discharges, the discharge that just tops the banks, the 20 and the 100 year discharges (Table 4.5). All the estimates are determined for that reach of river at cross section 7 in Fig 3.8.

TABLE 4.5

Estimates of sediment load at cross section 7
(see Fig 3.8)

Discharge (cumecs)	Recurrence interval (yrs)	Depth (m)	Slope	Channel velocity (m/s)	Load suspended kgwt/s/m width	Load bed kgwt/s/m width
800	2.3	16.38	0.00015	0.60	0.45	0.3
2200	20	18.35	0.00047	1.14	3.8	2.
4000	100	19.82	0.00080	1.58	20.	8.5

for 50m wide stream and 24 h duration

	load in tonnes suspended	bed	total
800	1 900	1 300	3 200
2200	16 000	8 600	25 000
4000	86 000	37 000	123 000

To adequately calculate the total sediment yield the flow duration curve for the entire range of flows would be needed. this curve was not available at the time of this project. In the absence of more detailed information on flow duration and the variation of the hydraulic conditions of the river with the flow it is assumed that the 20 year flow, occuring once each year, would give an indication of maximum sediment loads throughout the river. Assuming a 50 hour duration flood the sediment loads would, at the most, be of the order of 60 000 tonnes for the total load.

There are several important points to note above the estimate of sediment load. Firstly, these estimated values of sediment load as calculated with the Bagnold equation are of the same order of magnitude as those estimated from sediment yield studies of monitored catchments as discussed in section 4.8.1. Secondly, this calculation assumes that the river is not sediment limited. As it has been demonstrated that the river is probably in a sediment deficit the estimate of sediment load given above must be considered as a maximum value. Thirdly, the assumption that a 20 year flood occurs once a year leads to a gross overestimation of the sediment load, so the estimate should be considered as a maximum value of average annual sediment load.

It should be noted that the calculations presented above do not include wash load, that is the load of silt and clay being carried by the stream. No reliable estimates of this load can be given for the river, although the yield of silt and clay is probably several thousand tonnes.

4.8.3 Observations on sediment load

There are well defined bars of sandstone boulders up to a metre in diameter downstream of the railway bridge. The size of the particles suggests that the river is highly competent, and similarly has a high capacity for sediment transport. The considerable thickness of individual beds overlying the levees and the in-channel benches also suggests high sediment loads and high competence to transport sediment.

It would appear from the calculated velocities along the river (Chapter 3) that the sediment which enters the channel between the F5 Freeway and the railway bridges is capable of being carried through the section. Some may be carried onto the floodplain by transverse currents. The lower velocities in the Bergin weir reach suggests a lower competence and capacity and may account for the greater thickness of sediments seen in individual beds in this reach.

It appears at this stage that the river is supply- limited (i.e. is capable of carrying more sediment than it actually does). The increase in depth of the river over time, excluding the influence of mining, is indicative of a supply limited stream. To make up this lack of supply the stream scours the material from its bed and bank (see Warner, 1983). Thus, even though the river is carrying a large sediment load it is also capable of carrying much larger quantities of sediment.

It would be safe to say that if the extraction of sediment exceeded approximately 60 000 tonnes per year then the river would be in a net sediment transport deficit for this area. This does not mean that sediment would not be carried through the reach. But assuming a store of sediment that is kept constant over a period of time, mining of that store may cause the stream to either drop sediment into the mined reach, thus reducing downstream transport, or have that store unavailable for sediment exchange with the river floodplain and channel further downstream.

4.8.4 The effect of low flow on sediment load

The average cross-sectional area of the Nepean River in the 1km stretch downstream of Menangle Road bridge is 150 sq metres at low flow stages (it obviously increases as discharge increases). There is no evidence to suggest that flow within the pool behind Bergins weir is stratified when flow is taking place, although stratification may be possible under certain conditions when there is no flow in the River. Velocity measurements were taken 100m upstream of Bergins weir on 22/8/1987 when the Menangle Road bridge gauge was reading 1.45m. At depths of 1,2 and 3m below the water surface in a 4m deep section velocities were 0.2, .19, and 0.22 m/sec; almost uniform flow through the vertical section for a small flow event. Therefore, a discharge of 1 cumec through the reach would have an average velocity of the order of 0.01m/sec (assuming non-stratified flow). This velocity would be slightly higher in some constricted sections and lower in other wider sections of the reach.

An estimate may be derived of the size of particle that will settle-out of the water and be deposited on the bed if it is assumed that a fall velocity greater than stream velocity is the critical factor in determining suspension. This assumption tends to err in that it overestimates the size of particle that may be carried. Suspension of particles is closely related to the bed configuration, the viscosity of the water, and the magnitude of micro and macro turbulence within the stream.

A number of curves relating fall velocity and entrainment velocity to sediment size are available (Rubey, 1933; Hjulstrom, 1935; Graf and Acaroglu, 1966). At a velocity of 0.01m/sec materials with diameters greater than 0.012mm would tend to settle out and would not be scoured from the bed and banks. However, particles with diameters less than this would be held in suspension and would be moved (even if at low rates) along the boundaries and be subject to suspension. That is, for 87 percent of the time the river would not be able to transport particles greater than 0.012mm in diameter for any great distance downstream. On the other hand, finer particles, if disturbed, are likely to be carried a distance downstream before they settle onto the river bed and banks. The majority of the material in the bed of the Nepean River is coarser than 0.01mm (Table 4.2, Fig 4.5).

4.9 CONCLUSIONS

a) There are four distinct reaches of the river, each of which has a distinct history and sedimentology.

b) Banks in alluvial sections are subject to mass movement failure. Failure appears to be related to factors other than quarrying and dredging.

c) There have been significant changes in channel morphology, and in particular a deepening of the river that is independent of mining

d) Bed sediments show no impact of mining in terms of texture or composition.

e) The floodplain appears to consist of a thick veneer of loam overlying coarse sand.

f) The model that best accounts for the stratigraphy of the floodplain is a catastrophic one.

g) dredging has increased the depth and width of the river and quarrying has lowered the floodplain.

h) The maximum annual average sediment load of the river is approximately 60 000 tonnes and it is probably less.

i) The size of bed sediment is such that dredging during low flow would not create a downstream turbidity problem.

4.10 REFERENCES

Bagnold,R.A. 1966. An approach to the sediment transport problem from general physics. U.S. Geological Survey Professional Paper 422-I

Bishop, P. 1984. Modern and ancient rates of erosion of central Eastern NSW and their implications. In R.J.Loughlan (ed). Drainage basin erosion and sedimentation.. A conference on erosion, transportation and sedimentation in Australian drainage basins. Newcastle, May 1984. 35-43

Gardiner,V and Dackombe,R 1983. Geomorphological field manual. Allen and Unwin, London. 254pp

Graf,W.H., and Acaroglu,E.R. 1966. Settling velocities of natural grains. Bulletin International Association of Scientific Hydrology, 11(4),

Henry,H. 1977. Catastrophic channel changes in the MacDonald Valley, New South Wales, 1949-1955. J.Proc Royal Soc. NSW, 110,1-16.

Hjulstrom,F. 1935. Studies of the morphological activity of rivers as illustrated by the River Fyris. Bulletin Geological Institute, University of Uppsala, 25,221-527.

Northcote 1971. 3rd ed. A factual key for the recognition of Australian soils. Rellim, South Australia. 123pp

Olive,L.J. and Walker,P.H. 1982. Processes in overland flow - erosion and production of suspended material. In E.M.O'Loughlin and P.Cullen (eds) Prediction in water quality. Australian Academy of Science, Canberra, 87-119.

Oyama and Takehara 1967. Revised standard soil colour charts

Petts,G.E. 1979. Complex response of river channel morphology subsequent to reservoir construction. Progress in Physical Geography, 3(3),329-362.

Rubey,W.W. 1933. Settling velocities of gravel, sand and silt particles. American Journal of Science, 225,325-338.

SchoHowever,H.A. 1974. Geomorphology of New South Wales coastal rivers Univ NSW Water Research Laboratory Report 139. 179pp.

Taylor,K.V. 1978. Erosion downstream of dams. in Cadwick,W.L. (chairman) Environemntal effects of large dams. American Society of Civil Engineers, 165-186.

Warner,R.F. 1983 Channel changes in the sandstone and shale reaches of the Nepean River, New South Wales. In R.W.Young and G.C.Nanson (eds) Aspects of Australian sandstone landscapes Australian and New Zealand Geomorphology Group Special Publication No.1, 106-119.

Young,R.W., Nanson,G.C., and Bryant,E.A. 1986. Alluvial chronology for coastal New South Wales: climate control or random erosional events? Search, 17(10-12), 270-272.

Metropolitan Water Sewage and Drainage Board. 1985. Upper Nepean River stream gauging data. Report No.GSB 9026.

CHAPTER 5.

WATER QUALITY AND MINING

5.1 INTRODUCTION

Whilst extraction of sand from the river bed, banks and floodplain has been undertaken in the study area for many years (see review in Chapter 2) it was not until recently that the water quality monitoring has been oriented towards assessing the impact of the extraction. Nevertheless, there is a body of water quality data available for Menangle weir, Foot Onslow Creek, Bergins weir, Thurns weir and Camden weir. Thurns weir and Camden weir are some distance from the study site (Fig 5.1) but are used because there is no other local data available and because they establish whether the impact of the mining activity up to the present is evident some distance downstream of the site.

5.2 DATA

The water quality data used herein has been collected by the Metropolitan Water Sewage and Drainage Board (MWSDB) over a number of years.

The MWSDB test water samples for a number of quality parameters. Not all are examined here. Selected are turbidity, colour, conductivity, chloride ion content, phosphate, chlorophyll a, pH, and dissolved oxygen. Turbidity and colour are selected in lieu of total suspended solids (not sampled in the data set made available to the author) in order to define the extent of changes in sediment load and light penetration. Conductivity and chloride ion content are important because questions have been raised concerning the effect of high salt contents on irrigation downstream and the possibility that salt content may increase with extraction. Phosphate, pH, dissolved oxygen and chlorophyll a are all used as measures of the impact of the mining activity on the trophic state of the river (Tables 5.1 to 5.9).

5.3 WATER QUALITY IN THE POOLS OF BERGINS AND MENANGLE WEIRS

The hydrologic analysis showed that the Nepean River ceases to flow for 35 percent of the time (Chapters 3 and 4). That is, the two ponds created by Bergins weir and Menangle weir are stagnant ponds for this period.

5.1

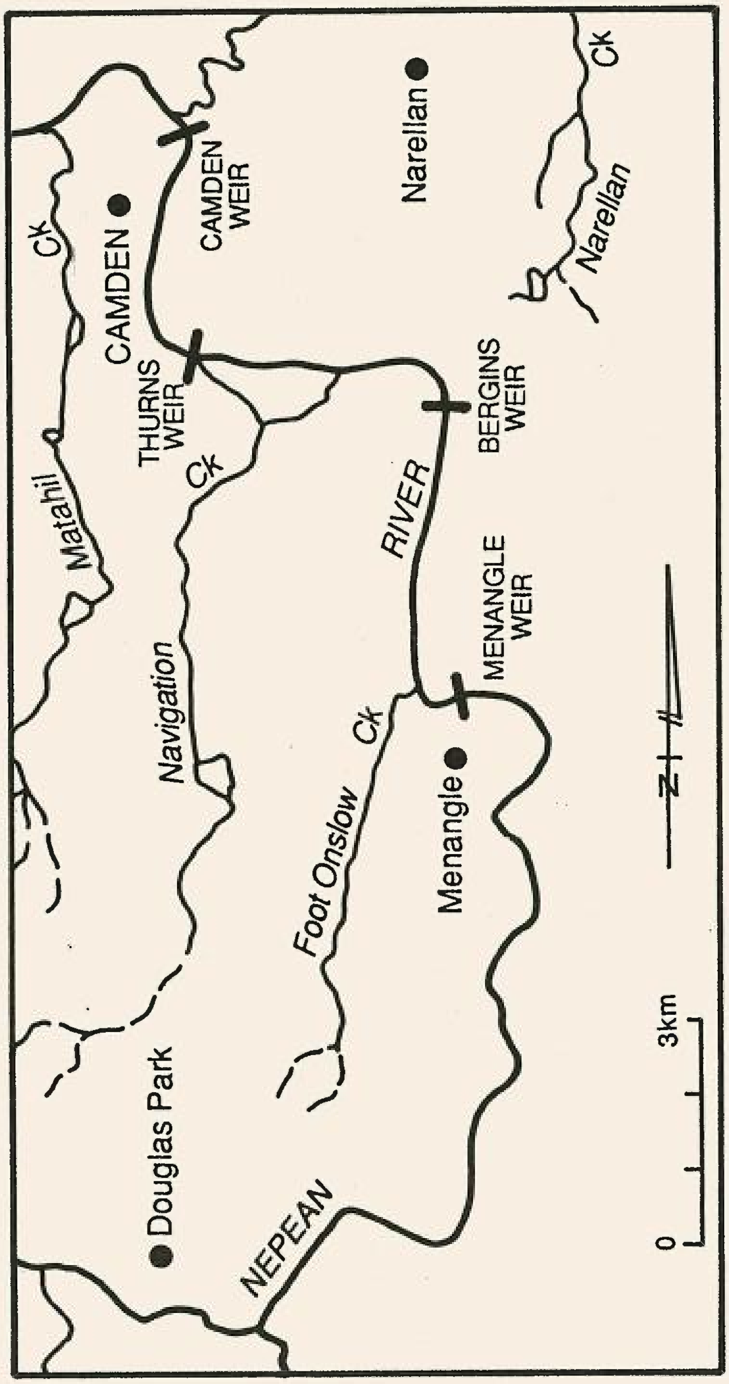


Figure 5.1 Water quality monitoring sites

TABLE 5.1

pH

DATE	TIME	Men. Rd.	LOCALITY Ft.Ons.Ck.	Bergins	Thurns	Cowp.Br.
Geom. mean 1977-81		6.6	-	-	-	-
Geom. mean 1982-83		7.2	-	-	-	7.1
20.02.84	14h55	6.6				-
05.03.84	08h40	6.7				6.3
23.03.84	16h45	7.2				
27.03.84	10h51					6.7
03.04.84	09h33	6.6				6.6
11.04.84	10h50	6.9				6.9
22.05.84	14h00	6.5				6.7
20.06.84	12h20	6.9				6.9
28.06.84	13h00	7.2				7.0
03.07.84	11h00	7.5				6.9
11.07.84	11h45	7.2				6.9
25.07.84	12h00	7.1				7.4
05.09.84	11h18	-				6.4
26.09.84	10h55	-				7.4
22.10.84	08h44	-				6.6
02.11.84	10h47	-				6.9
19.11.84	09h20	-				6.4
11.12.84	13h25	-				6.8
Geom. mean 1984		6.9	-	-	-	6.8
13.02.85	09h00	6.8				
28.03.85	11h35	-	-	Surface: 6.9 [1Km d/stream = 7.0]		
				2m: 7.0 [" " = 7.0]		
01.04.85	10h00	7.0	-		-	
29.05.85	11h00	6.7(Weir)	7.4		6.6	
17.06.85	10h40	6.5	7.6		6.8	
08.07.85	11h04	6.9	-		-	
16.07.85	10h30	7.0	7.5		7.6	
12.08.85	10h50	-	7.4		6.6	
16.09.85	11h05	-	7.5		6.9	
14.10.85	10h15	7.5	7.1		7.1	
11.11.85	10h00	6.8	-		-	
18.11.85	10h15	6.6	7.5		7.0	
16.12.85	10h10	6.5	7.6		6.9	
Geom.mean 1985		6.9	7.4	-	6.9	6.9
20.01.86	10h25	7.7	7.4		6.9	
17.02.86	11h00	6.7	7.5		7.1	
24.03.86	10h57	7.1	-		7.0	
21.04.86	10h39	6.7	-		6.9	
19.05.86	10h35	6.7	-		6.7	
23.06.86	10h45	6.9	-		6.9	
25.08.86	10h50	6.4	7.9		6.5	
22.09.86	11h00	6.8	-		6.8	
22.10.86	10h54	6.6	-		6.9	
17.11.86	10h20	6.6	7.9		6.9	
21.11.86	10h15	6.2	-		-	
15.12.86	11h15	6.8	-		6.7	
Geom.mean 1986		6.8	7.7	-	6.8	6.9
18.02.87	09h55	6.9	-		-	
09.03:87	10h15	7.1	7.5		7.1	
04.05.87	09h50	6.5	-		-	
01.06.87	10h25	6.9	-	6.7	-	
15.06.87	10h05	6.9	-	6.8	6.9	

TABLE 5.2

Dissolved oxygen mg/L (%satn)

LOCALITY

DATE	Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
Geom. mean 1977-81	8.9	-	-	-	-
Geom. mean 1982-83	7.3	-	-	-	7.0
20.02.84	7.4(87)				
05.03.84	7.1(83)				6.7(79)
23.03.84	8.9(106)				
27.03.84	-				7.9(90)
03.04.84	8.7(97)				8.5(96)
11.04.84	9.8(107)				9.5(104)
22.05.84	9.0(108)				9.6(99)
20.06.84	9.4(90)				9.9(94)
28.06.84	9.7(91)				9.7(91)
03.07.84	9.5(86)				9.3(84)
11.07.84	12.3(114)				11.3(103)
25.07.84	11.5(105)				11.4(105)
05.09.84	-				10.4(106)
26.06.84	-				9.6(100)
22.10.84	-				7.2(78)
02.11.84	-				5.9(66)
19.11.84	-				7.3(86)
11.12.84	-				9.5(112)
Geom. mean 1984	8.3	-	-	-	8.8
13.02.85	7.0(85)				
28.03.85			Surface: 7.1(85)	[1Km d/stream = 7.9(94)]	
			1m: 7.0(83)	[" " = 7.8(93)]	
			2m: 6.8(81)	[" " = 7.7(92)]	
01.04.85	6.5(79)				
29.05.85	(Weir) 8.6(87)	2.8(29)		8.7(88)	
17.06.85	9.1(90)	7.9(68)		9.0(85)	
08.07.85	9.3(86)	-		-	
16.07.85	10.3(94)	7.0(62)		10.4(95)	
12.08.85	10.3(94)	4.7(40)		10.4(105)	
16.09.85	11.2(116)	5.6(57)		9.6(100)	
14.10.85	6.6(81)	6.3(63)		6.5(70)	
11.11.85	8.0(91)	-		-	
18.11.85	7.8(90)	4.7(49)		8.1(93)	
16.12.85	7.7(91)	2.8(32)		7.8(93)	
Geom. mean 1985	8.4	4.9	-	8.8	8.7
20.01.86	7.2(87)	2.1(23)		7.6(94)	
17.02.86	7.0(86)	1.1(12)		8.2(101)	
24.03.86	7.9(98)	-		6.7(82)	
21.04.86	6.1(69)	-		8.1(91)	
19.05.86	7.1(75)	-		7.3(77)	
23.06.86	9.5(90)	-		9.3(88)	
25.08.86	9.8(88)	10.4(101)		7.7(75)	
22.09.86	9.9(106)	-		10.1(110)	
20.10.86	8.8(97)	-		10.6(121)	
17.11.86	8.0(91)	7.3(86)		7.4(89)	
21.11.86	-	-		-	
15.12.86	9.0(107)	-		9.3(113)	
Geom. mean 1986	8.1	3.6	-	8.3	8.7
18.02.87	7.4(90)	-		-	
09.03.87	7.5(87)	2.7(28)		8.3(98)	
04.05.87	6.0(65)	-		-	
01.06.87	8.0(79)	-	7.8(78)	-	
15.06.87	7.9(77)	-	8.9(86)	8.1(76)	

TABLE 5.3

Colour
Apparent/True

DATE	Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
		LOCALITY			
20.02.84	60/30				-
05.03.84	50/20				60/20
23.03.84	40/15				-
27.03.84	-				55/20
03.04.84	50/30				55/25
11.04.84	80/25				90/30
22.05.84	40/20				40/20
20.06.84	-				120/35
28.06.84	50/30				60/40
03.07.84	60/30				60/50
11.07.84	55/30				60/30
25.07.84	50/20				60/30
05.09.84	-				30/15
26.09.84	-				-
22.10.84	-				55/10
02.11.84	-				55/10
19.11.84	-				65/35
11.12.84	-				45/15
13.02.85	30/15				
28.03.85		Surface:	60/20	[1Km d/stream	= 65/15]
		2m:	60/15	[" "	= 70/15]
01.04.85	65/15				
29.05.85	(Weir) 30/15	75/15		35/15	
17.06.85	55/15	50/20		50/15	
08.07.85	30/20	-		-	
16.07.85	55/15	130/35		35/20	
12.08.85	33/15	75/15		55/15	
16.09.85	33/10	110/30		55/15	
14.10.85	501/101	55/15		55/20	
11.11.85	70/15	-		-	
18.11.85	55/20	110/40		35/20	
16.12.85	20/15	70/15		35/15	
20.01.86	40/20	150/40		60/30	
17.02.86	20/15	55/25		15/15	
24.03.86	15/10	-		10/10	
21.04.86	35/10	-		20/10	
19.05.86	20/10	-		15/05	
23.06.86	15/05	-		10/05	
25.08.86	35/15	30/10		65/15	
22.09.86	35/10	-		35/10	
20.10.86	50/15	-		60/15	
17.11.86	35/10	130/35		70/15	
21.11.86	-	-		-	
15.12.86	35/10	-		55/10	
18.02.87	20/05	-		-	
09.03.87	30/10	65/20		35/10	
04.05.87	35/10	-		-	
01.06.87	50/15	-	25/05	-	
15.06.87	15/10	-	20/10	15/10	

TABLE 5.4

Turbidity (NTU)

DATE	Men. Rd.	LOCALITY Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
Geom. mean 1977-81	-	-	-	-	-
Geom. mean 1982-83	9.8	-	-	-	12.2
20.02.84	21.0				-
05.03.84	5.2				6.7
23.03.84	11.1				-
27.03.84	-				13.1
03.04.84	4.6				5.2
11.04.84	33.0				52.0
22.05.84	6.0				4.5
20.06.84	13.9				54.0
28.06.84	9.8				10.6
03.07.84	13.9				8.3
11.07.84	5.7				11.1
25.07.84	5.0				14.0
05.09.84	-				4.0
26.09.84	-				7.0
22.10.84	-				6.0
02.11.84	-				5.4
19.11.84	-				6.7
11.12.84	-				11.4
Geom. mean 1984	9.5	-	-	-	9.6
13.02.85	3.7				
01.04.85	6.1				
28.03.85			Surface: 9.7	[1Km d/stream = 9.0]	
			2m: 9.6	[" " = 10.3]	
29.05.85 (Weir)	3.5	13.3		4.7	
17.06.85	7.1	8.4		8.8	
08.07.85	4.0	-		-	
16.07.85	6.8	21.0		5.7	
12.08.85	10.0	57.0		7.9	
16.09.85	5.6	28.0		5.6	
14.10.85	278.0	14.7		8.9	
11.11.85	20.0	-		-	
18.11.85	6.0	21.0		7.1	
16.12.85	6.6	15.0		7.0	
Geom. mean 1985	9.9	19.0	-	6.7	7.9
20.01.86	6.0	36.0		15.0	
17.02.86	3.1	26.0		4.0	
24.03.86	5.3	-		3.6	
21.04.86	5.6	-		3.1	
19.05.86	4.9	-		3.7	
23.06.86	3.0	-		2.6	
25.08.86	7.1	3.1		16.2	
22.09.86	4.8	-		6.1	
20.10.86	9.4	-		11.2	
17.11.86	5.6	70.0		25.0	
21.11.86	16.0	-		-	
15.12.86	9.0	-		4.6	
Geom. mean 1986	6.0	3.6	-	6.5	13.5
18.02.87	2.3	-		-	
09.03.87	3.8	7.9		6.9	
04.05.87	4.5	-		-	
01.06.87	5.0	-	5.0	-	
15.06.87	2.4	-	6.0	3.2	

TABLE 5.5

Chloride
(mg/L)

DATE	Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
		LOCALITY			
Geom. mean 1977-81	61.0	-	-	-	-
Geom. mean 1982-83	73.3	-	-	-	78.3
20.02.84	21.6				-
05.03.84	28.0				35.0
23.03.84	31.0				-
27.03.84	-				20.0
03.04.84	29.0				29.0
11.04.84	21.0				21.0
22.05.84	33.0				48.0
20.06.84	44.0				96.0
28.06.84	62.0				66.0
03.07.84	70.0				84.5
11.07.84	64.0				91.0
25.07.84	65.0				99.0
05.09.84	-				72.0
26.09.84	-				83.0
22.10.84	-				105.0
02.11.84	-				100.0
19.11.84	-				35.2
11.12.84	-				69.0
Geom. mean 1984	38.8	-	-	-	57.7
13.02.85	64.0				
28.03.85		Surface: 67.0 [1Km d/stream = 65.0] 2m: 64.0 [" " = 66.0]			
01.04.85	86.0				
29.05.85 (Weir)	33.0	640.0		43.0	
17.06.85	29.0	650.0		29.0	
08.07.85	34.0	-		-	
16.07.85	45.0	640.0		52.0	
12.08.85	37.0	950.0		41.0	
16.09.85	42.0	780.0		50.0	
14.10.85	75.0	280.0		90.0	
11.11.85	23.0	-		-	
18.11.85	26.0	588.0		33.0	
16.12.85	22.0	670.0		22.0	
Geom. mean 1985	39.6	620.0	-	41.4	52.4
20.01.86	28.9	345.0		32.0	
17.02.86	54.0	725.0		64.0	
24.03.86	54.6	-		68.1	
21.04.86	78.0	-		70.0	
19.05.86	68.0	-		69.0	
23.06.86	78.0	-		82.0	
25.08.86	35.1	1027.0		49.1	
22.09.86	43.0	-		54.0	
20.10.86	35.0	-		44.0	
17.11.86	33.2	602.0		56.7	
21.11.86	-	-		-	
15.12.86	27.0	-		33.0	
Geom. mean 1986	45.4	627.0	-	71.1	
18.02.87	42.0	-		-	
09.03.87	52.0	280.0		60.0	
04.05.87	66.0	-		-	
01.06.87	72.0	-	71.0	-	
15.06.87	79.0	-	73.6	81.2	

TABLE 5.6

Conductivity
(mS/m)

DATE		LOCALITY			
	Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
20.02.84	10.5				-
05.03.84	11.6				15.0
23.03.84	15.2				-
27.03.84	-				14.2
03.04.84	11.5				16.0
11.04.84	9.6				9.8
22.05.84	16.0				20.0
20.06.84	21.0				42.0
28.06.84	30.2				32.0
03.07.84	31.7				36.7
11.07.84	26.6				31.9
25.07.84	24.2				37.0
05.09.84	-				27.0
26.09.84	-				34.0
22.10.84	-				45.0
02.11.84	-				41.0
19.11.84	-				15.7
11.12.84	-				26.0
13.02.85	27.0				
28.03.85		Surface:	24.5 [1Km	d/stream	= 25.3]
		2m:	26.0 ["	"	= 26.3]
01.04.85	36.0				
29.05.85 (Weir)	14.45	288.0		16.3	
17.06.85	11.1	210.0		16.4	
08.07.85	15.0	-		-	
16.07.85	18.8	232.0		22.0	
12.08.85	14.0	303.0		14.9	
16.09.85	18.0	285.0		23.0	
14.10.85	38.0	129.0		42.0	
11.11.85	9.6	-		-	
18.11.85	12.0	249.0		13.0	
16.12.85	8.1	262.0		8.0	
20.01.86	12.6	137.0		14.4	
17.02.86	25.0	286.0		29.0	
24.03.86	25.4	-		35.5	
21.04.86	31.3	-		31.1	
19.05.86	31.0	-		36.0	
23.06.86	29.0	-		37.0	
25.08.86	15.1	326.0		22.2	
22.09.86	20.0	-		25.2	
20.10.86	16.9	-		21.4	
17.11.86	13.6	228.0		23.2	
21.11.86	-	-		-	
15.12.86	12.1	-		15.9	
18.02.87	19.0	-		-	
09.03.87	24.0	132.0		29.0	
04.05.87	30.0	-		-	
01.06.87	31.9	-	31.9	-	
15.06.87	34.0	-	33.5	40.0	

TABLE 5.7

Chlorophyll a
(mg/m)

DATE	LOCALITY Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br
Geom. mean 1977-81	6.4	-	-	-	-
Geom. mean 1982-83	14.9	-	-	-	11.1
20.02.84	8.66				-
15.03.84	11.55				14.23
23.03.84	-				
27.03.84	-				5.16
03.04.84	8.15				7.47
11.04.84	2.48				3.36
22.05.84	18.16				11.37
20.06.84	13.80				11.22
28.06.84	6.38				4.55
03.07.84	5.25				13.17
11.07.84	7.71				22.30
25.07.84	33.50				48.58
05.09.84	-				-
26.09.84	-				31.37
22.10.84	-				20.40
02.11.84	-				12.08
19.11.84	-				70.12
11.12.84	-				31.81
Geom. mean 1984	9.2	-	-	-	14.5
13.02.85	12.57				
28.03.85		Surface:	16.61 [1Km d/stream		= 16.65]
		2m:	21.19 ["	"	= 18.64]
01.04.85	12.67				
29.05.85 (Weir)	10.16	2.46		8.46	
17.06.85	2.26	2.63		4.53	
08.07.85	14.71	-		-	
16.07.85	18.8	6.50		4.11	
12.08.85	12.49	12.45		29.52	
16.09.85	25.99	11.60		20.20	
14.10.85	24.08	17.50		28.12	
11.11.85	4.55	-		-	
18.11.85	10.39	1.70		26.54	
16.12.85	2.92	6.69		2.51	
Geom. mean 1985	8.80	5.76	-	10.70	8.7
20.01.86	12.87	5.37		19.40	
17.02.86	4.31	4.34		8.65	
24.03.86	28.12	-		4.96	
21.04.86	16.36	-		6.62	
19.05.86	12.32	-		6.30	
23.06.86	11.40	-		5.46	
25.08.86	1.09	8.59		5.40	
22.09.86	11.99	-		12.87	
20.10.86	29.60	-		30.93	
17.11.86	5.40	7.67		7.23	
21.11.86	-	-		-	
15.12.86	19.93	-		18.11	
Geom. mean 1986	10.40	6.30	-	9.5	9.7
18.02.87	10.42	-		-	
09.03.87	13.25	2.89		17.69	
04.05.87	11.10	-		-	
01.06.87	3.84	-	5.43	-	
15.06.87	4.07	-	9.54	6.99	

TABLE 5.8

Total organic carbon
(mg/L)

LOCALITY

DATE	Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
05.03.84	5.0				4.5
11.04.84	8.5				19.5
22.10.84	-				6.0
19.11.84	-				3.0
11.12.84	-				4.0
28.03.85	-		Surface: 7.0 [1Km d/stream = 6.0]		
			2m: 7.0 [" " = 7.0]		
08.07.85	6.0				
16.09.85	5.0	11.0		4.0	
14.10.85	1.0	8.0		3.0	
11.11.85	4.0	-		-	
18.11.85	5.0	7.0		7.0	
16.12.85	2.0	5.0		2.0	
17.02.86	4.0	8.0		4.0	
24.03.86	12.0	-		5.0	
19.05.85	6.0	-		6.0	
23.06.85	7.0	7.0		7.0	
25.08.85	4.0	-		2.0	
22.09.85	-	-		4.0	
20.10.85	8.0	-		6.0	
17.11.85	5.0	11.0		5.0	
15.12.85	10.0	-		10.0	
09.03.87	4.0	10.0		6.0	

TABLE 5.9

PO4-P
(Total/ filterable, mg/m)

DATE	LOCALITY Men. Rd.	Ft.Ons.Ck.	Bergins	Thurns	Cowp. Br.
Geom. mean 1977-81	32.2	-	-	-	-
Geom. mean 1982-83	77.5	-	-	-	56.5
20.02.84	32/08				-
05.03.84	26/13				28/09
23.03.84	46/16				-
27.03.84	-				21/05
03.04.84	17/05				-
11.04.84	34/07				56/15
22.05.84	33/-				
20.06.84	-				100/24
21.06.84	270/180	Contamination by diesel accident			
28.06.84	80/38				80/43
03.07.84	70/13				64/18
11.07.84	50/26				34/10
25.07.84	240/24				45/09
05.09.84	-				15/03
26.09.84	-				28/05
22.10.84	-				27/04
02.11.84	-				19/05
19.11.84	-				17/09
11.12.84	-				20/05
Geom. mean 1984	56.7	-	-	-	32.0
13.02.85	16/06				
28.03.85		Surface: 23/07 [1Km d/stream = 21/06] 2m: 23/05 [" " = 24/08]			
01.04.85	24/09				
29.05.85	(Weir) 17/05	41/11		19/06	
17.06.85	44/26	28/13		25/09	
08.07.85	110/68	-		-	
16.07.85	28/10	65/21		36/17	
12.08.85	17/05	86/13		32/07	
16.09.85	59/09	180/95		26/04	
14.10.85	260/150	840/590		50/10	
11.11.85	39/11	-		-	
18.11.85	32/11	90/40		32/09	
16.12.85	14/05	55/16		11/07	
Geom. mean 1985	38.0	91.2	-	26.6	23.7
20.01.86	23/05	64/33		33/05	
17.02.86	70/06	68/12		15/05	
24.03.86	38/06	-		12/03	
21.04.86	18/04	-		12/04	
19.05.86	17/06	-		13/06	
23.06.86	12/05	-		11/05	
25.08.86	17/-	24/-		18/-	
22.09.86	16/05	-		18/05	
20.10.86	48/10	-		35/07	
17.11.86	12/04	120/70		25/06	
15.12.86	25/08	-		27/10	
Geom. mean 1986	22.9	59.5	-	18.3	23.7
18.02.87	11/04	-		-	
09.03.87	33/09	86/56		24/04	
04.05.87	11/06	-		-	
01.06.87	10/02	-	07/04	-	
15.06.87	10/08	-	10/03	07/04	

Sampling of the river bed in both ponds (see chapter 4) showed that the bed is composed of coarse sand with a minimum of clay and some organic material. Two sites had sandstone fragments. Fresh aquatic weeds were occasionaly dredged from the bed. Near Bergins weir the bed of the river is covered with a high density coal sludge, probably to a depth of 20 cm. This sludge hardens to the consistency of concrete when air dried.

Apart from the coal deposit, which is recent, the remainder of the bed of the river has no evidence of anoxic conditions. There is no mud accumulating on the bed and there is no putrifying vegetation. The sand is relatively fresh and clean looking. This is all evidence of a channel bed that is being well oxygenated and overturned to some depth by high flows. The lack of clay accumulation suggests that these materials are either deficient in the flows or that they pass through the ponds or they are flushed out during the periods of major flow. Which ever is the case, one of the major contributors to water quality deterioration, namely the accumulation of clays with adsorbed phosphorous (Smalls, 1987), are absent from the bed of this reach of the Nepean River. The channel banks are covered with a veneer of loam (Chapter 4) and the clay content is of the order of 15 to 30 percent (Tables 4.2 and 4.4). These clays may be important if river widening is considered.

Water quality has been measured for some time in the pond of Menangle weir (Fig 5.2). Foot Onslow Creek, which is a tributary to the Nepean River, entering between Menangle weir and Bergins weir, has also been monitored for a number of years. The pond of Bergins weir has been monitored only recently.

Comparison of Menangle weir and Foot Onslow Creek shows that the creek has a much poorer water quality than the weir. Dissolved oxygen levels in the creek are commonly half those in the weir, turbidity is often twice as high, chloride ion contents are 10 to 20 times as large, conductivity is 5 to 10 times as large, chlorophyll a values are approximately a half, but organic carbon is twice as large and total phosphate levels are 3 to 4 times as high. Yet comparison of the limited data on Bergins weir with that for Menangle weir taken at the same time shows that the two weirs do not differ significantly in terms of water quality. The water quality problems of Foot Onslow Creek do not appear to be degrading the quality of water in Bergins weir. This is again evidence of a relatively 'healthy' pond. During extremely long periods of stagnant flow problems may have arisen, but these problems could not be attributed to the mining activity in the area; they are probably a result of the large quanitites of agricultural materials (eg. fertilizers) that are being washed off the surrounding hillslopes into the stream.

At this stage it is worth noting that the only major user of the Bergins weir pool appears to be the Department of Agriculture, with the coal washery being reported to have pumped occasionally from the river (unconfirmed verbal report). The other main use is recreational. This pool did not exist prior to the construction of Bergins weir and is therefore artificial.

5.2

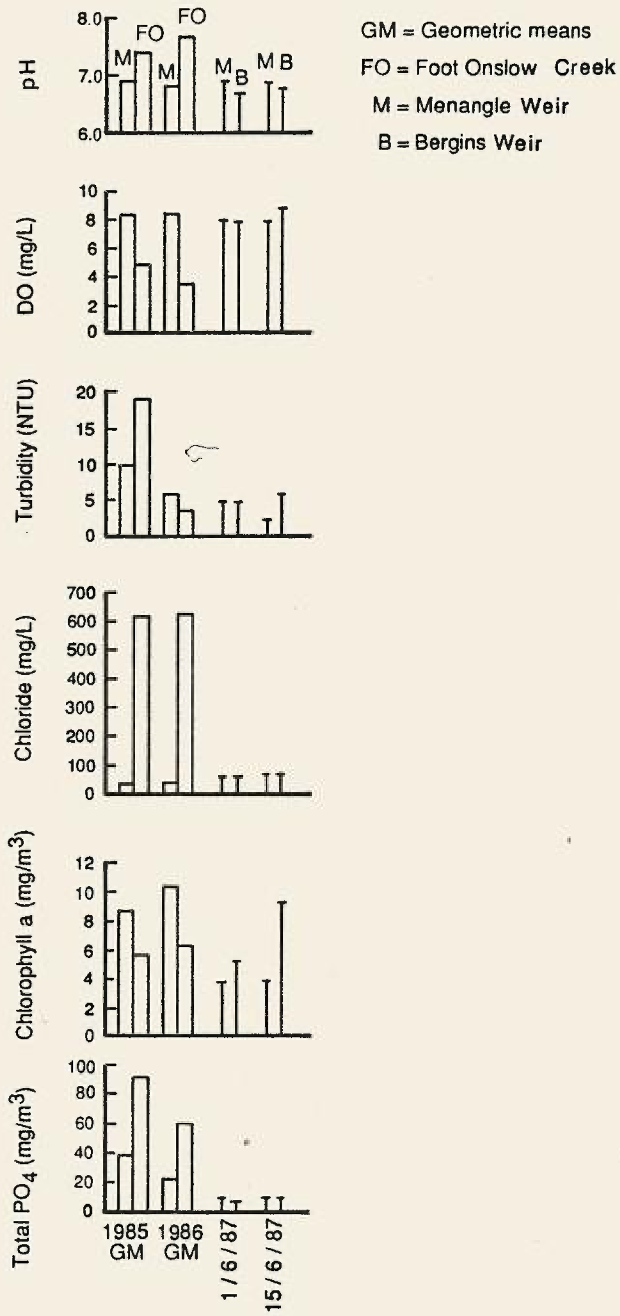


Figure 5.2 Comparison of water quality parameters at Menangle weir, Foot Onslow Creek and Bergins weir sampling sites

5.4 DOWNSTREAM IMPACT OF MINING ACTIVITY

Bergins weir has only recently been placed on a regular water quality sampling program. Menangle weir has been sampled since the mid 1970's, Camden at Cowpasture Bridge since the early 1980's and Thurns weir since the mid 1980's (Tables 5.1 to 5.9). Menangle weir is upstream of the mining operation, Cowpasture Bridge and Thurns weir are downstream not only of the Menangle mining operation but also of several other mining operations. In addition there are several tributaries joining the Nepean River between Menangle and Thurns weir. Consequently, it is not possible to uniquely attribute changes in water quality at Thurns weir and Cowpasture bridge to mining at Menangle.

The following analysis is on the basis of the geometric means for each station for each sampling period. Limited time prevented more detailed, event-based analysis. Such analysis would be required for a detailed examination of the factors controlling water quality in the Nepean River. However, since many of these factors are unrelated to mining it is considered that an analysis of the geometric means should indicate major trends in space and time. The mining operation is a relatively constant operation that has proceded over a number of years (see Chapter 2) and its impact, if there is one, should be consistent.

The downstream and temporal changes in key water quality parameters (Fig 5.3) do not suggest any significant influence of mining on the water quality of the Nepean River at least as far as Menangle is concerned. Dissolved oxygen has remained relatively high and uniform downstream of the Menangle site. Turbidity decreases slightly between Menangle and Thurns weirs although it increases at Cowpasture Bridge, either resulting from mining downstream of Thurns weir or from the urban stormwater and landuse activity of the Camden region. Chloride ion content shows a slight increase downstream, consistent with tributaries draining the salt rich Wianamatta Group shales and contributing to the salt load of the Nepean River. Chlorophyll a appears to fluctuate slightly from year to year in its downstream trend, but it is unlikely that this is a significant fluctuation. Total phosphorus appears to decline downstream and also appears to have declined in time. Improvement in wastewater disposal and land management practices in the catchment are the probable causes of the improvement in the phosphorus content of the water.

There appears to have been a water quality deterioration at Menangle between 1977-81 and 1982-83. Chloride ion, chlorophyll a and total phosphate are all lower for the first period than for the second period. However, it is not known how variable the data are for the two periods. The 1977-81 period is twice as long as the 1982-83 period and includes some large floods which may have had a flushing effect (see Chapter 4) whereas the 1982-83 period was drier. It was very wet in 1977 and 1978, 1979 was drier, 1980 was dry and 1981 was wet again (Table 5.10). The State pollution Control Commission (1985, p.4) noted that sewage effluent dominated water quality in the downstream section of the Nepean river in the dry period of 1979 to 1980.

5.3

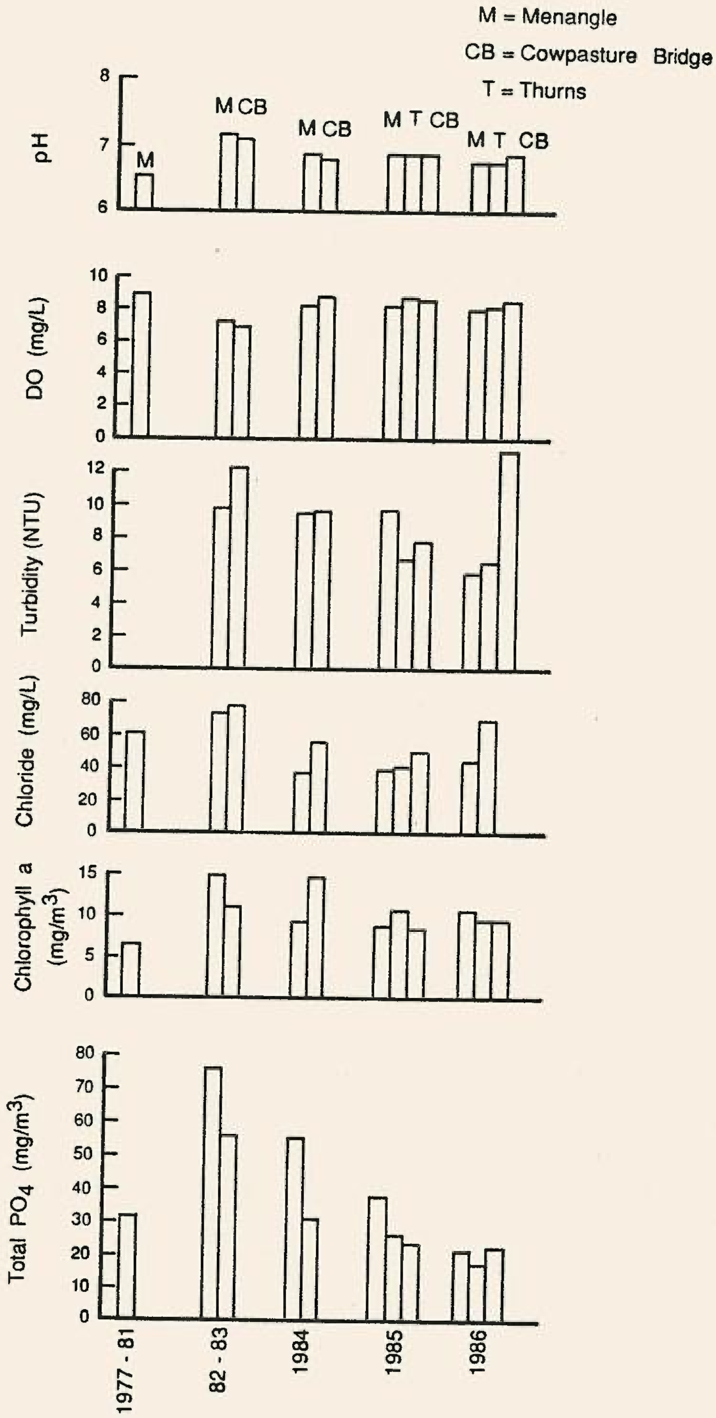


Figure 5.3 Downstream changes in water quality for the Nepean River for the period 1977 to 1986.

Table 5.10

Annual volumes of flow for Divines gauging station

Year	Volume (ML)
1977	240917
1978	624024
1979	5686
1980	6029
1981	incomplete record
1982	2081
1983	no data

5.5 ASSESSMENT OF WATER QUALITY AT MENANGLE WEIR IN 1986

The water quality data was examined to assess water quality at the site in an absolute sense. The data for Menangle weir for 1986 has a comprehensive record. The sample site at Menangle is the weir pond upstream of the present quarrying operations.

The mean values for each water quality attribute were compared to the standard water quality criteria of Hart (1974) and the SPCC (1985) (Table 5.11). Colour and total organic carbon have been omitted from the comparison as no common standard units could be found. It should be noted that the methods for determining the Nephelometric (NTU) and Jackson Turbidity Units (JTU) are different, however there is a theoretical 1:1 relationship between the values.

The water quality values are all within the criteria acceptible to Hart and SPCC. It is recognised that the mean values used in the comparison give no measure of the spread of values. Comparison with the data in Table 5.1 to 5.9 shows no major water quality problems. Extreme values for Chlorophyll a and total Phosphate are higher than the SPCC average goals. Total dissolved oxygen value is very high and oxygen saturation is also high.

The water quality of the Nepean River upstream of Bergins and Menangle weirs is good.

There is no significant local source of salt rich runoff and shallow groundwater. Walker noted morphological differences in local soils which he attributed to calcareous beds in the Wianamatta Group. There are higher reaction trends in the base of two auger holes, indicative of saline groundwater, however there is no observed saline groundwater springs at the site. Conductivity values at Menangle weir are low with extreme values in the medium range of water quality. Values for Foot Onslow Creek were 137-326 mS/m for the same period, registering in the high to very high range (Hart, 1974). The effect of this and other saline tributaries has little effect on downstream water quality at Thurns weir (Table 5.6).

Table 5.11

Comparison of measured and desired water quality values

		pH	Dissolved oxygen mg/L	Turbidity NTU
Menangle	Geometric mean	6.8	8.1	6.0
	Range	6.2-7.7	6.1-9.9	3.0-16.0
SPCC (1985) guide		-	-	-
Hart, 1974	Drinking	7.0-8.5	>6.0	25
	Irrigation	4.5-9.0	-	-
	Recreation	6.5-8.3	-	50
	Aquatic ecosystems	6-9	>6.2	<25

		Conductivity mS/m	Chlorophyll a mg/m	Total phosphorus mg/m
Menangle	Geometric mean	19.9	10.4	22.9
	Range	12.1-31.3	1.1-29.6	12-90
SPCC (1985) guide		-	20	50
Hart (1974)				
	Irrigation	0-28 low 28-80 medium 180-230 high 230-550 v.high		

5.4 CONCLUSIONS

a) There is no evidence to suggest that the mining activity at Menangle has had any long term effect on the water quality of the Nepean River.

b) Any impacts of the mining on the quality of water in the Nepean River must be short lived and the river appears to have the capacity to absorb them.

c) There is no evidence that the ponds behind Bergins and Menangle weirs are in a state of deterioration.

d) Water quality at Menangle can be considered high.

e) Salinity is not a problem

5.5 REFERENCES

Hart,B.T. 1974. A compilation of Australian water quality criteria. Australian Water Resources Council Tech Paper No. 7

Smalls,I. 1987. Sources and availability of phosphorus in urban runoff in the Sydney region. In Institution Engineers Australia. Proceedings seminar on Urban runoff and water quality July, 1987.

State Pollution Control Commission. 1985. A strategy for the management of the water quality of the Hawkesbury-Nepean River NSW Govt Printer

==================

SECTION B: IMPACTS

==================

CHAPTER 6.

MODEL FOR ASSESSING THE IMPACT OF THE PROPOSED EXTRACTION

6.1 INTRODUCTION

In this section a model is presented of the physical interaction between the environment and extraction of material from the river bed, banks and floodplain. The model is presented in two parts; the first involves the floodplain and the second the channel bed and banks. The purpose of this model is to define those aspect of the physical environment that must be examined in order to assess the physical impact of the extraction on the Nepean River system. The general character of the model, in schematic form, is presented in Fig 6.1. The model is applied in Chapter 7 as a mechanism of assessing the important impacts of quarrying and dredging.

6.2 EXTRACTION ON THE FLOODPLAIN

There are two major physical processes operating on the floodplain that are important in assessing the interaction between the floodplain and the extraction. The first of these is rainfall erosivity, the second is overbank (flood) flows (Fig 6.2). Each of these will be dealt with separately in the following discussion.

Rainfall can cause erosion of material on the floodplain through the processes of surface wash, rilling, rainsplash and mass movement. Rainfall erosivity is defined as that rainfall energy available to erode material. Rainfall erosivity depends on rainfall intensity (Rosewell, 1986). The effectiveness of rainfall erosivity depends on the material characteristics of the surface onto which the rain falls and the geometry of the land surface. The erodibility of the surface material is very low when grass covered and extremely high when disturbed. The geometry of the surface determines how effective the runoff will be in moving material across the floodplain and into the river. Steep slopes of loose material that concentrate flows and are oriented towards the river will be preferential sites of active rilling and flow of sediment laden water into the river. Horizontal slopes or battered slopes of low gradient lacking flow convergent shapes will minimise the flow of sediment into the stream; slopes internally draining into the floodplain will reduce the sediment loss to zero.

6.1

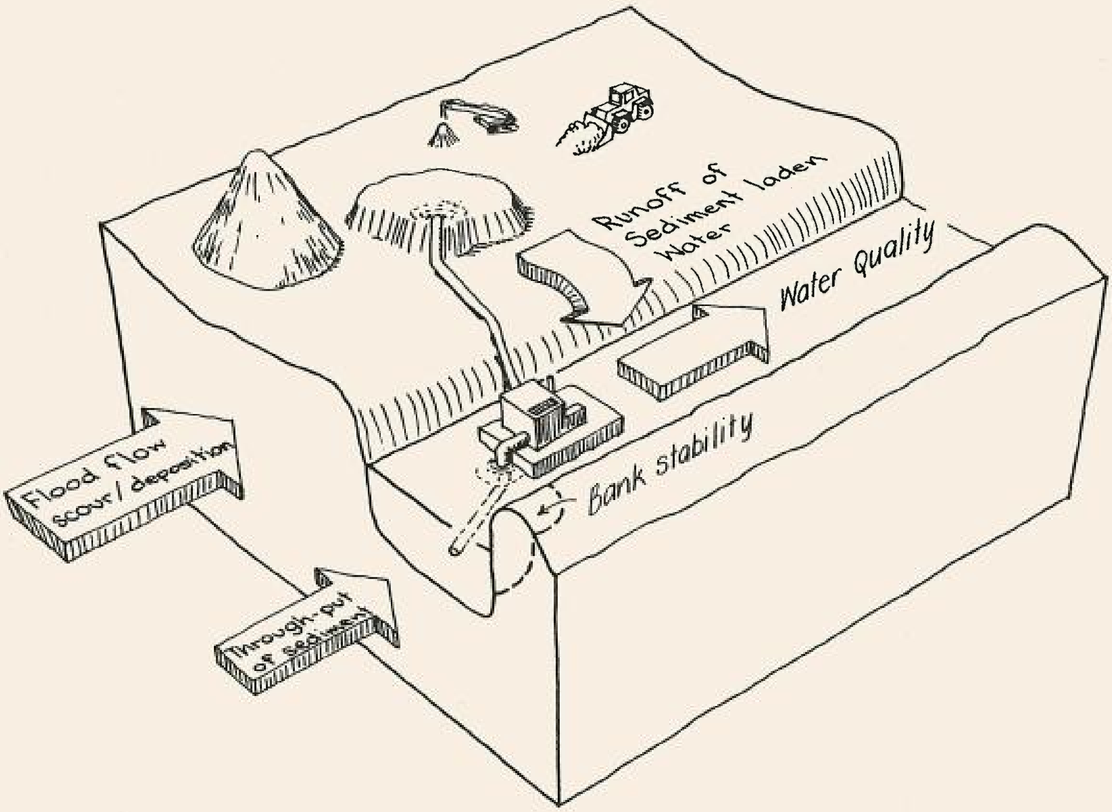


Figure 6.1 Schematic model of mining of the channel and floodplain of the Nepean River and its hydro-geomorphic impacts.

6.2

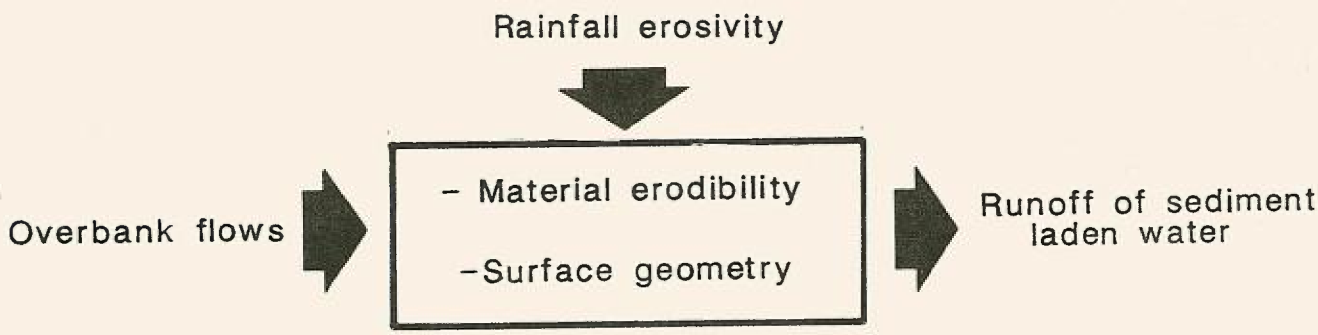


Figure 6.2 Model of the impacts of quarrying the floodplain

Sediment-laden runoff from the extraction site may also flow into areas other than the river. Flow of the water onto grassed slopes where velocity is reduced will cause deposition of material. This is considered a minor problem because it is mostly loam that is to be extracted from the floodplain and grass should rapidly re-colonise deposits of such materials. The more significant impact is on the valley marginal lagoons and swamps. Large quantities of sediment-laden flow into these will reduce their storage capacity and depth and increase turbidity. There may be other physico-chemical impacts if these ecosystems are disturbed.

Within the area of extraction, particularly the fresh unvegetated surfaces, the runoff, rainsplash and wash process may give rise to local rilling and even gullying on steep slopes where flow is allowed to concentrate. There may also be zones of deposition. In an area that is being worked these erosional sites are not problem areas because they are soon worked over. In an area that has been worked and is being regenerated these erosion and deposition zones are problem areas that must be avoided if regeneration is to be successful in a minimum of time.

The second aspect of interaction on the floodplain occurs when there is overbank flow (flooding). The greater the depth of flooding the greater are the potential problems although they will be less frequent provided the ground surface has not been lowered. Floods have two major effects on floodplains; they either scour them and transport the eroded material further down the floodplain or into the channel; or they cause deposition. The scouring potential of overbank flows is largely determined by the shear stress and power of the floodwaters. The degree of erosion or deposition that takes place is dependent on sediment load, flow velocity, erodibility of floodplain material, vegetation cover and surface geometry.

The actual contribution of eroded material from any one section of the floodplain to the river during a flood will only be a small fraction of the total sediment load carried by the stream and in all probability will be a negligible component in the dynamics of flow and sediment transport within the river. On the other hand large quantities of sediment eroded during a flood from one section of a floodplain may be deposited a short distance downstream on the floodplain. These deposits may be very deep. Such deposits may also have their source in sediment carried from the river onto the floodplain and may not have any relation to scour of the floodplain in the upstream area.

Modifications of the floodplain as a result of extraction may result in changes in the discharge, power and shear stress distribution between the floodplain and channel. Lowering of the floodplain will result in greater depths of flooding and increased power expenditure on the floodplain but will, on the other hand, increase storage on the floodplain which may significantly affect downstream flood characteristics and reduce flow velocities.

Lowering the floodplain may influence the groundwater flow adjacent to the river. If there is a substantial groundwater flow through the floodplain towards the river then the extraction may cause a zone of saturation to develop at the remoulded groundsurface. Extraction will have neglible effect on a river where there is flow from the river outwards, because such flow would be below the low to medium in-channel flow level. Since there is no intention to mine clay from the floodplain in the Menangle site the impact of removal of impermeable barriers to groundwater flow will not be assessed. There is no evidence of substantial groundwater flow. Augering on the levee top and banks showed groundwater levels close to river water surface level.

6.3 CHANNEL EXTRACTION

The model for extraction of material from a reach of river (Fig 6.3) involves the interaction of the river flow and sediment load within the area of extraction in terms of changes in the channel geometry and material characteristics of the bed and banks. The bed and banks of the river cannot be separated in this analysis because they are dependent on each other in terms of establishing stable profiles under given hydro-dynamic forces and sedimentologic regimes.

Extraction from the bed of the river results in an increase in the depth of flow through the reach and increased bed slopes in the transverse direction. Extraction of the banks results in an increase in the width of the stream. In both situations the sediment and flow dynamics of the stream through the reach and downsteam will be altered, although the degree of alteration is dependent on the site as discussed in Chapter 7. It may be possible for extraction to take place with no alteration in the thoughput of sediment. Sediment flow through a reach is dependent on the stream power and the availability of sediment for transport. Extraction interrupts this throughflow, the extent must be determined.

Channel geometry, both cross sectional and pattern, are a response to the hydrological and sedimentological regimes of the river. At any one time the geometry will not be constant along a reach of river, but over a period of time, in a stable system, average geometry at a section and along a reach are constant. It must be established that the changed channel geometry as a result of the extraction will be stable. It must be established that changes in channel geometry at the extraction site will not trigger changes either upstream or downstream.

The Nepean River at Menangle does not tend towards a stable regime. It moves from one state to another in reponse to large changes in inputs in a 'catastrophic' manner. The impact is not to change the river from some stable condition but to impose a change which will act as a base for future inputs of water and sediment to modify. Widening the channel by dredging is identical to widening by a series of large floods. The river has adjusted to this change in the past by reducing channel cross-sectional area through the construction of benches and in-channel ridges, presumably during periods of lower or less frequent floods. The timescales needed for these changes to take place are not known. It is also not known if the most recent catastrophic event was a 'one-off' response to aboriginal fire regimes or other inputs.

6.3

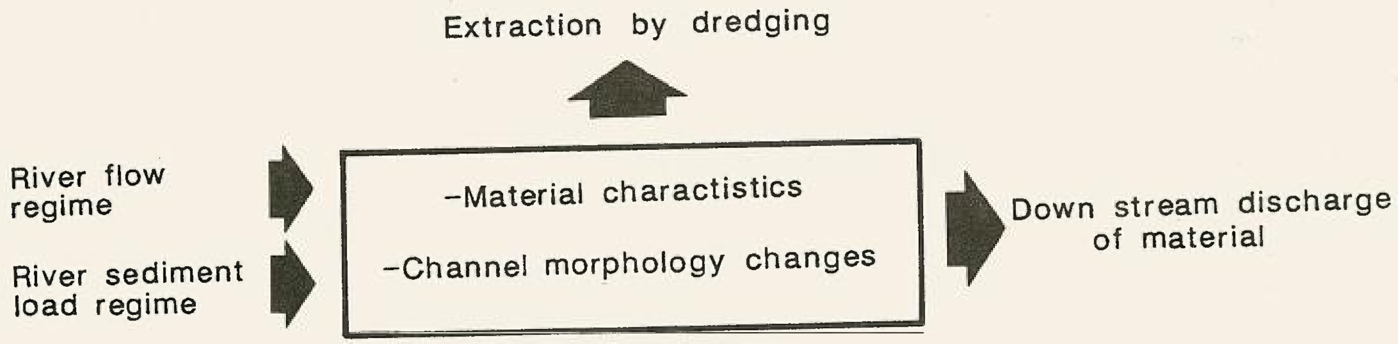


Figure 6.3 Model of the impacts of excavation from the channel

Extraction will disturb material on the bed and throw it into suspension. If there is flow in the river then the disturbed material will be carried downstream. If there is no flow the material will be dispersed by minor currents if the extraction is carried out in a pool, as is the case at the Menangle site. Disturbance of material and deepening of the river may also result in changes in the biochemical regime of the river, resulting in changes. in terms of aquatic ecosystems and human use of the water resource. In general these changes are important in situations where clays and organic material are released into the water after being buried beneath the stream bed for some time. However, in the bed of the Nepean River there appears to be only a minor amount of clay.

6.5 TEMPORAL FRAME OF REFERENCE

Complicating the assessment of the impact of extraction on the floodplain and the river is the long term dynamics of the river system. Floodplains and river beds can be in one of three long term conditions. A aggradational phase is one in which the floodplain is building up over a period of time, ie. the material resource is being added to the site. The degrading floodplain is one that is abandoned by the river as it has cut to a lower level and is usally being destroyed on its river margin; this is a declining resource for both the floodplain and channel. Finally, a stable floodplain and channel is one which maintains its gross geometry; the material resource is essentially constant over a long time period. Further complicating the assessment of the impact is that there are a number of short term changes that take place in period of years or decades. A series of floods in quick succession may cause localised rapid aggradation or degradation of the floodplain. Extraction cannot be looked at in a time frame that is short nor can it be assessed in terms of a steady state frame. At the very least an intermediate time frame must be used (Schumm and Lichty, 1965) and in the context of other similar operations, past, present and future.

6.5 CONCLUSION

a) Models of the impact of quarrying and of dredging are presented. These models provide the framework for assessing the important interactions between the proposed operation and the river

b) Modification of the floodplain and the effect on hydraulics and sedimentology of flow in the channel and over the floodplain must be addressed.

c) Erosion of material and resultant runoff on the floodplain during local rainstorms must be examined.

d) The timescale of interest for assessing the impact of the extraction is of the order of tens to hundreds of years.

6.6 REFERENCES

Rosewell,C.J. 1986. Rainfall kinetic energy in eastern Australia. J Climate and Applied Meteorology, 25,169-1701

Schumm,S.A. and Lichty,R.W. 1965. Time, space and causality in geomorphology. Am J. Sci., 263,110-119.

CHAPTER 7

THE IMPACT OF PROPOSED MINING OPERATIONS

7.1 INTRODUCTION

In this chapter the impact of the proposed mining operation on the river hydraulics and sediment transport will be assessed. The impact of the mining operation on the river downstream of the extraction site will also be assessed.

Section 7.2 outlines the those aspects of the proposal for quarrying and dredging that are relevant to this study. The issues are summarised in section 7.3, the total impact of the proposal is examined in section 7.4, and the impacts at specific sites are reviewed in the following sections.

7.2 THE PROPOSED MINING OPERATION

The proposed extraction is detailed elsewhere and in this report only those aspects of the extraction that directly relate to assessing the physical impact of the extraction on the river system and the river system on the extraction will be discussed.

The proposal is to dredge the river in stages 1, 2, 3, the upstream part of stage 4 and in stage 7.

The Department of Water Resources guidelines for dredging for this area are that the width of the channel shall not be increased to greater than 50 metres, that a 18 metre wide buffer zone between the bank and channel centre be left on either side and that the remaining 14 metres of channel shall not have cross-sectional slopes greater than 1 in 3. This implies that the depth of the channel at the centre will not be greater than 6.3m below low water level.

For the left floodplain and left bank of stage 2, the right bank and floodplain of NSW Trotting Club land and Campbelltown City Council land, and the left bank and floodplain of stages 6 and 7 it is proposed to leave a bank 3 to 5 metres above low water level and to cut into the floodplain, leaving a surface with a slope of 1 in 40 towards the channel. Extraction will proceed out onto the floodplain for distances of the order of 200 to 300 metres except for the NSW Trotting Club and Campbelltown City Council land, where extraction will only extend to approximately 150m from the bank.

The left floodplain of stage 1 will not be further developed as maximum extraction has been completed in that area.

In stage 6 it is proposed to leave a buffer zone around the margin of the river, the stream to the east and the road to the west and to extract material to a depth of 3 to 4 metres.

In stages 1,2,3 and 7 no dredging will take place within 100m of the bridges and weirs. For stage 7 a 50 m wide buffer zone will be left between the quarry and the small creek to the west and between the quarry and the F5 Freeway bridge. No dredging will take place upstream of the F5 Freeway bridge. For the Campbelltown City Council land a 100m wide buffer zone will be left between Menangle Road and the quarry.

It is proposed to use a cutter-suction dredge which the SPCC (1984, p.13) have shown creates a minimal turbidity problem and does not return fines to the river.

7.3 THE ISSUES

The issues identified as important in assessing the impact of the extraction proposals were detailed in Chapter 6. These issues are:

a) the impact on the depth of flow
b) the impact on velocity of flow
c) the impact on scour potential
d) the impact on sediment transport
e) the impact on bank stability
f) the impact on water quality
g) the impact on weir stability
h) the impact of flooding on the operations
i) the downstream impacts
j) the cumulative impacts of this proposal plus other mining operations further downstream
k) the impacts on groundwater.

Each one of these impacts will be examined for each of the proposed areas of dredging and quarrying. The impacts will be examined from the upstream areas and cumulative effects through the operation downstream will also be examined.

7.4 TOTAL CHANGE IN CHANNEL AND FLOODPLAIN HYDRAULICS

In order to assess the total change in the Nepean River at Menangle as a result of the quarrying and dredging a 20 year flood with a discharge of 2200 cumecs has been taken for purposes of comparison. It has been assumed that all the proposals are approved. The effect on the hydraulic characteristics of the river at the completion of the extraction are examined since these will be the most extreme changes.

The change has been assessed by applying the HEC-2 backwater model used in Chapter 3.5 to the channel and floodplain of the Nepean River as it would exist at the completion of the operations and comparing the differences between the results of the model applied to the present river system (Fig 3.8) and the future river system. Table 7.1 shows the changes in channel hydraulics at the significant cross sections along the river as computed by the HEC-2 model for the two channel and floodplain configurations.

Table 7.1

Velocity, depth and slope changes along the Nepean River at Menangle as a result of extraction -for the 20 year flood (refer to Fig 3.8 for cross sections)

Cross section	Channel depth (m)	Channel velocity (m/s)	Slope	Change in Flood level (m AHD)	Left Hand bank velocity (m/s)	Right Hand bank velocity (m/s)
			Stage 7			
25	+3.14	-0.01	-0.00001	-0.86	-0.04	*
20	-1.24	-0.26	-0.00025	-0.74	+0.23	*
19	-0.66	0.	-0.00014	-0.66	+0.04	*
17	-0.65	+0.10	+0.00022	-0.65	*	*
			Stage 6			
15	-0.65	-0.08	-0.00002	-0.65	+0.16	*
			Stage 1			
13	-0.66	-0.05	-0.00030	-0.65	-0.17	-0.04
12	-0.44	-0.02	-0.00006	-0.61	-0.06	-0.07
11	+2.09	-0.09	-0.00031	-0.67	-0.20	-0.14
10	+3.07	-0.08	-0.00015	-0.50	-0.12	-0.04
			Stage 2			
9	+2.28	-0.31	-0.00040	-0.39	+0.07	-0.22
8	+2.19	+0.01	-0.00004	-0.38	-0.06	-0.04
7	+2.83	-0.21	-0.00033	-0.34	-0.09	-0.09
			Stage 3			
6	+3.17	-0.14	-0.00034	-0.20	-0.07	-0.07
5	+3.13	0.	-0.00028	-0.12	-0.13	-0.07

- indicates a decrease after the dredging and quarrying

+ indicates an increase after the dredging and quarrying

The effect of the dredging and quarrying is to decrease the height of flooding relative to AHD by 0.20 to 0.30 metres in stages 3 and 2 and by 0.6 to 0.8 metres in stage 7. This decrease is a result of the large increase in storage on the floodplain and increased cross sectional area of the channel. Also, with the quarrying, the removal of shrubs and trees will reduce the resistance to flow.

Velocities in the channel generally decrease throughout the whole area, the decrease being of the order of 0.1 m/s although it is slightly greater in some sections. There are two sites where the velocity increases and one where there is no change.

Depths increase in the dredged areas of stage 1, 2 and 3. There is a small decrease in depth in stage 7 at 3 sections. This is because the reach of channel at stage 7 is already much deeper than the proposed depth of dredging. Some account has been taken of infilling of the channel by sedimentation from the river. Floodplain flow velocities decrease in all areas except for stage 7. The decrease is generally small.

Details of the impacts in each stage is given in the following.

7.5 THE IMPACTS IN STAGE 7

7.5.1 Impact of Dredging on depth and width of channel

Dredging in this area between the Railway bridge and F5 Freeway bridge will widen the river slightly, approximately 15 metres maximum at a position approximately 200m downstream of the F5 Freeway bridge where a sand bar protrudes into the river (Fig 4.4). The depth of the river will be affected only slightly since the majority of the channel is deeper than 6.3 metres (Fig 4.3). Two small sand bars will be trimmed.

7.5.2 Impact of dredging on stream velocities

Dredging will not significantly alter stream velocities. The greatest change in channel velocity is a result of the quarrying of the left hand floodplain. The maximum decrease in velocity along the channel is 0.26 m/s (Table 7.1). There is an increase in velocity of flow through the Railway bridge of 0.10 m/s.

7.5.3 Impact on scour potential

There is a slight decrease in depth of flow through the channel and a decrease in the energy slope. Consequently the shear stress at the channel bed will decrease, ie. a decrease in scour potential.

7.5.4 Impact on sediment transport

Within the channel the decrease in depth, slope and velocity of flow means that the power expended on the bed will decrease slightly. Thus, the sediment transport capacity of the river will decrease at all flows, although the decrease will be greater at higher flows.

7.5.5 Impact on bank stability

The right hand bank is composed of bedrock and no stability problems will arise on that side of the channel. The left hand bank has no stability problems at present, the channel is wider than 50m in most cases, so new channel banks will not be cut by the dredge.

7.5.6 Impact on water quality

Dredging of the relatively clean sands with a cutter suction dredge should give no water quality problems. There is little clay and only a small amount of organic material. Assuming that there are no oil spills from the dredge the actual extraction operation should have no effect at low flows.

At medium flows, of the order of 5 cumecs discharge, velocities in the stream will be such that some material may be carried downstream over the weir.

7.5.7 Impact on weir stability

The only changes in channel geometry will be minor and at some distance upstream of the weir because the majority of the channel upstream of the weir is deeper than the allowed limit of dredging (Fig 4.3).

7.5.8 Impact of flooding on operations.

There is a possibility that a 20 year flood will occur whilst the dredge is in the reach. The dredge could cause damage to the railway bridge and the road bridge if it moved off site and was swept downstream. The impact of the dredge by itself may not be sufficient to damage the bridges but the accumulation of debris around a sunken object could create problems. Measures will have to be taken to reduce this impact and ensure that the dredge does not break its moorings.

7.5.9 Cumulative effects downstream

The dredging operation will remove sediment from the river. The alteration of channel geometry is slight and the sediment load will not change significantly.

7.5.10 Impact of dredging on groundwater

Groundwater is not an issue. Bedrock material will not be intersected and there is no evidence of significant groundwater leakage into the Menangle weir pool.

7.5.11 Impact of floodplain extraction on depth of flow

The effect of mining the floodplain is to increase the depth of flow by more than 10 metres in some sections along the river bank. A large proportion of the left hand floodplain is above the 20 year flood level at present. The quarring will place the area well into the 20 year flood zone. This will mean that the frequency of flooding of this area will increase, from less than once every 20 years to more than once a year for the areas adjacent to the channel and once every 3 to 5 years for areas further away from the channel.

7.5.12 Impact of floodplain extraction on velocity of flow

The impact of floodplain extraction and general lowering of the topography is to increase the flow velocity across the area, which is to be expected because most of it was not inundated by the 20 year flood. Overbank flow velocities will be of the order of 0.40 m/s.

7.5.13 Impact of floodplain extraction on scour potential

Because the depth and velocity of flow increase across the floodplain the shear stress acting on the floodplain during a flood will increase. This is true no matter what the recurrence interval of the flood. Areas not protected by vegetation will be susceptible to scour. However, as the quarried area is on the inside of a meander it is highly likely that any material scoured from the floodplain will be carried in towards the centre of the meander and deposited there. This area should have a positive sediment budget.

7.5.14 Impact of floodplain extraction on sediment transport

Sediment transport potential of the overbank flows across the floodplain will increase because there is a greater stream power distribution over the area and greater shear stresses being exercised on the surface of the floodplain. Most of material transported through the reach should be carried to shallower areas towards the south and deposited. Some material will be carried directly across the excavated floodplain.

7.5.15 Impact of floodplain extraction on bank stability

The considerable lowering of the floodplain should reduce the potential for bank collapse. There is no evidence of bank collapse or instability in this area at present and it is unlikely that there will be any problems as long as natural vegetation and grass maintains a cover over the bank from the water line to the surface of excavation.

7.5.16 Impact of floodplain extraction on water quality

There are considerable quanitites of organic materials and silts and clays in the floodplain sediments. During a flood some of these sediment would be entrained and a carried into the river. However, the flood that would be entraining the material would probably have a high sediment load already and the contribution from floodplain scour and entrainment is unlikely to significantly affect flood water quality.

Rainfalls in excess of 20mm will probably produce runoff. There is a strong possibility that fine grained sediment would be carried into the river. This material, which is probably rich in nutrients from fertilizers and animal excreta, could cause some water quality problems. Every effort must be made to prevent wash of material into the river.

7.5.17 Impact of floodplain extraction on weir stability

The effect will be discussed in the section on cumulative impacts

7.5.18 Impact of flooding on floodplain extraction operations

Flooding will put machinery at risk, but the majority of this machinery is mobile and readily moved to higher land to the south. Any equipment that is flood sensitive should be installed on the higher, southern area.

7.5.19 Impact of floodplain extraction on cumulative effectes downstream

The will be examined in the section on the total effects of extraction in stage 7

7.5.20 Impacts of floodplain extraction on groundwater

There is no evidence of significant groundwater at shallow depths and within the depth of quarrying in this area, although piezometers have not been installed to determine the potentiometric surface. Groundwater table is likely to be below the bedrock contact because the sand and loam are highly permeable and transmit water rapidly. Hence, the grounwater table should be well within the bedrock. There are no plans to mine the bedrock, hence it is unlikely that groundwater will be a problem.

7.5.21 Total effects in stage 7 on weir stability

The Menangle weir is 95 percent built on bedrock and it is highly unlikely that the quarrying and dredging operation will have any effect. Dredging is at least 100 metres upstream of the weir and there will probably be no significant dredging of the river for a distance of at least 500m upstream because the river is already deeper than the permissable depth of dredging. The quarrying operation will come no closer than the edge of the small tributary that enters the river approximately 150m upstream of the railway bridge.

Velocities of flow under the Railway bridge are not significantly altered by the dredging and quarrying operation, the change in velocity for the 20 year discharge being +0.10 m/s, the actual velocity after the completion of dredging and quarrying being 1.57 m/s.

No sediment of a large calibre is being discharged into the river by the dredging and quarrying operation so abrasion and impact damage as a result of the operation will be negligible.

7.5.22 Total effect in stage 7 on sediment transport

The sediment load of the river is negligable during low flow stages simply because velocities are significantly below those required to transport the bed material load. Local runoff from the quarry site, if not controlled, would increase the wash load component of the river, with consequent increase in turbidity and nutrient input. However, in terms of total sediment load the wash load contribution from any one rainfall event or over bank flood would probably be of the order of tens and possibly hundreds of tons, which is several orders of magnitude less than the 25 000 tonnes of a typical 20 year flood.

The excavation of the the floodplain is in a site which is a natural sink for sediment. Thus, it is more likely that sediment carried into stage 7 from upstream would be deposited on the flooodplain than material be entrained from the floodplain and carried downstream.

There is only a minor amount of deepening of the channel between the Freeway and railway bridges and it is unlikely that the minor amount of excavation of the river bed will create any more traps for sediment carried into the reach than exist at present.

In summary, there is a possibility of a slight decrease in sediment load as a result of the quarrying, but it is unlikely to be significant. It is impossible to predict the exact quantity of sediment that would be deposited and withdrawn from downstream transport.

7.5.23 Total effects in stage 7 on downstream impacts

The downstream impacts of the dredging and quarrying operation would first be felt at Bergins weir. A small decrease in the sediment load would not influence the Bergins weir section. The most significant impact downstream would be a decrease in water quality if fine grained sediment was allowed to escape into the river from the quarrying operation.

7.5.24 Impact on the Railway bridge

There is an increase 0.1 m/s in velocity and 0.00022 m/m in slope but a decrease of 0.65 m in water depth of flow through through the railwayway bridge. The shear stress will increase through the bridge. However, the bridge supports are apparently built on bedrock and appear to be designed to withstand large floods. No quarrying takes place within 100 metres of the bridge on the left hand bank. Hence a permanent vegetation cover will be maintained over the surface and scour of the floodplain around the railway will probably be minor.

7.6 IMPACTS IN STAGE 6

It is not planned to dredge the river in stage 6, the reach of channel between the Menangle Road bridge and the Railway bridge. The river is already in excess of 10 metres deep and the width is much greater than 50 metres. Hence, in this area the only impacts are those associated with the proposed quarrying operation on left hand bank. This operation is limited because bedrock outcrops within 5 metres of the surface in the left hand bank of the river, so it will not be possible for quarrying to extend down to within 3 metres of the low flow stage.

7.6.1 Impact on depth of flow

The effect of the proposed quarrying is to increase the depth of flow across the floodplain. Some areas previously above the 20 year flood level will be 3 to 4 metres below it after quarrying. Flood frequency would increase from approximately 20 years to more than 6 years.

7.6.2 Impact on velocity of flow

The impact of the quarrying is to increase the velocity of flow across the area by 0.16m/s (Table 7.1). However, there was a large area previously not flooded which is now subject to inundation and the scouring impact of those flows. Velocity across the floodplain will be 0.32 m/s.

7.6.3 Impact on sediment transport

The area of quarrying is to have a buffer zone established around it. If a flood occurs during quarrying and before the surface is revegetated then the material on the surface will be mobilised by the flood. Some of this may be filtered out in the downstream buffer zone. Some material may be carried further away from the channel because there of transverse currents that flow from the channel to the floodplain. Nevertheless, some material will be carried into the channel, adding slightly to the sediment load. The contribution of this sediment load to the total sediment load of the river is likely to be negligible.

Large stockpiles of material in exposed areas with limited protection from flood flows are prime sites for mobilisation of sediment and its transport further downstream.

7.6.4 Impact on bank stability

The left hand bank of the river is bedrock and there are no plans to mine to the bank of the river. The vegetation will not be disturbed and the rock core of the bank will provide adequate protection from scouring floods and mass movement.

7.6.5 Impact on water quality

If stormwater drainage is allowed to freely run into the river there could be a significant turbidity and possibly phosphorus problem with the adsorbed nutrients on the clays and organic particles present in the loams.

7.6.6 Impact on weir stability

The changes in sediment load and flow direction and velocities are minor in stage 6 and it is unlikely that any of the impacts of the quarrying would have an effect on Bergins weir.

7.6.7 Impact of flooding on operations

Flooding will scour the surface and mobilise any loose material that is not protected. The increased frequency of flooding as the floodplain is lowered will increase the need to remove machinery to higher flood free land. Most macinery is mobile and should be capable of being moved rapidly should the need arise.

7.6.8 Cumulative impacts downstream

The quantity of sediment that could be washed off this site during a flood is probably small and the majority of the material would be fine grained, behaving as wash load or fine grained suspended load. It is highly probable that the area will be one of net sediment accumulation from the floodwaters. There are transverse currents in the area, the site has been a zone of deposition before, and there are no changes in channel geometry that would alter the previous pattern of deposition, It is not possible to predict the exact rate of sediment accumulation.

7.6.9 Impacts on groundwater

The quarrying operation will not be excavating sandstone and the water table is well below the surface of the sandstone. Groundwater is not a problem in this area.

7.7 IMPACT OF DREDGING IN THE BERGINS WEIR POND (STAGES 1-4)

7.7.1 Impact on depth of flow

The proposed dredging operation will increase the depth of the channel in the centre by approximately 2.3 metres, the average depth of the channel at present being 4m (Fig 4.4). Downstream in stages 3 and 4 the depth will be slightly greater, by 0.5m.

7.7.2 Impact on velocity of flow

The effect of the excavation is to decrease velocities in the stream by 0.10 m/s or less, for the 20 year flood. Velocities range from 0.6 to 1.2 m/s along the dredged reach. The marginal increase in cross section area will mean that for low flows the velocity through the reach will decrease, which will increase residence times in the pond of water and the material that it carries.

7.7.3 Impact on scour potential

Whilst the depth increases, velocities and slopes (Table 7.1) decrease. The decrease in slope is up to 50% of the water surface slope before the dredging. Hence, shear stress on the bed will decrease. There is less scour potential in the dredged section.

TABLE 7.2

Estimate of bed material load after extraction in Nepean River at Menangle

Discharge (cumecs)	Recurrence interval (yrs)	Depth (m)	Slope	Channel velocity (m/s)	Sediment load (kg/s/m width) bed	suspended
800	2.3	19.41	0.000039	0.44	0.06	0.07
2200	20	21.14	0.00014	0.93	0.6	1.3
4000	100	22.50	0.00029	1.40	2.6	6.4

assuming 50m width and 24 h duration

	load (tonnes) suspended	bed	total
800	300	260	560
2200	5 600	2 600	8 200
4000	28 000	11 000	39 000

TABLE 7.3

Difference in sediment transport at cross section 7

Discharge (cumecs)	Recurrence interval (yrs)	Sediment load (tonnes) suspended	bed	total
800	2.3	-1 600	-1 000	-2 600
2200	20	-10 000	-6 000	-17 000
4000	100	-58 000	-26 000	-84 000

- indicates a decrease in load

7.7.4 Impact on sediment transport

Sediment transport capacity will decrease for cross section 7 (Tables 7.2 and 7.3). The decrease in sediment load is a result of a significant decrease in water slope, which is itself a result of the large increase in floodplain storage created by the lowering of the floodplain.

In estimating the change in sediment load it is assumed that the bed material grade does not change. In an aggrading reach particle size may decrease, which would mean that the sediment load calculated here is underestimating the sediment load after the extraction. The excavation of a deeper channel will mean that sediment will have a greater opportunity to be deposited on the bed during low flows. The floodplain, which has been lowered by 6 metres or more along the margins of the river will also be an important site for sediment accumultion.

Because the majority of the sediment load is carried as suspended load, is probable that a considerable quanitity of sediment that enters the section will be carried onto the floodplain where velocity and capacity is less. In excess of 75% of the sediment load carried by the river into the reach could be deposited in the reach. A very conservative estimate of the effect of the dredging and associated quarrying on sediment load would be a 50% loss by deposition of sediment carried into the reach.

7.7.5 Impact on bank stability

With the restriction of dredging to the centre-line of the channel and the fact that the channel is already in excess of 50m wide in many places there should be no adverse impact on the banks. The centre-line dredging will not cause any major deflections in the flow, ie. meandering. There is no evidence of meandering actively developing at present and there is no reason to consider that it will develop in the future with the proposed plan of dredging.

In section 4 the 50 m dredging will result in the removal of 10 to 20 m of the left hand bank of the river. Some minor collapse of the left bank is to be expected when it is cut back to the required width. At the limit of widening trees will remain on the bank top and these should prevent further bank collapse unless they are undermined in the dredging operation, in which case some tree fall, with associated bank collapse, is to be expected.

The restriction on dredging near the right hand bank (18 m buffer strip) should protect the bank from any impact of deepening of the river. Thus dredging would not contribute to the collapse of this bank.

7.7.6 Impact on water quality

The bed of the river is largely composed of clean sand with a minimum of clay and organic matter. Some increase in turbidity is expect, but the material should rapidly settle-out because of its coarse nature. There was no opportunity to core the centre of the channel to a depth of 3m, but there is no reason to believe on the basis of the stratigraphic and geomorphic investigations of Chapter 4 that coarse clean sand with organic fragments does not extend to depth and that silts and clays are not to be found in the bed.

The increased depth of the river in the centre of the channel will mean that a small area of the river bed receives less light than at present, but the area of channel bed to be deepened represents 14/50 of the total bed area and less than 3/50 of total bed area will be more than a metre deeper than it is at present.

Oil spills from the dredge could create problems in a low flow period, although the chances of such spillage is reported to be low.

Turbidity will probably increase during higher flows where velocities are high enough to entrain the medium sand and the organic debris in it. Restriciting dredging to the 90 percent of time when flows are low would remove this problem.

Absolutely no dredging should be allowed in the area of the coal sludge. The disturbance of this material by flood flows has been noted. Its disturbance during low flows or when there was no flow would create a large water quality problem with coal sludge being spread even further than it is at present.

7.7.7 Impact on weir stability

There will be a slight decrease or no change in velocity through stages 2 and 3. Dredging will not release large calibre material that could abrade or impact the weir. Furthermore, it is not possible to dredge within 500m of the weir without creating substantial water quality problems. Thus there is no serious threat to the stability of the weir as a result of the dredging.

Bergins weir is not keyed into bedrock and there have been problems with scour on the left hand bank and downstream. However, none of the problems that have arisen have been related to quarrying and dredging in the river and it is unlikely that a problem will arise as a result of the present proposal.

7.7.8 Impact of flooding on the operations

The problems of flooding are related to the anchoring of the dredge during large flows and the stability of the settling ponds. A loose dredge during a flood could cause some problems, especially if it was washed into Bergins weir. The settling ponds are also susceptible to scour by overbank flows and material in them can be entrained and washed downstream into the river or into the lasgoons

7.7.9 Impact downstream

There will be no significant water quality problems that may be carried downstream provided the procedures outlined in Chapter 8 concerning the type of dredge and low flow dredging are adopted. However, there will be a significant decrease in sediment load until the floodplain aggrades. A conservative estimate of the sediment load deposited on the bed and banks by large infrequent floods is 50 percent of sediment entering the reach. The decrease may be as high as 75 percent of the total load entering the reach.

7.7.10 Cumulative impacts

The total effect of the operation on downsteram miners and the river system is likely to involve a reduction in sediment load of the order of 50 percent. This will probably cause the river to scour its bed and banks downstream. However, as pointed out previously, the exact quantity of sediment removed from the stream cannot be accurately predicted nor can the effects of that removal on channel geometry be predicted with any accuracy with the data at hand. General trends hve been indicated by Warner (1982) and are essentially those indicated here, ie. increased width and depth of channel.

Assessing the effects of the proposal is complicated by the fact that it appears that extraction operations along the whole of the Hawkesbury-Nepean system are removing more sediment than the river is carrying. Furthermore, there are changes in sediment load and discharge as a result of secular climatic changes, dam construction and agricultural practices. The impact of any one of these factors cannot be sorted out from the others with the data presently at hand.

7.7.11 Impacts on groundwater

This is not considered to be a problem in this area. Water levels in the Bergins weir pond are unaffected by the dredging and the connections with aquifers int he banks of the river will be unaffected with the 18 metre restriction on dredging near the waters edge.

7.8 IMPACTS OF QUARRYING ON RIGHT HAND BANK OF BERGINS WEIR POND

7.8.1 The effect on the depth of flow

The extraction of material from the floodplain will increase the depth of flow from approximately 1 m near the centre of the proposed extraction to 6 to 7 m for the 20 year flood. This increased depth of flow results from the substantial ground surface lowering. The frequency of flooding will increase from once every 3 to 8 years to at least once every year.

7.8.2 Impact on velocity of flow

The velocity of the flow over the floodplain decreases by 0.05 m/s and ranges between 0.1 and 0.4 m/s. Flow velocities are less after the quarrying, but the flow depths are greater and there are more floods.

7.8.3 Impact on scour potential

The increased depth of flow is many times greater than the decrease in slope and velocity. Hence the shear stress on the floodplain increases. Furthermore, there is a longer period of increased shear force because of the increased frequency of flooding.

7.8.4 Impact on sediment transport

Under the present regime sediment appears to be dropped out of the channel onto the banks and floodplain. The levee, once mined, would probably slowly rebuild , particuilary when dense stands of trees were able to establish themselves along the margins of the channel and edge of the reconstructed floodplain. Thus there would be a negative sediment budget, with material being taken out of the total load.

If the quarried floodplain surface is not well covered with vegetation a 20 year flood would have the potential to scour it significantly, with consequent downstream sedimentation on the floodplain and possible washing of material from the floodplain into the channel.

The large area of excavated floodplain at this site would cause a significant changes in sediment transport regime, namely a decreased capacity to carry sediment.

7.8.5 Impact on bank stability

The reduction of the height of the bank from 10 to 13 metres to 3 metres will reduce the mass of material available for landslide type bank failures. With vegetation left on the bank, particularly the trees, bank stability should be maintained

7.8.6 Impact on water quality

The entrainment of sediment during floods will increase the quantities of fine material, silts and clays, in suspension. However, the absolute quantities of material suspended relative to the total quantity of sediment in suspension during a 20 year flood will be small.

The greater problems of water quality in this area are associated with storms that generate runoff from the stockpiles of material and the bare ground surfaces. Considerable quantities of sediment could be washed into the river by local rainstorms if no adequate safeguards are taken. This fine grained silt-clay and organic material would lead to a deterioration in water quality.

7.8.7 Impact on weir stability

The stability of the weirs is more related to the flow of water in the main channel rather than to the flow of water in this section of the floodplain. There is little likelihood that the quarrying will affect the weir.

7.8.8 Impact of flooding on operations

The quarrying lowers the ground surface with the consequence that flooding is more frequent. The flooding will also erode stock piles of quarried material and may be able to move small structures, such as fences.

Some machinery will be affected by flooding, but since most of the machinery is highly mobile it should be easy to move it to higher ground when the need arises.

7.8.9 Impact downstream

Apart from a possible passing of scoured sediment downstream, along the floodplain, the impacts of the quarrying will be minimal.

7.8.10 Cumulative impacts downstream

Quarrying in this area, together with quarrying in all other areas, will result in a further reduction of sediment in the flow because the quarried areas should become net zones of deposition. It is impossible with the present data to predict the exact nature of the loss of sediment. The stream may well replace any sediment lost in the Menagle section by eroding its bed and banks downstream.

7.8.11 Impacts on groundwater

There are no plans to mine the underlying bedrock and the quarried surface will be at least 3 metres above low water surface. For these reasons, and for reason given in the discussion of water tables around Barragal lagoon, groundwater is not considered a problem.

7.9 IMPACT OF QUARRYING IN STAGE 2

7.9.1 Impact on depth of flow

For the 20 year flood the change in the depth of flow near the channel is approximately 6 m. With the lowering of the floodplain the frequency of flooding increases to at least once a year near the channel.

7.9.2 Impact on velocity of flow

The velocity of flow over the floodplain decreases by 0.1 m/s, and will be approximately 0.2m/s. One concern with the lowering of the floodplain in this area is that there would be an increased possibility for flow to pass down the flood channel that runs between the present levee and the hillslope to the west. Increased flow may cause increased erosion along this flood channel.

7.9.3 Effect of scour potential

The increased depth of flow is many times greater than the decreased velocity and water surface slope. Hence the shear stress on the floodplain surface will increase and the duration of scouring floodwaters will increase because of the lowering of the surface.

7.9.4 Impact on sediment transport

The impact is the same for the quarried region upstream and on the opposite bank. The area will become a deposition zone, particularly when the shrubs and trees re-establish after quarrying. This deposition will reduce the quantity of sediment flowing downstream.

7.9.5 Impact on water quality

The impact on water quality will be a problem if runoff and surface wash is not controlled in the area.

7.7.6 Impact on weir stability

Apart from contributing a small quantity of sediment during flood flows from stockpiles and from scour of exposed surfaces, it is unlikely that the extraction will have any affect on the weirs.

7.9.7 Impact of flooding on the operation

Flooding effects are the same as those discussed for the right hand-bank.

7.9.8 Downstream impact

The downstream impact should be negligible provided erosion controls are used.

7.9.9 Cumulative impacts

As for the previous section, the loss of sediment from this area reduces the quantity of sediment flowing through the system.

7.9.10 Impacts on groundwater

A 50m wide strip will be left around the eastern margin of Barragal Lagoon and the groundwater in the lagoon does not appear to be associated with shallow groundwater in the sand beds that crop out in the present river channel. Groundwater will not be a problem.

7.10 IMPACTS DURING AND AFTER THE OPERATION

All the impacts reviewed above will occur during the period of operation, some will intensify during the work, eg. flood frequency on the quarried floodplain will increase as the floodplain is progressively lowered.

Those impacts relating to scour of the floodplain by local rainstorms should decline rapidly after the completion of works. Revegetation of quarried surfaces and stabilisation of drainage lines will reduce the erosion of material from the surface.

The impacts related to the flow of floodwaters over the quarried floodplain will remain untill the floodplain aggrades, which may take several hundreds or thousands of years. The quarried floodplain will have increased flood frequency, greater than once a year in some cases, and considerable depths of flows (of the order of 6m or more near the channel) and high velocities.

The increased river width and depth will remain untill the river aggrades and vegetation, combined with in-channel bench construction and levee construction, causes the river to narrow. It may take several hundred years for the river to return to its present form, if it ever does. Velocities and water surface slopes will remain low relative to the present condition.

The sediment loss along the river will remain high untill the river aggrades. This will mean that there will be long period (of unknown extent) during which sediment loads downstream of Bergins weir will be significantly affected. The exact effect on the Nepean River and other quarrying and dredging operations downstream cannot be predicted.

Water quality should not be significntly affected by the operation in either the short term or the long term.

The area where the operations will have the greatest impact on the river is along the Bergins weir reach of the river. In Stage 7 and Stage 6 the impacts, as listed in the preceding, are much less than in the Bergins weir reach. Increases in channel depth and channel width and increases in storage area created on the floodplain are the largest in the Bergins weir reach.

7.11 CONCLUSION

General

a) Dredging of the river in stages 2, 3 ,4 and 7 will not change the hydraulic character of the river to any great extent.

b) River water quality should not be significantly affected during the dredging operations.

c) Mining of the floodplain materials on the right and left hand bank of the Bergins weir reach of river will have a significant effect on the river by greatly increase storage during floods. This increased storage will cause a significant decrease in channel slope will will consequently cause a significicnt decrease in sediment transport capacity.

d) There will be a reduction in sediment load downstream as a result of the mining operation. The significance of this decreased load can not be fully assessed, but may contribute to bank and bed scour downstream.

e) there will be a significant increase in flood frequency for all quarried areas. Some areas will be flooded as frequently as once a year as a result of the quarrying.

Impact on depth and width

f) channel depth will increase in stages 1 and 2 and depth and width will increase in stages 3 and 4.

Impact on stream velocity

g) stream velocity will decrease in most sections of the the river except near the railway bridge. Velocities will increase on some sections of the floodplain simply because the lowering of the floodplain makes the areas subject to flooding.

Impact on scour potential

h) Scour potential will generally decrease along the river but will increase over the quarried sections of floodplain becase of increased depths of flow.

Impact on sediment transport

i) Sediment transport will slightly decrease in stage 7 but will significantly decrease in stages 1,2,3 and 4 by at least 50 percent of the present load.

Impact on bank stability

j) Bank stability will not be effected except in stage 3 and 4 where the left hand bank will be excaated during dredging.

Impact on water quality

k) Dredging and quarrying will have minimal effect on water quality provided the dredging is not carried out at high flows and the quarried sites are protected from rilling and wash during rainstorms.

Impact of flooding on operations

l) Machinery may need to be moved during large floods and should be stored in flood free zones. The dredge will need to be anchored.

Cumulative impacts downstream

m) The floodplain quarrying in Stage 2 and on the Campbelltown City Council and Trotting Association land will result in a significant decrease in sediment load downstream. This may increase bank and bed scour, although the exact effect cannot be predicted.

Groundwater

n) There is no significant groundwater problem, particularly as it affects the lagoons.

Weir stability

o) The weirs are some distance downstream from dredging and quarrying operations, stream velocities are lowered as a result of the operations

7.11 REFERENCES

State Pollution Control Commission 1984. Sand and gravel extraction in the Upper Hawkesbury River. NSW Govt printer. 18pp.

========================

SECTION C: RECOMMENDATIONS

========================

CHAPTER 8

RECOMMENDATIONS FOR AMELIORATING THE IMPACT OF QUARRYING

8.1 INTRODUCTION

In this chapter suggestions are made that will assist in reducing the impact of the mining operation on the environment.

The following discussion is in general terms. The details are a matter for the management plan of the proposed quarrying and dredging. Location of sedimentation ponds, drainage pits and so forth will be a matter for the detailed planning.

This chapter is organised on the basis of the two major types of extraction, dredging and quarrying. The several areas that are involved in each category have essentially the same impacts and need the same amelioration procedures.

8.2 DREDGING

8.2.1 Dredging during low flows

The preceeding analysis has suggested that the texture of bed sediments is such that they will not be suspended at low flows. Consequently, if the operation of the dredge is restricted to periods of low flow, defined here as the period when river discharge is less than 5 cumecs, then the possibility of turbid water being carried downstream will be greatly reduced. The dredge will only have to cease operation for 10 percent of the time if this condition is applied.

8.2.2 Anchoring the dredge

Adequate precautions should be taken to anchor the dredge. The anchorage should be strong enough to withstand the 20 year flood.

8.2.3 Type of dredging

A cutter-suction dredge is to be used.

8.2.4 Settling ponds

Settling ponds should be established some distance away from the channel banks and be so designed that there is no possibility of flow of sediment laden water back to the channel. Settling ponds should be located on high areas in order to reduce the frequency of their inundation by floods.

8.2.5 Bank stability

Strict adherence to the Department of Water Resources guidelines for this reach will reduce the possibility of bank instability.

8.3 QUARRYING

8.3.1 Pushing of materials into the river

Quarrying operations should avoid the pushing of fine grained floodplain sediments into the river when working near the river banks. If it is not possible to quarry the banks without pushing material into the river the banks should be left. Use can be made of contour banks to prevent material being washed or pushed into the river.

8.3.2 Exposure of ground surface

A minimum area should be exposed at the surface. It is often necessary to have several areas of excavation open at one time because materials are mixed to provide the right grade. If it is not possible to quarry a 200m wide strip at one time (as recommended by the Department of Water Resources) then quarried areas should be isolated from each other to provide a minimum area of continuously exposed surface.

Revegetation should take place immediately that quarrying is completed and every effort should be made to establish a grass cover.

8.3.3 Stockpiles of materials

Material stock piles should be located at the higher points in the area and as far distant from the river as is possible. This will reduce the frequency of inundation of the stockpile and also increase the probability that material that is washed by floodwaters will be deposited on the floodplain.

Rainstorm runoff from stockpiles should be directed into sedimentation ponds and all stockpiles should have a series of embankments around them in order to reduce the possibility of uncontrolled runoff and loss of sediment laden wash into the river. The Soil Conservation Service of NSW should be engaged to advise on the layout of erosion abatement structures.

8.4 CONTROL OF RUNOFF FROM THE SITE

All drainage lines formed during the extraction and at the completion of the operation should be identified. A management strategy should then be drawn-up which ensures that drainage lines are controlled through the use of settling ponds, embankments and hay bale filter walls. All drainage lines should be designed in such a manner that velocities and depths of flow are minimised and that ample opportunity is allowed for the sedimentation of entrained material. Wherever possible storm water flow from the site should not be discharged into the river before it has passed through sediment traps.

All slopes should be graded during the quarrying in such a manner that the slope towards the river is minimised. Use should be made of internal drainage systems, ie. large flat bottom excavation pits with low angle slopes grading into them.

8.5 DOWNSTREAM IMPACT

The largest impact downstream will be on the sediment load. It is not possible to accurately predict the loss in sediment load, but it is probably substantial, probably of the order of 50 percent of the present load. The only way that this loss can be reduced is to ensure that floodwaters are confined in a narrow deep channel and not allowed to spill out. Such confinment is not possible without either leaving a substantial part of the levee along the river or forgoing the excavation of the floodplain in the Bergins weir reach.

The exact details of the downstream impact cannot be given. However, a reduction in sediment load should contribute, if not entirely cause, an increase in bed scour and bank erosion.

The Bergins weir reach can be dredged, because dredging, which increases the depth by only 2.5 to 2.7 m and width by 10 to 20 metres, will have minimal impact on the sediment load capcity of the river.

CHAPTER 9

CONCLUSIONS AND MONITORING

9.1 CONCLUSIONS

This report has shown that the Nepean River at Menangle was until recently in an aggrading phase. The Menangle site is probably an area of net sediment accumulation on the floodplain and channel benches, but the channel bed appears to be incising. Since the late 1940's the river bed has entered a period of incision, probably as a result of increased rainfall in the last 4 decades and the impact of dam and weir construction on sediment supply.

The probable extraction rate is likely to exceed the sediment yield of the river by at least 2 to 3 times.

There is no evidence from available water quality data that past mining activity has had an effect on the water quality of the river and it is unlikely, with the implimentation of the suggested control works outlined in Chapter 8, that the proposed extraction would significantly influence the river.

There will be a significant increase in the frequency of flooding of the quarried area simply because the land surface has been lowered by up to 6 metres in places. In areas near the river the frequency of flooding will be at least once a year. Some thought needs to be given to the use of the land following the extraction.

It is unlikely that banks will become unstable as a result of the extraction program, but further bank stability may result if the river continues to incise its bed.

Every effort should be made to maintain maximum vegetation cover on the floodplain and channel banks.

The dredging and quarrying operation will probably reduce the sediment yield downstream and thus reduce the replenishment of dredged and quarried materials further along the river. However, it should be noted that the rate of extraction along the Nepean river appears to greatly exceed the sediment yield. The long term effects of the total extraction program along the Nepean will be a significant decrease in the stores of alluvium in the bed, bank and floodplain and a possible increase in the depth and width of the river as local sources of sediment are used by the river to compensate for a deficit in its sediment capacity.

The quarrying of the floodplain in the Bergins weir reach must be carefully considered because there are large changes in sediment transport capacity as a result of the extraction. Existing data are not good enough to accurately predict the results of quarrying in this area.

The two areas that appear to have the least impact downstream and in the local area are Stage 7 between the F5 Freeway and railway bridges and Stage 6. Dredging of Bergins weir pond using the Department of Water Resources guidelines will have minimal impact on the river either at the site or downstream.

9.2 MONITORING

There are two aspects of monitoring within the Menangle area. Firstly, there is the aspect that relates to assessing the direct impact of the operation on the river and the changes in the river following the operation. Secondly, there is that aspect that relates to the more general question of the impact of dredging and quarrying in the Hawkesbury Nepean system. The first could be undertaken by Menangle Sand and Soil P/L if required. The second is a more ambitious study that should be the subject of a combined program of study by the various Local and State government authorities.

The Menangle area is worthy of more detailed government study because it is a well defined study site with a minimum of complicating extraneous factors impinging on the river system. Several government reports have noted the need for more detailed monitoring. A detailed monitoring program enable the nature of the hydrology, hydraulics and sedimentology of the river to be quantified and modelled. These models could then be applied elsewhere.

9.3 LOCAL MONITORING

Local monitoring should consist of cross sectional and longitudinal surveys of the river over the period of operations and for several years afterwards. Surveys immediately downstream of Bergins weir and surveys upstream of the weir to a point upstream of the F5 Freeway bridge would be desirable. These surveys should be undertaken before works begin and after the completion of each major work and after major floods. The data collected should enable changes in channel depth and width and the progression of sediment waves to be assessed.

A photogrammetric study of key sections of river bank should also be undertaken in order to assess changes in bank form. Photogrammetric techniques should be less costly than detailed surveys and contain much more information for future work.

The Sydney Water Board should be encouraged to continue its monitoring program and should also measure sediment concentration in the Menangle, Bergins and Thurns weir ponds. Some effort should be made to measure changes in water quality through several floods during and after the operations.

Menangle Sand and Soil P/L should undertake a stratigraphic investigation of the deposit as it is quarried. This site has some significance in terms of the geological history of the Nepean River, as discussed in Chapter 4. The quarrying operation would provide a good opportunity to examine the stratigraphy and to retrieve samples for Carbon 14 dating. Information gained would enable an assessment to be made of the rate of sediment delivery and enable the catastrophic hypothesis for the sedimentary deposit to be confirmed.

9.4 DETAILED STUDIES

The more detailed studies, whilst not directly impinging on the merit of this proposal, would use the Menangle site as a laboratory for gaining the detailed data that is needed.

A very detailed program of repeated surveying of cross sections and photogrammetric survey of river banks of the Nepean River needs to be undertaken between Camden and the Black Hole if the long term impact of the Menangle extraction and other operations is to be fully documented and evaluated. This surveying should be repeated after each flood event in order that changes in channel geometry related to particular floods can be fully documented.

A number of sampling sites need to be established along the river and on the floodplain in order to measure sediment load. There is no data on actual sediment loads in the river and over the floodplain. Five stations would be needed, one upstream of the extraction area at the F5 Freeway, one at Menangle weir, one at Bergins weir, and two on the floodplain at Stage 2, one on each side of the river. In association with these sampling sites automated water level recording stations with the capacity to record turbidity, temperature and conductivity need to be established. There are automatic sampling site already established further downstream.

A thorough study of the stratigraphy of the area, including absolute dating of materials, needs to be undertaken in order to confirm the history that has been presented in this report. This study should extend downstream to Camden and some distance upstream of Menangle.

The monitoring program should be aimed at developing and validating a model of river hydraulics and sedimentology that may be used to evaluate future extraction proposals.

LIST OF AERIAL PHOTOGRAPHS USED IN THIS STUDY

The following table lists the aerial photographs used in this study. The photography was selected in order to provide a long and evenly spaced temporal coverage using the largest scales available. Aerial photography available but not used was flown in 1947 (1:12000, negatives destroyed), 1949 (1:32 000), 1969 (1:57 500), 1972 (1:52 000), 1979 (1:40 000), 1980 (1:60 500), and 1983 (1:40 000). All photography is from the NSW Depart- ment of Lands or the Commonwealth Aerial Photography (Natmap).

Year	Date	Scale (1:)	Map sheet	Film no./ Index no.	Run nos	Photo nos
1945	30/4	12 000	Camden	SWV 547	1	V1-V4
			(map 1509)	I56-9-428	2	V19-V22
					3	V31-V34
1956	2/7	15 000	Camden	NSW 240	33	5123,5124
					34	5129-5134
					35	5215,5216
	7/8	15 000	Camden	NSW 241	36	5035-5037
					37	5042-5044
1966	22/3	37 500	Wollongong-Port Hacking	NSW 1440	2C	20-22
					3C	86,87
					4C	63,64
1975	2/4	40 000	Wollongong	NSW 2300	2	86,87
	30/11	40 000	Wollongong	NSW 2362	3	90-92
1984	8/10	16 000 colour	Wollongong	NSW 3410	4	145-148
					5	205-208
				NSW 3411	6	11-14
					7	64-66

GLOSSARY OF TERMS

Baseflow: stream discharge supported by seepage rather than storm runoff

Bifurcate: to divide into two branches

Catastrophic: having significant morphologic change in a single event or sequence of events - not used in a human sense

Competence: the ability of the stream to move sediment of a particular sie. The largest grain size that can be transported by a river at a give stage.

Capacity: the ability of the stream to transport sediment; the maximum sediment load carried by the stream.

Cumec: cubic metres per second; a unit of discharge

Equilibrium: a state aof balance in any system, created by a variety of forces.

Erodibility: the susceptibility of land surface materials to detachment and transport (soil erosion)

Erosivity: the ability of rainfall to cause the detachment and transport (erosion) of land surface materials

Facies: a grouping of sediments having like characteristics and presumed processes of deposition; facies change refers to the gradual change in the character of sediments from one seidmentary environment to another within a single stratigraphic unit.

Holocene: the most recent Epoch in geological time, generally taken as the last 10 000 years

Mass movement: the downslope movement of land surface material under forces created mainly by the materials own weight.

Pleistocene: the Epoch preceding the Holocene in the geological time scale; generally taken as the period from 10 000 to 2 million years ago.

Pore-water pressure: the pressure exerted by water contsained in the voids in land surface material.

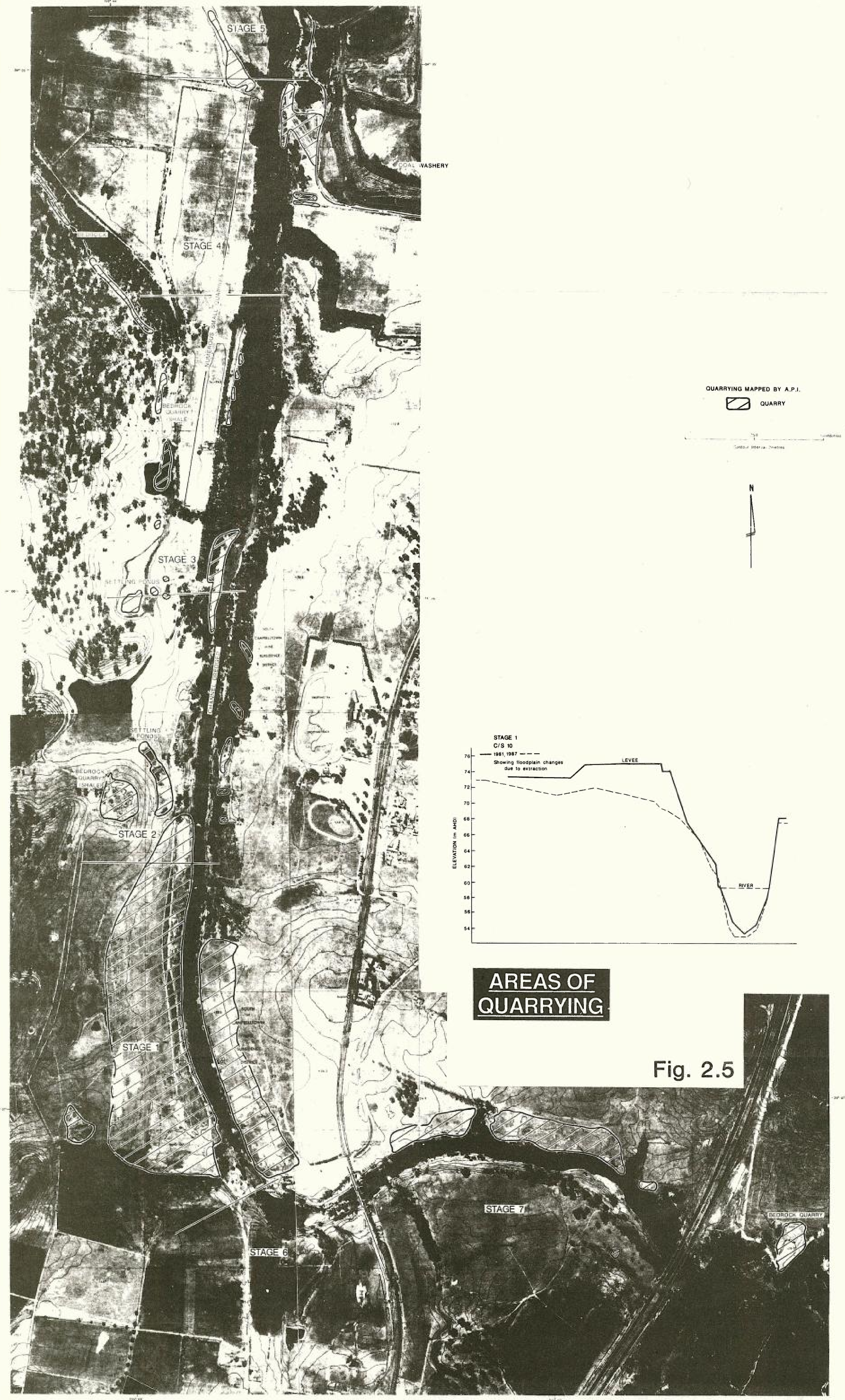
Potentiometric surface: the level to which groundwater will rise in a piezometer tube or well. The water table surface.

Stream Power: the shear stress exerted on river bed particles per unit time per unit length of channel.

Secular change: change or trend resulting from long term forces of the order of 50 to 100 years duration.

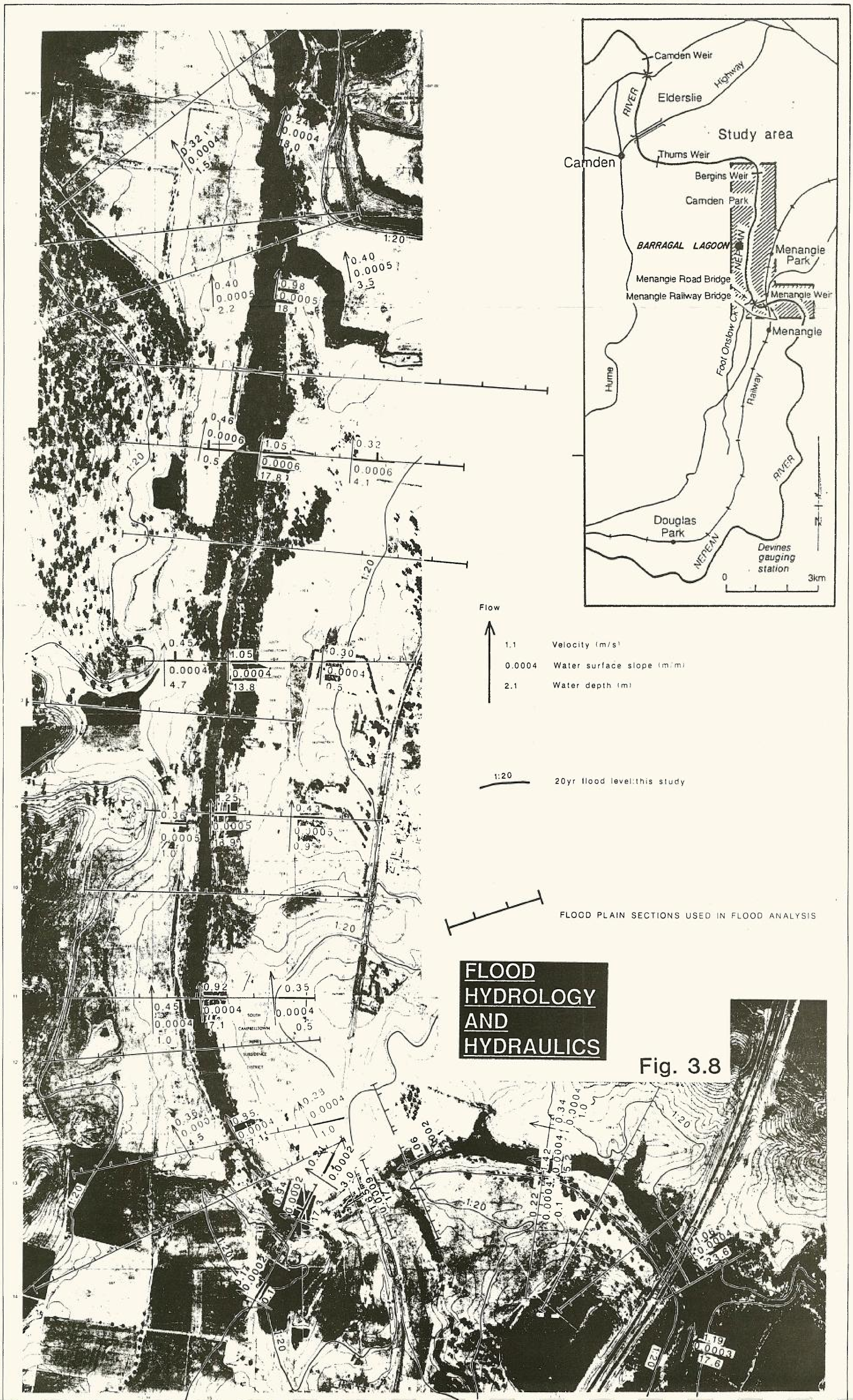
Sediment delivery ratio: the ratio of amount of material enetering a stream to the amount of material eroded from a hillslope. The remaining material is stored on the hillslope.

Thalweg: a line connecting the deepest points in a channel; this defines the longitudinal profile.



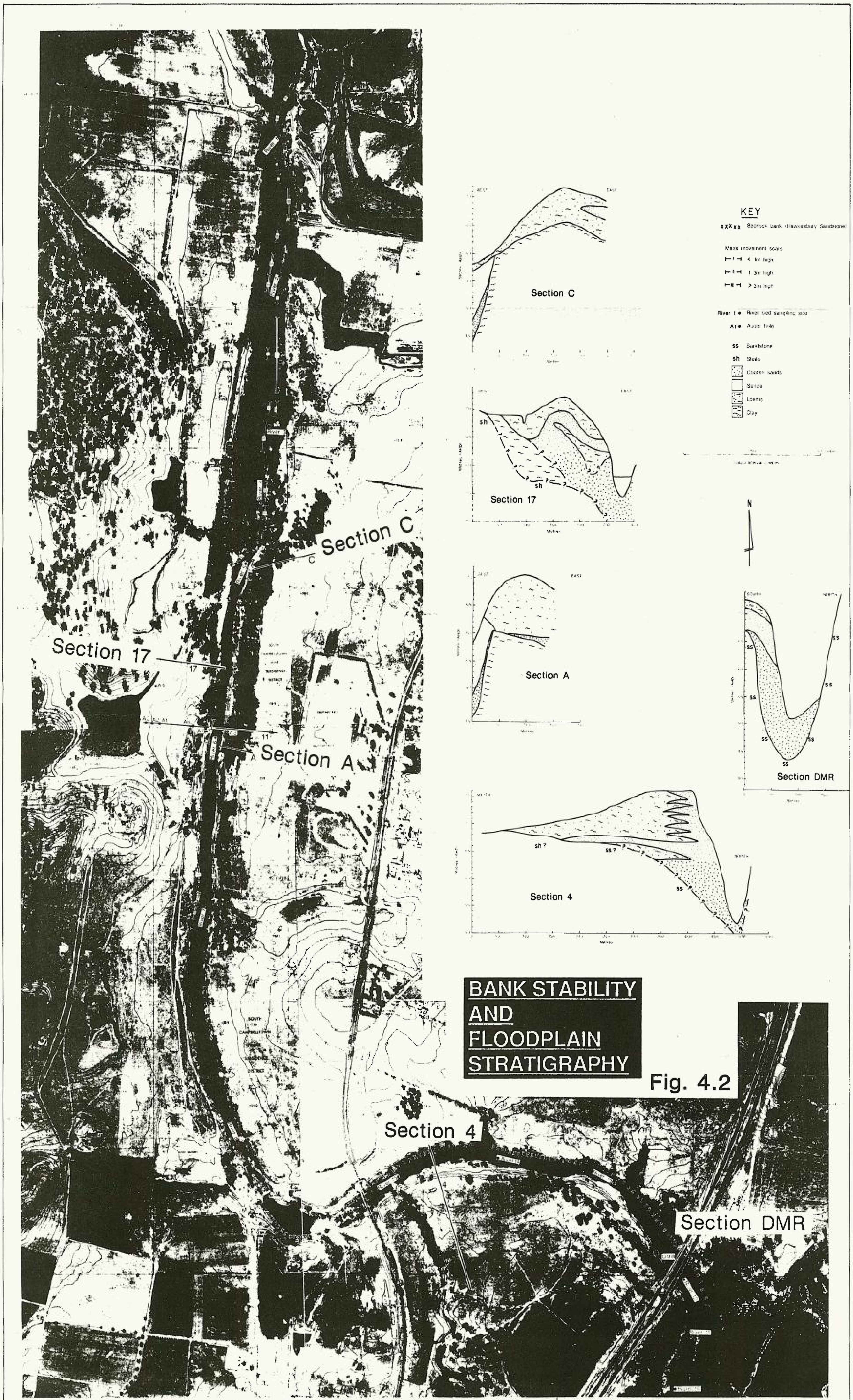
AREAS OF QUARRYING

Fig. 2.5



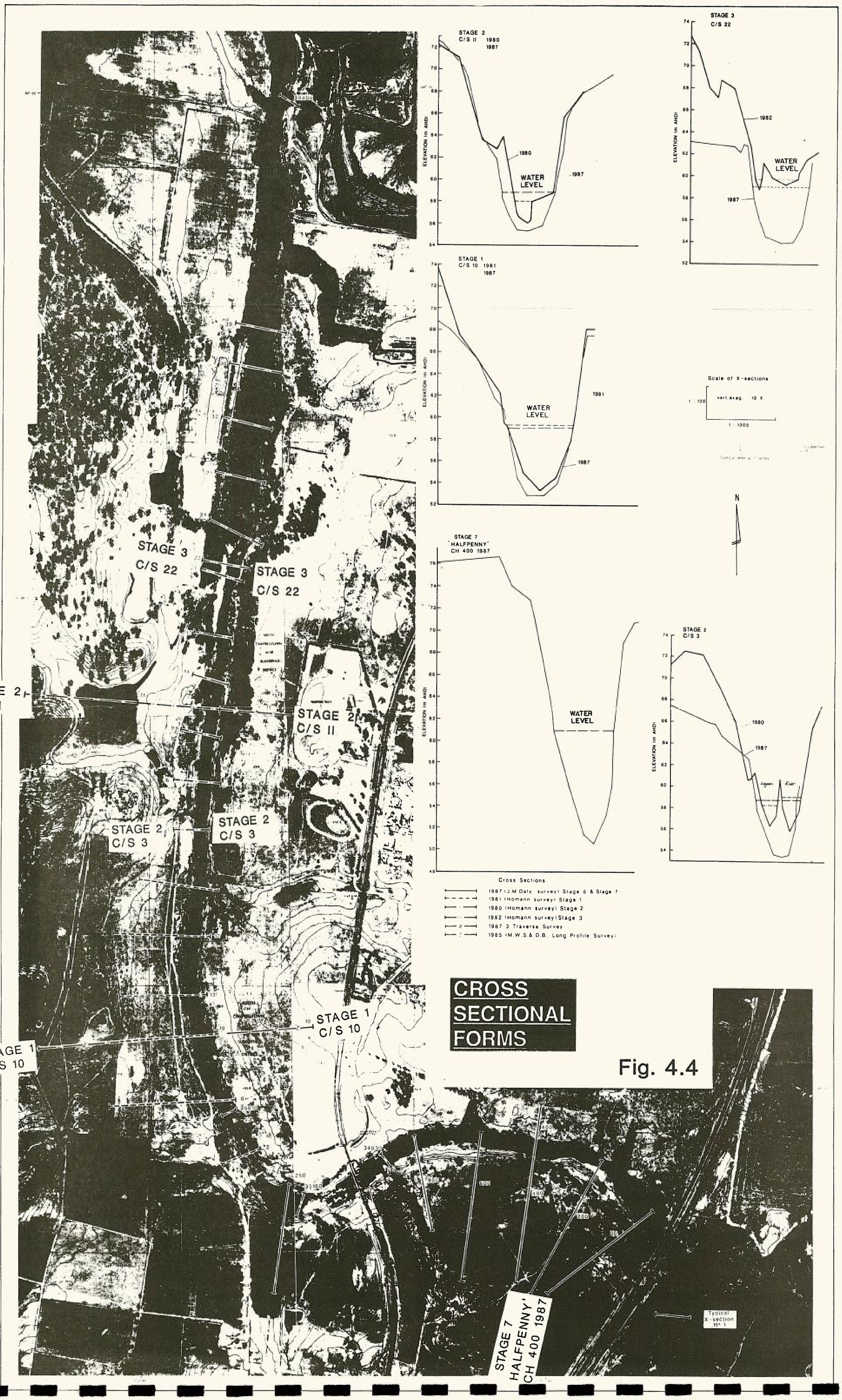
FLOOD HYDROLOGY AND HYDRAULICS

Fig. 3.8



BANK STABILITY AND FLOODPLAIN STRATIGRAPHY

Fig. 4.2



CROSS SECTIONAL FORMS

Fig. 4.4

planning workshop

APPENDIX IV

Air Emission Assessment

INVESTIGATIONS INTO AIR EMISSIONS

AT

SAND & SOIL EXTRACTION INDUSTRY

AT

MENANGLE, NSW.

Prepared for: Planning Workshop
on behalf of: Menangle Sand & Soil Supplies Pty. Ltd.

Prepared by L.J. O'Keefe
& R.T. Benbow

for Dick Benbow & Associates Pty. Ltd.

Report No. EE1257PW.

July - August 1987.

Dick Benbow & Associates Pty. Ltd.,
2/5-9 Hunter Street,
PARRAMATTA NSW 2150.

Telephone 635 5099
(ah) 635 1425
(047) 57 1366

CONTENTS PAGE

1.0 SOURCES OF FUGITIVE DUST

Six potential sources of fugitive dust occur at the Menangle River Sand & Soil Supplies Pty. Ltd. operations at Menangle. In decreasing order of magnitude these are:

1. Internal haulage road traffic on unsealed roads.
2. Office and maintenance facilities area.
3. The extraction operation.
4. Stockpiles.
5. Rehabilitated areas.
6. Haulage on external sealed roads.

1.1 Internal Haulage Road Traffic

Particulate emissions from unpaved roadways typically comprise 50 to 85 percent of all particulate emissions from surface mines. These mines have many other major sources of dust including draglines, blasting, elevated crushing and loading facilities, etc., The Menangle sand and soil operation typically comprises only loading, screening and transport. A visual inspection would reveal that up to 90% of the total fugitive particulate emissions are derived from transport of material and other vehicular activities on unpaved roads.

It is generally considered that particles less than 30 micrometres in diameter comprise the major component of visible fugitive dust emissions. Although there is little material less than 30 micrometres in the resource the unpaved internal road surfaces contain a high proportion of these particles due to the mechanical breakdown of larger particles by mobile equipment and highway trucks.

1.2 Recommendations

1. Adequate watering can be considered to be the most economical

and effective suppressant for the control of roadway fugitive dust. Extensive studies conducted by the State Pollution Control Commission at a Hunter Valley coal mine on "Dust Control on Coal - Haul Roads" (Refer to Ref. 1) indicated that watering of unsealed roads is very effective in controlling dust near roadways with the majority of the dust having been removed from the air by deposition within 50 metres of the unsealed road.

2. Spillage along haul roads must be kept to a minimum by not overloading haul trucks.

3. Menangle Sand & Soil Supplies personnel should monitor for road deterioration, excessive shoulder build-up and excessive road dust emissions.

4. During high wind episodes non-haulage vehicles (sedans, utilities, etc.) should maintain a low speed on unpaved roads.

5. The strands of trees lining both banks of the Nepean River act as a very effective catchment area for fugitive dust emissions. Although it will be necessary to remove large portions of these trees to recover the resource strong emphasis must be placed on adequate early replacement of these trees. At no time should resource recovery occur (particularly haulage) without the benefit of a screen that these trees provide. Considerable dispersion of fugitive dust may occur if the benefit of these trees as a screen is not used.

1.3 Office and Maintenance Facilities area

The unsealed office and maintenance facilities area has a strong potential to provide both wind and vehicular derived fugitive dust emissions.

1.4 Recommendations

1. The provision of a coarse surface to protect this area against wind and vehicular disturbance would be advantageous. A gravel material as used at the existing Camden site would be suitable.

2. Watering particularly during high wind episodes would again be an effective and economical suppressant. The frequency of watering will be increased during periods of hot dry weather eg. late spring through to early autumn.

1.5 The Extraction Operation

The extraction operation comprises:

a. Removal of topsoil to be used in rehabilitation work later.
b. Recovery of the resource by bulldozer and front end loader prior to loading or processing.
c. Loading by front-end loaders into haulage vehicles.
d. Where necessary screening of sand and soil to remove over-sized material.

Fortunately most of the material being handled in these operations is wet, that is it has a high moisture content. This fact alone almost eliminates the extraction operation as a source of fugitive dust. Also the recovery operation takes place section by section and tends to be confined close to and between strands of trees. Any dust arising from this process is captured by the trees and only under the extreme set of circumstances of high winds and dry material would dust escape the natural catchment of trees.

The height of emissions from these sources is usually ground level and is considerably below that of the tree-line. Again this acts to inhibit the dispersion of fugitive dust.

1.6 Recommendations

1. The major recommendation is clearly the retention of as many trees as possible and when this is not possible the early replacement of felled trees to provide adequate screening for the extraction operation.

2. Limiting areas of extraction to as small as practicable will also aid in the reduction of any fugitive dust emissions from this source. The size of the areas currently extracted would be adequate.

1.7 Stockpiles

Some stockpiling of material takes place away from the extraction operation. Special mixes are kept on site for delivery as required. These stockpiles are generally less than 4 metres in height, and, similar to the extracted material, are relatively wet. Drying out of the surface does occur but is actually beneficial in that a crust of coarse material occurs protecting the stockpile from further wind erosion.

1.8 Recommendations

1. Stockpiling areas be limited in size and the amount of material kept within the existing practices.

2. The height of stockpiles should not exceed their current height.

3. If stockpiled areas are to be permanent, adequate screening with native shrubs should be implemented.

4. If necessary a portable spraying unit be used to wet down stockpiles and vehicular areas in the confines of the stockpiling area. This could readily be accomplished with the water tanker currently at the Camden Site.

1.9 Rehabilitated Areas

Rehabilitated areas can be a considerable asset to the natural environment particularly in cases where previous extraction processes have been abandoned. The fugitive dust potential from this source arises where ground has been graded prior to seeding and planting and wind erosion is allowed to develop.

1.10 Recommendations

1. Establish as quickly as possible adequate ground covers.

2. Establish tree root structures particularly on sloping ground in order to reduce water erosion.

3. Keep vehicles off rehabilitated areas except for maintenance, planting and watering.

1.11 External Road Haulage

A major cause of nuisance dust to residents can be delivery trucks on paved roads. Although most material to be delivered will have a high moisture content spillages will dry out and further mechanical action by vehicles will create a fugitive dust problem on public roads.

1.12 Recommendations

1. All delivery trucks must be covered.

2. Overloading should not occur.

3. Public authorities should be reminded of their responsibility to maintain roads in order to decrease the likelihood of fugitive emissions from this source.

4. The entrance road to the Menangle Office is unsealed at present. This roadway should be paved in bitumenous material to at least the steel bridge on the entrance road. From this point to the weigh bridge, the gravel surface should be progressively implemented using gravel similar to that used at the existing Camden site.

2.0 EXISTING ENVIRONMENT

There are limited existing sources of air emissions within the general vicinity of the proposed extractive operations. It is considered that the existing levels of dust deposition would not exceed the State Pollution Control Commission's (SPCC) guidelines on acceptable rates for dust deposition.

The level of 4.0 gm/sq.m/month is the dust deposition rate that if exceeded would give rise to complaints from residents.

Specific sources of air emissions in the general vicinity of the proposed extraction industry are:

- Menangle Sand & Soil Supplies Pty. Ltd. existing extractive operations.
- Farming pursuits on a Department of Agriculture Land.
- Vehicle emissions from traffic flow on the south western freeway.
- Fugitive emissions from the southern railway line.
- Trotting track activities.
- Glenlee Coal Washery and Dump.
- Existing quarry immediately south of the freeway.

- Dairying activities at Menangle.

Observations during field studies in the general area are that the existing levels of fugitive dust are low. The proposed extractive operations will not give rise to levels of dust deposition that would exceed the SPCC guidelines of acceptable dust deposition rates. Extractive industries, with appropriate controls in place as recommended in this report, have operated within 500 - 800 metres of large numbers of residences at many other localities within urban areas of Sydney and Wollongong.

3.0 POTENTIAL EFFECTS OF FUGITIVE DUST EMISSIONS

Five "sensitive" areas exist in proximity to the leased areas.

1. The Camden Park Estate.
2. A number of lagoons or ponds.
3. The existing river vegetation.
4. An area designated as an orchard.
5. Residences in Menangle and Menangle Park.

Without doing a computer modelling study it is difficult to quantify potential effects. However a number of factors exist in this environment from which it is possible to comment sensibly on effects for each of the "sensitive" areas.

3.1 The Camden Park Estate

The Camden Park Estate lies to the north-west of the leased area approximately 750 metres from Stage 3 of the proposed extraction programme. At this distance it is expected that no dust nuisance at all will occur at the Estate.

3.2 Lagoons

No deterioration or other effects are expected due to dust settling on the lagoons. The level of expected dust fall at these sites is so low providing adequate watering occurs on the haul roads as not to represent any threat.

3.3 Existing River Vegetation

No effect of dust deposition on trees from current and past extraction at this site can be detected. The trees on the lease potentially exposed to dust concentrations appear healthy and reportedly have grown quickly despite the potentially high dust loadings.

3.4 Orchard

The areas designated as an orchard near Stage 3 will experience minor nuisance dust if haulage road watering is not maintained. However, this would have no effect on growth unless dust sensitive plants are used. It is not clear whether this orchard area is under cultivation or not and what future crops may be planted.

3.5 Residences

The leased area lies mid-way between the populated areas of Menangle and Menangle Park. At the proposed level of operation no nuisance dust can be expected to reach these populated areas providing the recommendations mentioned earlier are adhered to. This similarly applies to the occupied cottages on the Camden Park Estate which are within the vicinity of Stage 3 of the extraction operations.

4.0 CONCLUSIONS

None of the "sensitive" areas can be expected to suffer a deterioration in their amenity due to fugitive dust emissions from the leased areas. This conclusion is based on several factors:

1. The nature of the resource - the loam, sand and gravel are coarse grained materials not normally subject to wind-borne dispersion.

2. The condition of the resource - the high natural moisture content aids in the prevention of dispersion either from mechanical activity (e.g. loading) or from wind forces.

3. The location of the resource - the material is generally being won from river banks and levees. Naturally these represent some of the lowest lying land in the area. Additionally the large strands of trees that line the river banks act as a natural barrier to the dispersion of fugitive dust.

5.0 REFERENCES

1. Ferrari, L.M, etal "Dust Control on Coal - Haul Roads" State Pollution Control Commission. Workshop on Fugitive Dust Control of Coal Industry Works, 30th October 1986, IEA, Sydney Divison.

2. Rosebury, K.D. & Zimmer, R.A. "Cost-Effectiveness of Dust Suppressants on Surface Coal Mine Haul Roads". PEDco. Environmental, Inc., Golden, Colorado.

3. Mann, C.O. & Cowherd, C.C. "Fugitive Dust Source", AP-42, Section 11.2.

4. Orlemann, J.A. etal, "Fugitive Dust Control Technology" Pollution Technology Review No. 96, Noyes Data Corporation. (A book prepared from studies by the OHIO EPA and PEDCO Environmental Inc).

5. Longworth & McKenzie Pty. Ltd. Job no. YLT0337 Dated 20/7/87.

planning workshop

APPENDIX V

Noise Impact Assessment

NOISE IMPACT ASSESSMENT

AT

SAND & SOIL EXTRACTION INDUSTRY

AT

MENANGLE, NSW.

Prepared for: Planning Workshop
on behalf of: Menangle Sand & Soil Supplies Pty. Ltd.

Prepared by R.T. Benbow

for Dick Benbow & Associates Pty. Ltd.

Report No. EE1238PW.

August - September 1987.

Dick Benbow & Associates Pty. Ltd.,
2/5-9 Hunter Street,
PARRAMATTA NSW 2150.

Telephone 635 5099
(ah) 635 1425
(047) 57 1366

CONTENTS PAGE

1.0 INTRODUCTION

It is proposed to extract sand and soil from the Nepean River and adjacent land at specific locations in the vicinity of the Camden Park Estate and Menangle. The proposed extraction industry will be an extension of the existing operations by Menangle Sand & Soil Supplies Pty. Ltd.

This company has been conducting a sand and soil extraction operation adjacent to the Menangle bridge over the Nepean River for several years. The proposed extension of their operations would involve similar plant, equipment and processes that are already being conducted.

This report presents the details that enable an assessment to be made of the effects that noise emissions from the proposed extension of the extractive operations may have on the nearest residential dwellings to the proposed extraction areas.

2.0 ASSESSMENT CRITERIA

There are well established acoustic criteria that enable the noise emissions from an extractive industry to be assessed. The criteria are based on maintaining control of the noise emissions from the extractive industry so that the existing background noise levels, as measured at the nearest residences, are not exceeded by 5 dBA. There are also recommended outdoor background noise levels which are quality objectives. For rural residential areas, a level of 45 dBA would be considered acceptable. Refer to SPCC Environmental Noise Control Manual 21-1.

The operation of a sand and soil extractive industry of greater than 20,000 sq. metres comes under direct control of the State Pollution Control Commission through the Noise Control Act (1975). The proposed operation of Menangle Sand & Soil Supplies Pty. Ltd. will be a scheduled premises and will be licenced under this Act to control noise emissions to specific levels set in approval conditions.

3.0 EXISTING ACOUSTIC ENVIRONMENT

The existing acoustic environment is determined by measuring the levels of background noise in the area adjacent to the existing residences. The predicted level of noise emissions from the proposed extractive operations are then compared to the measured background noise levels to assess the likely noise impact.

The background noise measurements were conducted using two sets of instruments. A Bruel & Kjaer Modular Precision Sound Level Meter Type 2231 with a Type 1625 1/3 - 1/1 octave band filter, 12.5 mm diameter microphone and wind shield was used to obtain the frequency spectrum of the existing environment. A Bruel & Kjaer Statistical Level Analyser, Type 4426, fitted with a 12.5 mm diameter microphone and windshield was used to obtain the statistical levels - L90 and L10 in particular. The instruments were calibrated before and after the measurement periods using a Bruel & Kjaer calibrator model 4230.

The weather conditions during the noise studies were acceptable for conducting measurements.

The background noise levels are shown in Tables 1 and 2 (on next page) The location of the noise measurements positions are shown on Diagram 1. The background noise is described using the term L90. Briefly this means the level of noise that is exceeded for 90% of the time and represents the average minimum of the noise levels during the measurement period. The L10 level is the level of noise exceeded for 10% of the time and is the average maximum of the noise fluctuations.

Table 1. Statistical Noise Levels Date: 10th September 1987.

Location	Time	dBA L90	L10	L1	L5	L50
1.	7.20 am	38.5	45.8	49	46.5	42.3
	11.45 am	41.8	51.3	56.3	53.5	44.8
2.	8.20 am	44.3	58.8	62.5	60	51.8
3.	7.00 am	47.5	71.5	80.3	75.3	56.8
4.	11.20 am	46.8	57.5	74.3	60	50.8
5.	6.10 am	42	52	75.3	58.8	45
	10.55 am	46.5	53	64.3	54.8	49.3
6.	6.35 am	43 3	57.5	67.3	60.5	48.8
7.	7.50 am	48	55.5	68	59	51.8

Table 2. Typical Octave Band Levels Date: 10th September 1987.

A weighted octave band levels at centre frequencies in Hertz

Location	Time	dBA	63	125	250	500	1k	2k	4k	8k
1.	7.25 am	42	30	34	32	35	35	40	28	26
5.	6.15 am	44	32	30	30	35	39	36	37	31
6.	6.40 am	45	37	39	30	39	37	30	26	16


SOUTH CAMDEN
MOUNT ANNAN
GLENLEE
GLEN ALPINE
CAMDEN PARK
CAMDEN PARK ESTATE WILDLIFE REFUGE
NEPEAN RIVER
MENANGLE
MENANGLE PARK
closest residences
blg noise levels measured
Area 1
Area 2
PROPOSED SAND & SOIL EXTRACTION
CAMPBELLTOWN STEAM MUSEUM
MACARTHUR CHRISTIAN COLLEGE (Under Construction)
ROSEMEADOW
SOUTH CAMPBELLTOWN MINE SUBSIDENCE DISTRICT
JOHN THERRY HIGH SCHOOL
MOUNT GILEAD
DOUGLAS PARK
MAIN SOUTHERN RAILWAY
HUME HIGHWAY
Navigation Creek
Onslow Creek
Menangle Creek
Woodhouse Creek

Diagram 1

3.1 Description of Existing Noise Sources

The proposed extension to the extractive operations will take place in the Menangle Park area. The extent of the proposed operations are detailed in environmental reports supporting the proposed development. Diagram 1 shows the locations of the 2 areas of extraction and the surrounding community activities.

The nearest residences are located at the following locations as referred to in Tables 1, 2 and Diagram 1.

1. At least 3 occupied cottages on the Camden Park Estate/Department of Environment & Planning Land.

2. A new residence under construction by a landowner of one of the areas to be used for the extractive operations. This residence is adjacent to the existing site entrance and will be the closest residence to the proposed operations.

3. Residences along Menangle Road and south of the proposed operations.

4. Menangle village and residences.

5. Menangle Park residences.

6. Nearest residences to the proposed operations south of Menangle bridge over the Nepean River. These residence are off Menangle Road.

7. Nearest residence to the proposed operations east of the south western freeway.

The existing noise sources within the community area are the following:

- Traffic on the South Western Freeway.
- Passing of trains on the main southern railway line.
- Local traffic on Menangle Road including the existing truck movements of the sand and soil extractive industry.
- Farming, dairying and general community activity.
- Menangle Park trotting track, horse exercising which begins prior to 7.00 am.

The existing extractive industry operations were audible at locations 5 and 6. Intermittent truck or mobile equipment movements were barely audible at location 1. Locations 2 and 3 were affected by traffic noise. At the majority of locations bird noise, general community traffic and traffic were the main noise sources.

The existing acoustic environment has a noise level closest to the proposed operations varying from 38.5 to 46.5 dBA. As such it will be necessary to control the level of noise from the proposed extension of the extractive industry to within 43.5 dBA at location 1, and at other locations to within an L10 level of 45 dBA during normal operating conditions. An intermittent upper level of 50 dBA should be maintained.

4.0 DESCRIPTION OF PROPOSED EXTENSION TO THE EXTRACTION OPERATIONS

The proposed extensions and operations are detailed in environmental reports supporting the development. Therefore a full description of the proposed operations will not be repeated in this report. The existing equipment and processes already in operation have been studied to prepare this report. The operations involve several pieces of processing equipment and mobile equipment for extracting the sand and soil.

4.1 Times of Operation

It is proposed to operate the proposed extraction and processing equipment during the following times:

4.1.1 Overburden removal.

7.00 am - 6.00 pm	Monday to Friday
7.00 am - 1.00 pm	Saturday

4.1.2 Sand and soil extraction equipment and processing plants.

6.00 am - 6.00 pm	Monday to Friday
7.00 am - 1.00 pm	Saturday

4.1.3 Highway truck movements.

The access routes for the three extractive areas (as shown on Diagram 1) will be located within land occupied by the extractive industry as much as practicable. The access routes will be established to maximise the distance between nearest residential areas. Further discussion of proposed access routes is included later in this section of the report.

The SPCC guidelines on truck movements are as follows:

- Normal movement of trucks is preferred between 7.00 am - 6.00 pm Monday to Saturday. At substantially reduced truck movements between 6.00 am - 7.00 am and 6.00 pm - 10.00 pm. Minimal or no movements outside these hours.

For the delivery of sand and soil by highway trucks it is recommended that the following times of movements apply:

4.1.3.1 For truck deliveries south along Menangle Road 6.00 am - 6.00 pm with minimal truck movements between 6.00 am-7.00 am.

4.1.3.2 For truck deliveries north along Menangle Road normal movements between 6.00 am-6.00 pm.

4.1.3.3 Any proposal for earlier hours of delivery would require a detailed truck noise impact assessment and application to the SPCC.

4.1.4 Recommended Restriction on Operating Hours

A reduction in operating hours at specific areas of the extraction operation within 500 metres of the nearest residence is recommended. These occur at the Camden Park Estate cottages (Location 1, Diagram 1) during a part of the Stage 3 extraction area. For Location 3 part of the extraction operations will be within 350 metres of this residence. A starting time of 8.00 am is proposed. A similar start time could be applied to the residence at Location 2.

4.2 Frequency of Operation

The mobile equipment and processing plants would operate throughout the year. The processing plants run generally continuously throughout the day operating in a load/unload cycle. The load cycle, when material is being fed through the processing machinery, is usually quieter than the unload cycle when the machinery is running without sand/soil on the conveyors, screens and chutes. The loaded cycle dampens sheet metal vibration of the chutes and is quieter. Engine noise output does not vary. The mobile equipment carryout a number of different operations and are used continuously throughout the day.

4.3 Location of Operations

The proposed operations are shown on Diagram 1 as two distinct areas. For the purpose of this report these areas are described as:

- Area 1. Menangle - Menangle Park Extractive Area. This encompasses the Stages 1, 2 and 3 detailed in the Environmental Impact Statement and relate to operations on within and to the west of the Nepean River. A separate extraction area, on land owned by Campbelltown Council and the Trotting Club, are to be found on the eastern bank of the river.

- Area 2. The site immediately east of the Menangle Road bridge over the Nepean River.

The mobile equipment will operate within the full extent of these three areas. The dredge will operate only along the existing width of the Nepean River in these three areas. The diesel generator and small sand washing plant that acompanies the dredge will be located within a 180 metre radius of the dredge.

The several processing plants that screen and blend the various products are mobile plant that are strategically located close to the winning of the sand and soil but at a minimum distance of 650 metres from the nearest residence. This distance could be reduced if specific noise control measures such as bunding adjacent to the plants and acoustic enclosing of the diesel engines should be undertaken.

A blending plant for the organic mixes produced by Menangle Sand and Soil Supplies Pty. Ltd. is located within proximity to the existing workshop, weighbridge and office facilities.

The following equipment can be expected to work in close proximity to the various processing plants.

- The dredge has a diesel generator and small washing plant within a 180 m radius of the dredge location.

- The organic mixes area has one front end loader to fill the hopper on the plant and to load finished product into highway trucks.

- The bulldozer operates either isolated from other mobile equipment or acoustically screened from the other mobile equipment by an extractive face or stockpile of unprocessed top soil.

- The 3 Powerscreen processing plants (Agamotors) will be separately located adjacent to where material is being extracted. These plants will be located in the two extractive areas so that it is doubtful that noise emissions from the three plants will be cumulative at a specific location. If this should occur because of production requirements then the use of bunding or noise reduction to the diesel engines on the plants would be recommended.

4.3.1 Description of Operations.

The bulldozer is used to initially remove overburden/vegetation from a new extractive site. Topsoil is then removed by forming an extraction face and operating in a trench of cut of varying depth depending on the material being extracted. The width of the cut is gradually extended. The material is pushed into a stockpile. A front end loader removes material from the other side of the stockpile and fills the hopper on the processing plant. The bulldozer will usually be acoustically shielded from the front end loader and processing plant. During the noise studies, the bulldozer operated within 50 - 100 m of the front end loader and processing plant but was not audible at the processing plant. This factor limits the bulldozer noise emissions from contributing to the noise from the combination of a front end loader and processing plant.

The organic mixing area will be located several hundred metres from any other processing plant and so will not contribute to noise levels from other equipment. The existing site for the organic mixing is remote from the nearest residences.

Table 4. Processing Plant

Description	Purpose	Noise Level at 7m
1. Two Powerscreen plants, Lister diesel engine, single screen, single conveyor	Organic mixing, sand and soil screening	82 dBA
2. One Powerscreen plant powered by two Deutz diesels, single large screen, two conveyors	Soil screening and blending	83 dBA
3. One sand washing plant with launderer, pumps and two cyclones	Sand washing from the dredge	70 dBA
4. One diesel generator set housed in an open building recently acoustically treated. The acoustic treatment would obviously be relocated to any new site for this item	Power generation	70 dBA with existing acoustic treatment

The frequency spectrums of this machinery and the mobile equipment for point of maximum noise output are shown in the appendix. The noise source of these plants are the diesel engines. Therefore maximum noise levels occur at 7 metres from the location of the engines. There would be a minor advantage in orienting the plants so that the hopper on the plants faces the direction of the nearest residences. However the predicted levels of noise, based on the maximum noise emissions, can be held within the acceptable noise levels and therefore the plants can be located for the most cost effective operation.

Table 5. Mobile Equipment

Description	Purpose	Noise Level
5. Diesel powered dredge	Sand extraction from the river	81 dBA at 10 m
6. Cat D7H bulldozer	Overburden removal, winning of soil, rehabilitation	81 dBA at 7 m
7. Frone End Loader (FEL) Kobelco LK700A/8	Organic mixing plant, soil blending plant, truck loading	82 dBA at 7 m
8. FEL, early model Cat 950 and later model Cat 980C	As above	85 dBA at 7 m
9. Two FEL's Kawasaki KSS 852 11	As above	82 dBA at 7 m
10. Albion Water truck 5000 gallon capacity	Dust control on haul roads, stockpile areas	71 dBA at 7 m

(Refer to appendix for typical octave band levels).

The locations of the processing plant and mobile equipment relative to the nearest residences vary as each stage of the extraction occurs. The distances between the extraction areas and the nearest residences are chosen to represent the worst case and average situations.

4.5 Buffer Distances

The distances to nearest residences are shown on Diagram 1 at locations 1 - 7. The distances between the closest point of extraction and the residences were measured using Lands Department maps. The distances are shown in Tables 6.1 - 6.4 for each of the two extraction areas. The distances from the existing processing plants are the recommended minimum distances that should apply to prevent the combined noise level at the residences from exceeding SPCC acoustic criteria.

Table 6.1 Buffer Distances. Metres. Area 1 - Stage 2

Residences	Distance from edge of Extraction Area and Mobile Equipment	Distance from Dredge	Recommended min distance from processing plant
1	400	675	650
2	not affected	not affected	not applicable
3	not affected	not affected	not applicable
4	not affected	not affected	not applicable
5	750	750	650
6	550	675	650
7	not affected	not affected	not applicable

The residential locations that are more than 1 km from the noise sources will not be affected by the operation of the equipment located in that stage of the development. For example, location 2 is 1.1 km from Area 1 - Stage 2 and will not be affected by any of the equipment located in this part of the development. In this situation the recommendation to locate the processing plant at a minimum distances of 650 m is obviously not applicable.

Table 6.2 Buffer Distances. Area 1 - Stage 3

Residences	Distance from edge of Extraction Area and Mobile Equipment	Distance from Dredge	Recommended min distance from processing plant
1	350	625	650
2	not affected	not affected	not applicable
3	not affected	not affected	not applicable
4	not affected	not affected	not applicable
5	750	750	not applicable
6	not affected	not affected	not applicable
7	not affected	not affected	not applicable

Noise levels will be predicted for the residential locations within 1000 metres from the noise sources.

Table 6.3 Buffer Distances. Area 1 at Menangle Bridge

Residences	Distance from edge of Extraction Area and Mobile Equipment	Distance from Dredge	Recommended min distance from processing plant
1	not affected	not affected	not applicable
2	90	750	*
3	250	675	650
4	650	1000	650
5	not affected	not affected	not applicable
6	750	750	650
7	not affected	not affected	not applicable

* noise levels from mobile equipment and the dredge will far exceed acceptable criteria, that processing plant noise will be a lesser noise source.

Table 6.4 Buffer Distances. Area 2

Residences	Distance from edge of Extraction Area and Mobile Equipment	Distance from Dredge	Recommended min distance from processing plant
1	not affected	not affected	not applicable
2	575	575	650
3	750	900	650
4	1050	not affected	not applicable
5	not affected	not affected	not applicable
6	650	650	650
7	not affected	not affected	not applicable

There will be topographical differences for the bulldozer and dredge that will provide a useful reduction in noise levels. For the processing plants and mobile equipment the landform is such that acoustic shielding does not occur. A degree of shielding may occur at some areas as the depth of extraction progresses but a reduction in noise levels would only occur as equipment operated close to (within 30 m) the extraction face.

4.6 Truck Routes

The haulage routes on internal roads within the extractive areas should be located within 50 - 100 metres of the river bank to maximise the buffer distances between the internal truck/mobile equipment routes and nearest residences.

The following recommendations are considered necessary to prevent unacceptable acoustic impact from the truck/mobile equipment movements on internal haulage routes.

4.6.1 The internal haulage routes be clearly defined in each of the two extraction areas shown on Diagram 1.

4.6.2 These routes should have only one access point to Menangle Road.

4.6.3 The existing entrance off Menangle Road to the existing office be upgraded with bitumen sealing up to the steel bridge over the creek on the entrance road.

4.6.4 The road surface on internal routes be maintained in a good surface condition by routine grading and maintenance. The body rumble of empty truck bodies on uneven road surfaces is an unneccesary source of impact noise which was audible at background noise locations 5 and 6.

4.6.5 Maximum road speeds of 20 km/hr be applicable with speed signs erected on haulage routes.

4.6.6 There should not be a haulage route from Stage 3 of Area 1 on the eastern side of the Nepean River through to Menangle Park. The haulage route alongside the river should need to suffice.

It is considered that these recommendations, if implemented, would reduce the potential acoustic impact from the haulage routes. A further detailed acoustical study of hauage routes is not considered to be warranted.

5.0 PREDICTED NOISE LEVELS

The predicted impact of noise emission from the proposed extensions to the extractive operations has been determined based on noise

An upper level of 50.5 dBA would apply which is considered to be unacceptable. Control measures to screen the movements of mobile equipment behind an earth berm or by locating the haulage road in Stage 3 alongside the bank of the river where shielding could be provided would be necessary.

Summary of Noise Impact for Residences at Location 1

The extraction operations will have no noise impact on the residences at Location 1 until the extraction occurs at the Stage 3 section of Area 1 and when within 500 metres of the residences. Within this distance the combined level of mobile equipment noise may exceed the acceptable level of 45 dBA by 5.5 dBA. The following control measures are recommended:

- A later starting time to 8.00 am.
- The provision of a 3 - 4 metre bund wall as indicated on Diagram 2 in the appendix.
- Locating the haul road alongside the bank of the river.

It is considered that with these measures applied, the potential noise levels can be adequately controlled and there will be no significant impact on the residences.

Summary of Noise Impact for Residences at Locations 5 and 6

For the residences at these locations, the extraction operations are at distances greater than 650 metres. These two locations will have similar maximum noise emissions levels to the buffer distances are of the same order. For the residences the noise levels will be at or below the existing background levels. It is therefore considered that for the residences at each of these locations, the noise impact will be negligible.

5.2 Residence under Construction at Location 2

Measured Background Noise Levels 44.3 dBA.

The noise level for this location will far exceed acceptable acoustic criteria. A combined noise level from equipment of 62 - 65 dBA will occur. Practical noise control measures to reduce this level to 45 - 50 dBA would involve using a bund wall 3 - 4 metres minimum height around the southern edge of the extraction area facing the residence. A further ameliorative measure would include a later starting time of 8.00 am. Noise compliance testing would be required during the extraction operation at this area to ensure acceptable noise levels are maintained.

Summary of Noise Impact

Considerable attention to constructing a bund wall along the southern edge of the extractive area facing the residence will be needed to control the noise level to within an acceptable level of 45 dBA. This level is considered to be acceptable to prevent significant impact to this residential location.

5.3 Residence at Location 3

Measured Background Noise Levels 47.5 dBA.

This residential location will be within 250 metres of the edge of the extraction operations for part of the extraction from Area 1. Noise levels from the bulldozer operating without shielding provided by an extractive face and with front end loader movements will result in a maximum noise level of 49 - 53.5 dBA. This is the worst case condition that could occur and has the potential to lead to annoyance to residences.

For the time period that the material would be extracted from this area, specific noise control measures would be considered necessary. These include:

- A later starting time of 8.00 am when equipment operates within 250 - 350 metres of the residences.
- Forming a 3 - 4 metre high bund wall along the boundary of the extractive area - as shown on Diagram 2 in the appendix.

Summary of Noise Impact for Residence at Location 3

Ameliorative measures are required when mobile equipment operates along the edge of the extractive area. With these measures in place the noise levels at this location would be within acceptable levels.

5.4 Residence at Location 4

Measured Background Noise Levels 46.8 dBA.

The buffer distances between the residences at this location and the extraction operations are such that negligible noise impact would occur. Noise levels from the extractive operations of less than 40 dBA would exist.

5.5 Residences at Locations 5 & 6

Measured Background Noise Levels 42 - 46.5 dBA.

5.5.1 Equipment at Area 1. Stage 2. Table 6.1.

- Bulldozer at edge of extractive area.
- Front end loader at processing plant, bucket towards residences.
- Dredge and ancillary equipment at river bank.

Combined level of 41 dBA.

Comment: Within acceptable levels.

With bulldozer and front end loader travelling at edge of extractive area, an upper limit of 41.5 dBA applies.

These levels are considered to be acceptable when compared to the recommended upper limit for rural residential areas and the existing measured background levels.

(No additional attenuation has been allowed for the effect of shielding provided by the main southern railway line.)

5.6 Residence at Location 7

Measured Background Noise Levels 48 dBA.

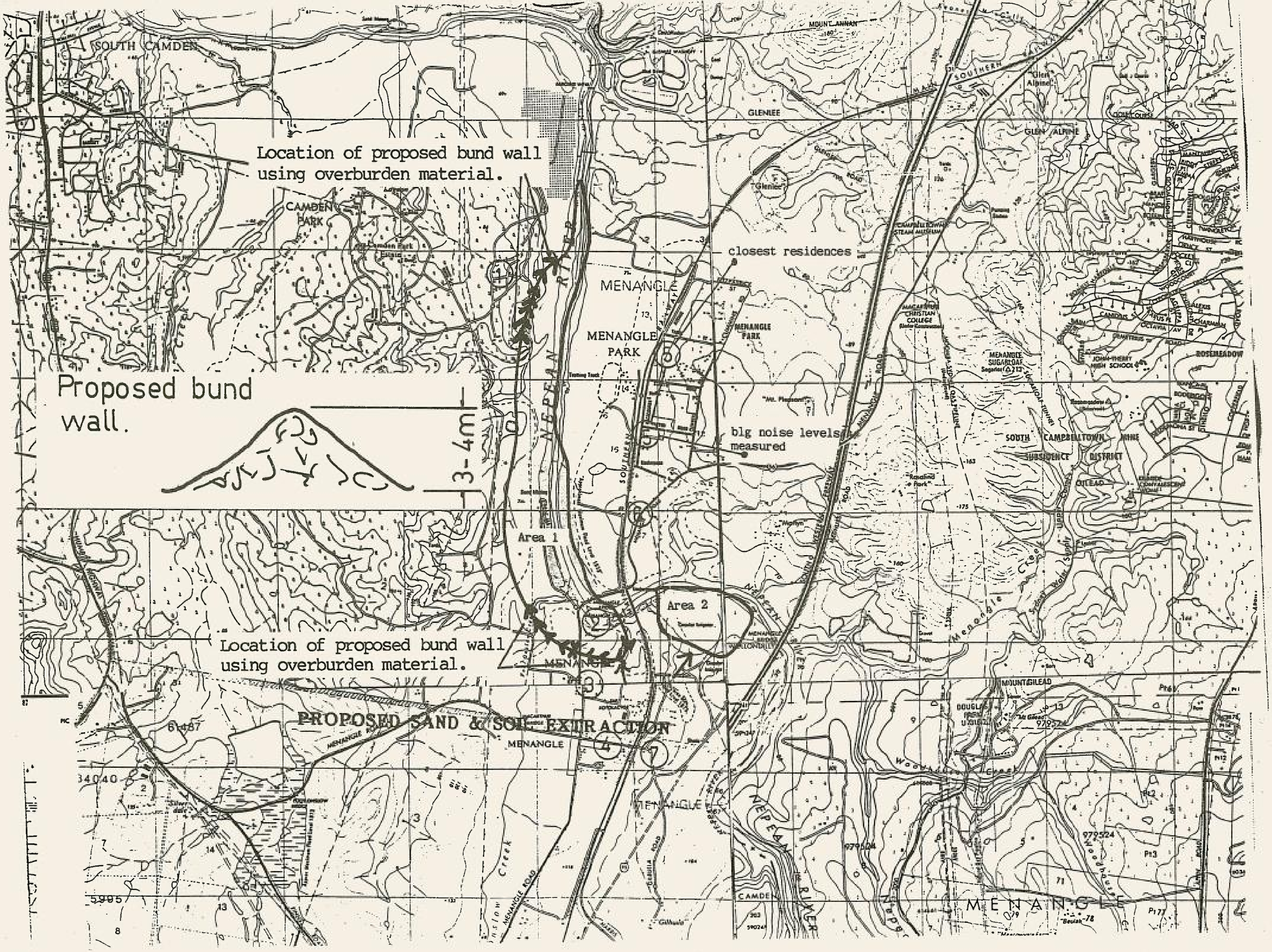
The buffer distances between the residence at this location and the extraction operations are such that negligible noise impact would occur. Noise levels from the extractive operations of less than 40 dBA would exist.

6.0 STATEMENT OF IMPACT

The majority of the areas proposed for extraction will not cause an unacceptable impact to the nearest residential areas. The buffer distances, acoustic shielding and use of modern machinery limits the potential acoustic impact. There are however two areas where excessive noise levels will occur and specific measures have been proposed to ameliorate the potential annoyance to residents. For the residence under construction near the entrance to the existing site, practical noise measures have been proposed. The construction of an earth berm for relatively long distances around the edge of two areas has been shown on Diagram 2 in the appendix. For the areas requiring the use of bund walls as a noise control measure noise compliance tests should be incorporated in the operations to ensure the length and height of the walls is appropriate.

The assessment of the noise impact for all other areas indicates that the proposed extensions to the extractive areas can operate with negligible acoustic impact at the nearest residences.

R.T. Benbow,
Principal Consultant.



SOUTH CAMDEN
MOUNT ANNAN
GLENLEE
GLEN ALPINE
Location of proposed bund wall using overburden material.
CAMDEN PARK
closest residences
MENANGLE
MENANGLE PARK
NEPEAN RIVER
Proposed bund wall.
3-4m
blg noise levels measured
SOUTH CAMPBELLTOWN MINE SUBSIDENCE DISTRICT
ROSEMEADOW
Area 1
Area 2
Location of proposed bund wall using overburden material.
PROPOSED SAND & SOIL EXTRACTION
MENANGLE
MOUNT GILEAD
NEPEAN RIVER
MENANGLE

planning workshop

APPENDIX VI

Traffic Impact Report

MENANGLE RIVER SAND & SOIL
SUPPLIES PTY LTD

PROPOSED SAND & SOIL EXTRACTION, NEPEAN RIVER, MENANGLE - TRAFFIC IMPACT REPORT

AUGUST 1987

CHRISTOPHER HALLAM & ASSOC. PTY. LTD.
31 George Street, Sydney
Telephone: (02) 241-2007

Job 8725

CONTENTS

1. INTRODUCTION

1.1 Background

In July 1987 Christopher Hallam & Associates Pty Ltd was commissioned by Planning Workshop, on behalf of Menangle River Sand and Soil Supplies Pty Ltd, to undertake a traffic impact study on the proposed extension of the existing sand and loam extraction works adjacent to the Nepean River at Menangle. This report presents the findings of our study.

1.2 Scope of Report

This report specifically addresses factors for consideration ((i) and (j) as set out in Section 90 of the Environment Planning and Assessment Act, 1979, these being:

"(i) whether the proposed means of entrance to and exit from that development and the land to which that development application relates are adequate and whether adequate provision has been made for the loading, unloading, manoeuvring and parking of vehicles within that development or on that land;

(j) the amount of traffic likely to be generated by the development, particularly in relation to the capacity of the road system in the locality and the probable effect of that traffic on the movement on that road system;"

The report is set out as follows:

* Section 2 describes the existing situation;
* Section 3 reviews the proposed development, with particular regard to access options;
* Section 4 assesses the traffic impact and summarises conclusions.

2. EXISTING SITUATION

2.1 Transport Network

Current access to the existing extraction activity is by Menangle Road - Main Road 179 - an arterial road providing sub-regional access. Regional movement is mainly carried on the South Western Freeway, that generally runs parallel to Menangle Road. While the South Western Freeway is built to at least a four lane divided carriageway 110km/hour speed limit standard, Menangle Road is generally a two-lane undivided carriageway with geometric alignment limitations in the vicinity of the site restricting the speed of travel. Menangle Road has a sealed carriageway width of about 7.4 metres, except on the bridge over the Nepean River, where the carriageway width is 5.0 metres. To the south of the River bridge, Menangle Road rises and bends sharply. While the speed limit at this point is 100km/hr, the alignment restricts actual speeds to considerably less than this. With the River bridge, signposted "No Passing or Overtaking", drivers who know the area generally exercise a degree of caution. Further to the South, on the the straight section of Menangle Road approaching the village of Menangle, the speed limit changes to 60km/hr. To the north of the River bridge, Menangle Road rises and bends sharply to pass underneath the Southern Railway Line. A warning sign recommends a maximum speed of 55km/hr. North of the Railway Line, particularly north of Cummins Road, Menangle Park, the standard of Menangle Road noticeably improves. Menangle Road joins the Camden-Campbelltown Road - Main Road 178 - at Campbelltown. Access to the Freeway is available just to the west of this intersection.

The Southern Railway Line at Menangle provides a low frequency passenger service. From Menangle Station, a short-platform unattended station, there are five trains to Sydney Central Terminal on weekday mornings and one train on weekday afternoons. These services generally start at Moss Vale. In the southbound direction there are two services on weekday mornings from Sydney Central Terminal and six services on weekday afternoons/evenings. The majority of these services terminate at Moss Vale.

Being a small unattended country station, Menangle Station has no provision for bulk freight shipping, though there is a small siding.

2.2 Traffic Flows

Daily traffic flows in the area are monitored by the Department of Main Roads (1). For Menangle Road, the flows were as given in Table 2.1.

Table 2.1	Annual Average Daily Traffic Flows Menangle Road - MR179 (1)		
Location	1978	1980	1982
South of Camden Road (MR178) Campbelltown	3750	4960	4330
At Nepean River bridge	2880	3590	2300

(1) Dept. of Main Roads, N.S.W., Traffic Volumes and Supplementary Data 1984, Illawarra Division

Given Menangle Road's function as an arterial road, the levels of flow indicated in Table 2.1 are low. For reference, an arterial road in an urban area is generally expected to have an average annual daily traffic flow in excess of 15,000 vehicles per day (2). In reality, Menangle Road at Menangle functions as a rural arterial road with consequent lower traffic flows.

To get more up to date data on traffic flows a count was undertaken on Menangle Road north of the railway underpass in the week Saturday 8th August to Sunday 16 August, 1987. An automatic counter recorded hourly movements in each direction of travel for the week. The full results are reproduced in the Appendix. Key results are summarized below.

Flow Type/Period	Traffic Flow on Menangle Road
Average daily flow (7 days)	3100
Average weekday flow	3111
Average weekday flow: 6.0 am to 4 pm	198
Peak hour flow:	282

The counter provided details on vehicle types. For the week these were:

Car	Light Truck	Heavy Truck
96.1%	1.6%	2.3%

2.3 Existing Extractive Industry Operation

The location of the site is shown on Figure 1. Sections of the site - Stages 1, 2 & 3 - have been previously worked and extraction is continuing. The material is removed from the site by trucks. The site is the sale point. Customers generally use their own trucks or those of cartage contractors to pick up their orders. As such, truck types and sizes vary considerably.

(2) Traffic Authority of N.S.W., Policies Guidelines and Procedures for Traffic Generating Developments, November 1984.

With production and sales following demand, substantial monthly fluctuations occur. Table 2.2 lists the monthly production figures since January 1980. The figures represent total production of both soil and sand. The percentage of soil in the annual production is given in the final row.

TABLE 2.2 MONTHLY PRODUCTION OF SOIL AND SAND FROM CURRENT OPERATIONS ON THE SITE

Month	1980	1981	1982	1983	1984	1985	1986	1987
Jan	2,662	6,564	4,894	19,644	21,617	35,580	17,386	34,310
Feb	4,808	7,609	17,279	13,094	12,267	14,640	20,512	38,006
March	3,686	8,873	15,743	11,631	12,090	16,104	16,175	51,816
April	4,269	6,532	22,122	9,795	10,897	9,950	16,158	13,104
May	5,982	6,119	22,544	7,619	10,225	6,532	15,069	9,612
June	5,403	6,550	16,762	9,812	11,098	6,842	16,979	9,233
July	7,088	13,014	18,565	9,968	9,031	9,957	13,649	-
Aug	7,167	16,671	20,984	14,688	19,538	15,790	9,692	-
Sept	10,728	30,711	23,124	21,733	24,052	13,832	21,126	-
Oct	6,031	44,477	26,083	17,917	26,022	17,901	25,466	-
Nov	7,972	32,641	25,676	21,145	20,383	24,531	18,848	-
Dec	4,688	24,334	16,046	11,082	Incl in Jan 85	18,531	22,107	-
Total for year	70,484	204,095	229,732	168,128	177,220	190,190	213,167	-
Soil %	9	67	61	83	99	94	85	-

Table 2.2 indicates substantial monthly fluctuations as well as annual fluctuations. The average annual production between 1981 and 1986 was 197,089. In this period the minimum annual production was 15% less and the maximum annual production was 17% more. Truck movements to the site would follow the same patterns.

To get an indication of the number of truck movements per day and the average load per truck, weighbridge records were reviewed for the month of September 1986, this month being chosen as indicative of a month of higher than average activity, with 10% of annual sales. For September 1986, loads per vehicle were collated, together with details of materials in the loads. Where the destinations of the loads were known, these were also collated. Table 2.3 summarises the number of loads per day. Note that one load represents two truck movements.

TABLE 2.3

TRUCK LOADS FROM SITE - SEPTEMBER 1986

Day of Week	Week 1	Week 2	Week 3	Week 4	Week 5
Monday	47	78	30	70	28
Tuesday	54	39	56	68	24
Wednesday	39	51	36	57	-
Thursday	52	57	31	57	-
Friday	53	42	43	60	-
Saturday	36	38	38	45	-

* From records of Menangle Sand and Soil Pty Ltd.

On average, there were 49 loads per weekday and 39 loads per Saturday. Over the month, the average load per truck was 17.4 tonnes. The total amount of material that left the site was 21,368 tonnes. Based on a sample of 265 loads where destinations were quoted, some 98.5% of truck movements would have probably been from and to the North i.e. turn left after leaving the site, cross the Nepean River and travel towards Campbelltown.

To get additional information on the destinations of loads, specific questions were asked by weighbridge staff for all loads leaving the site in the period 22 July to 28 July 1987. A total of 112 loads were despatched in this week, with an average of 22 loads per weekday and 3 loads on Saturday. The average load was 18.0 tonnes. Of those loads, some 96% were to the north of the site and hence likely to turn left out of the site.

There are currently employed on site a total of 16 persons, being six management/clerical/sales, eight production and two maintenance. In addition to these, there are several subcontractors operating trucks from the site. When there is an increased demand for production, some company employees from other quarry locations assist on the site.

2.4 Traffic Safety

The existing access to the site is via a driveway off the western side of Menangle Road, just to the south of the Nepean River bridge. Figure 2 shows the driveway on the right, looking to the South from the Nepean River bridge, while Figure 3 shows the driveway on the left, looking to the North. This driveway is not sealed. It has a width of about 5.6 metres, flaring out at the intersection, sight distance to the north is not restricted, though it is restricted to the south. Sight distance between a northbound vehicle on Menangle Road - to the South of the intersection - and a vehicle turning left out of the site's driveway is about 145 metres. Sight distance between the same northbound vehicle on Menangle Road and a vehicle turning right - from the North into the site - is more restricted, being about 100 metres. Guidelines for recommended sight distances at driveways and intersections are published by the Traffic Authority of N.S.W. (2). They are reproduced in Table 2.4 below.

TABLE 2.4

STOPPING AND DESIRABLE MINIMUM SIGHT DISTANCES (METRES)

Approach Speed of through road (km/hr)	S.S.D. (1.5 sec reaction time)	S.S.D. (2.5 sec reaction time)	D.Min. S.D. for 2 lane roads	D. Min. S.D. for roads with more than 2 lane
50	35	50	100	115
60	50	65	120	140
70	65	85	140	160
80	85	105	160	185
90	110	140	180	205
100	140	170	200	230

The 100 metre sight distance at the driveway is adequate for stopping sight distance (2.5 seconds reaction time) for speeds up to about 80km/hr. In comparison with the desirable minimum sight distance (two lane road) it is only adequate for approach speeds of up to 50 km/hr. Based on a limited survey of 50 vehicles, we estimate that the appropriate design speed for northbound vehicles approaching the site driveway is 80 km/hr. That is, at the point at which northbound drivers can see trucks entering the driveway, the speed is 80 km/hr. This point is beyond the 55 km/hr advisory speed sign and approximately level with the 45 km/hr advisory speed sign. It is evident that many drivers do not follow these advisory speed signs. We conclude that the current access is sub-standard.

From discussions with the Wollondilly Shire Engineer, we understand that potential safety hazards at the site access are exacerbated by material falling from the trucks into the outside edge of Menangle Road, reducing the coefficient of friction of the roadway. This would not appear to result from spillage from the load but rather because of material picked up off the unsealed internal access road by the truck's tyres.

With the sight distance restrictions to the South, the Wollondilly Shire Engineer saw the need to relocate the access to the South, to a point at the top of the crest at the end of the straight section of Menangle Road. Such a relocation would also be suitable for a possible future replacement of the Nepean River bridge by a wider, higher structure on a less restricted horizontal alignment. We are not aware of when such a new bridge will be built.

To provide an indication of road safety in the area, accident statistics were obtained for Menangle Road within both Campbelltown City and Wollondilly Shire areas - i.e. between Camden Road, Campbelltown and Picton Road, Maldon. The statistics were for the most recent three year summary period - 1983 to 1985 - available from the Traffic Authority of N.S.W. In this three year period no accidents were reported at the intersection of the site driveway with Menangle Road. One accident was reported 11-20 metres south of the Nepean River bridge involving a northbound car in Menangle Road 'going the wrong way' and hitting a southbound car in Menangle Road 'going straight'. (Accident occurred at 12.20 pm on Sunday 11 February, 1984). For reference, the current driveway to the site is about 90 metres from the river centreline. Three accidents occurred at the Menangle Bridge:

Date	Time	Vehicle 1	Vehicle 2
Tues 16/8/83	7.20am	Utility eastbound 'going wrongway'	Lorry westbound
Fri 18/11/83	5.10pm	Car southbound 'going straight'	Car northbound
Fri 16/8/85	7.10pm	Car northbound hit bridge	-

The accident on 16 August 1983 was the only accident on Menangle Road between Menangle and Campbelltown involving a heavy vehicle. To the south of Menangle, there were three accidents involving heavy vehicles in the three year period.

In conclusion, the current access to the site is constructed to a lower standard than desirable, with sight distances lower than those recommended by the Traffic Authority but nevertheless adequate for stopping. The low standard nature of the access has not resulted in any accidents in the period 1983 - 1985 , the most recent period for which the Traffic Authority has accident statistics available.

3. THE PROPOSED DEVELOPMENT

3.1 Description

The proposed development is a continuation and extension of the existing sand and soil extraction activities on and adjacent to the current site of operations. An indicative schedule of resources and the time periods for their extraction is given in Table 3.1 below. Locations are indicated on Figure 4.

TABLE 3.1

PROPOSED EXTRACTION SCHEDULE

Stage Numbers	Location	Sand in Floodplan	Sand in Channel/ Banks	Sand in River Bed
1	West bank, west of road	1987-88 0.4 Mt	0	0
2	West bank, west of road	1987-95 1.2 Mt	1988-92 0.2 Mt	1994-98 0.6 Mt
3	West bank, west of road	1993-95 0.2 Mt	1987-90 0.2 Mt	1992-94 0.4 Mt
6	South bank, road to railway	1989-98 0.7 Mt	0	0
7(a)	South bank, railway to Freeway	1995-2020 1.1 Mt	1998-2020 0.7 Mt	2010-2020 1.2 Mt
7(b)	West bank, east of Freeway	0	1998-2020 0.1 Mt	2010-2020 0.4 Mt
1 East	East bank, west of road (Council)	1987-2000 0.7 Mt	1990-95 0.2 Mt	2000-2005 0.9 Mt
2 East	East bank, west of road (Trotting)	1987-2000 0.7 Mt	1993-98 0.1 Mt	1998-2000 0.4 Mt
3 East	East bank, west of road (Trotting)	1998-2005 0.3 Mt	0	2005-07 0.1 Mt
3 East	East bank, west of road (Mac Arthur)	2000-2010 0.8 Mt	2000-2005 0.1 Mt	2007-10 0.5 Mt
Total	All	1987-2020 6.6 Mt	1987-2020 1.6 Mt	1992-2020 4.5 Mt

Mt = millions of tonnes.

This schedule indicates a total resource of 12.7 million tonnes to be extracted over a 33 year period. In terms of the five areas indicated on Figure 4, the extraction breakdown is as follows:

LOCATION	RESOURCE (Total)
West bank, west of road	1987-1998 3.2 Mt
South bank, road to railway	1989-98 0.7 Mt
South bank, railway to Freeway	1995 - 2020 3.0 Mt
West bank, east of Freeway	1998 - 2020 0.5 Mt
East bank, west of road	1987-2010 5.3 Mt

In terms of specific amounts of material extraction per area per year, the total resource divided by the extraction period gives appropriate design estimates. In practice, precise annual quantities will vary with demand. If there is a slump in demand then the life of the facility might be longer than anticipated. With a higher than anticipated demand the annual output could be greater than the average with a consequent reduction in resource life.

The proposed development would see an increase in total staff employed on site through the requirement to provide separate weighbridge facilities in the three main areas: current, east bank west of road and south bank east of road. Relative numbers would not be expected to be great. Production staff would be relatively flexible, able to change work locations according to priorities and demands.

3.2 Access, Layout and Parking

The primary fixed points would be the driveways onto the public road network and the office and weighbridge facilities. The internal road layout within the extraction area would change with time. While we have not seen detailed site layout plans, we consider that there is adequate scope within the areas for appropriate design standards to be met and parking areas for staff provided. We recommend that internal areas be laid out in general conformity with the Traffic Authority's guidelines (2), and that parking be provided at the rate of one space per two employees as a minimum.

The key site layout item is the location of the driveways. The area currently being mined would continue to have its access at the point just to the south of the Nepean River bridge. As is discussed in Section 3.3, the current average weekday generation of 88 truck movements would increase to 110 truck movements over the period 1987 to 1998. While the three year accident history at the intersection indicated no accidents, we have some concern about the sight distance limitations. There are three options:

- i) no change to existing layout;
- ii) upgrade layout at existing location; and
- iii) construct new intersection at a new location.

In view of the projected generation, we consider that option i) is not acceptable. With option iii), one problem is that the lease of the area changes in 1995 from 350 metres south/west of river centre-line to 175 metres. An intersection constructed on the outer edge of the 175 metre limit would improve current sight lines but would still not be up on the hill and straight section of Menangle Road. From this point to the South the sight distance would be about 140 metres. The bank on the eastern side of Menangle Road would need to be cleared to get adequate sight distance from the North. Note that this 175 metre point is to the north of the 45 km/hr advisory speed sign. If the lease was changed to permit an access junction up to 350 metres from the river then a location about 280 metres from the river centre-line appears reasonable. For reference the 55 km/hr advisory speed sign is about 320 metres from the river and the existing gate on the eastern side of Menangle Road is about 340 metres from the river.

The concept of having a four-way cross junction servicing the extraction operations on the east and on the west of Menangle Road has been suggested by the Wollondilly Shire Engineer. We see little point in this because each extraction area will be self-contained, with individual weighbridges and offices. We are informed that there will be no need for trucks to drive from the eastern to the western site in the normal course of transporting extracted material. It is possible that vehicles would travel to the western site for maintenance purposes, though the numbers of such movements would be small. The disadvantage of a cross-junction is that it is inherently more dangerous than a pair of T-junctions. On the balance of the issues, we see no necessity for a combined junction.

One advantage of moving the access location to the south is that it could better fit in with any realignment associated with a new bridge over the Nepean River. However until such times as these works are programmed, we see little point in considering their implications. The driveway under discussion would be needed up until about 1988, so a new bridge would need to be completed by then.

Options are available to upgrade the intersection at the existing location. The north bank of the eastern side of the intersection is the principal restriction on sight distance. Based on the location of fences, it would appear that there is a wide section of road reserve east of the current alignment. It would appear logical for the developer to excavate material from this reserve to provide room to improve the layout and to improve sight lines and at the same time extract saleable material. While we have not done a detailed survey, we estimate that with suitable extraction the sight distance to the south could be improved to about 160 metres, a distance in conformity with the desirable minimum sight distance for two lane roads with approach speeds of 80 km/hr.

We recommend that the intersection at the existing location be upgraded, as discussed above. Widening of the carriageway on the eastern side to allow a southbound vehicle to pass a truck waiting to turn right would be desirable, though with the traffic flows on Menangle Road the probabilities of a truck needing to come to a stop is low. We recommend that the intersection on the western side be flared and the carriageway widened, not so much to provide an acceleration lane but to better separate turning and northbound traffic and minimise the chance of material from truck tyres spilling onto the main carriageway. Given the very limited number of movements from the South into the driveway, there is not a particular need for a deceleration lane though some additional flaring would be desirable, as would the sealing of the final section of the site driveway, to reduce the incidence of material picked up by tyres spilling onto the road. An indicative layout is shown on Figure 5.

The area on the east bank, west of the road would have access via a driveway currently under construction. At this point, Menangle Road has a sealed carriageway width of some 7.4 metres, with a total formation width of some 13.5 metres. For a vehicle turning out of the driveway, sight distances to the north and south are 145 metres and 140 metres respectively, the latter ultimately restricted by the horizontal alignment of Menangle Road whereas the railway overbridge abutments provide some restriction on the former. Sight distances for a vehicle turning right into the driveway are greater. A minimum sight distance of 140 metres provides adequate stopping sight distance for approach speeds up to 90 km/hr (2.5 second reaction time) and meets the desirable minimum sight distance guidelines (2) for approach speeds up to 70km/hr. In the light of the constrained approaches on Menangle Road to the driveway, we consider that sight distances and the location of the driveway are satisfactory. We recommend that the driveway be designed to provide for the free movement of maximum dimensions articulated trucks, in accordance with the guidelines (2).

The area on the south bank between Menangle Road and the railway line would need a new direct access onto Menangle Road. There is considerable latitude of choice for the location. We suggest a point about in the middle of the straight, though a point further to the north - say at the point where there is currently a driveway - would also be acceptable. While the speed limit at this point is 100 km/hr and speeds can approach this limit, sight distance is not restricted.

As an alternative, it would be possible to make this access onto the east-west side road through Menangle village - Station Street. While meeting the theoretically desirable objective of providing access to a minor instead of a major road, given the relatively low flow on Menangle Road, the lack of sight distance limitations and the adverse impact of directing heavy trucks through Menangle Village, we consider that direct access to Menangle Road is the preferred option.

With the extraction area between the railway line and the Freeway, we recommend that a link road be built to connnect this area with the area west of the railway line. This road would pass underneath the railway line at the railway bridge shown on Figure 6. As indicated, width is not a constraint, nor is vertical clearance. The alternative option of providing access onto the east-west road through the village is less desirable. This proposal has not been specifically discussed with the State Rail Authority. Based on our field observations, we forsee no engineering constraints on the access proposal. A road would not unduly restrict flood waters.

Access into the area east of the Freeway is more difficult to satisfactorily resolve. Under the southern Freeway bridge abutment adjacent to the Nepean River there is an access that appears to have been provided to maintain access by farm vehicles across land otherwise bisected by the Freeway. This is shown on Figure 7. Unlocked gates are provided at each end of the underpass. We do not believe that the Department of Main Roads envisaged that this underpass would be used by heavy trucks on a regular basis. Unless substantial pavement works were undertaken to stabilise the surface, to prevent adverse effects on the bridge abutments and to prevent slippage towards the river, we consider that this underpass is unsuited to the regular movement of heavy trucks. We see four options:

i) don't develop the resources in this area;
ii) provide a road access to Moreton Park Road and hence through Menangle Village to Menangle Road;
iii) provide a conveyor belt facility to transport material under the Freeway adjacent to the bridge abutment underpass; and
iv) upgrade the Freeway underpass.

If the facility is to be developed then negotiations should be opened with the Department of Main Roads to determine their requirements for a heavy vehicle route under the Freeway. If the DMR does not agree to such an option or if the cost of construction is not justified by the quantity of material to be moved then the conveyor belt option should be assessed. This option is more acceptable from the point of view of amenity not only of Menangle Village but also of the Gilbulla Memorial Conference Centre, located between the area of possible extraction and Moreton Park Road. If the conveyor system proved too expensive for the quantity of material to be moved then the southern access route could be considered. At the current intersection of Moreton Park Road with the driveway to Gilbulla, sight distance is relatively unrestricted to the west and about 170 metres to the east, an adequate amount. At this point Moreton Park Road has a sealed carriageway width of 6.4 metres. West of the Freeway, this width reduces to 5.5 metres. The road has a very short radius turn up over the railway overbridge and then passes some 10 houses, a school, a general store and a School of Arts Hall before meeting Menangle Road. Physically, this road could provide access though it would have environmental disadvantages, the extent of which depend on the volume of truck traffic, as is discussed in the next section.

3.3 Traffic Generation and Distribution

The proposed extraction schedule listed in Table 3.1 can be used to estimate the number of truck movements for each area of extraction. While in theory precise estimates for each year between 1987 and 2020 could be obtained, based on the summation of individual elements in Table 3.1, in practice those elements are only projections, the realisation of which will depend on demand. To estimate truck trip generation we have assumed an equal volume of extraction per year within the principal areas. We have also assumed a 48 week year, an average of 17.5 tonnes per load and a distribution of weekday and Saturday loads based on current patterns observed in September 1986. Table 3.2 listed the results.

TABLE 3.2

TRUCK TRAFFIC GENERATION SCHEDULE
OF PROPOSED DEVELOPMENT

Area	Period of Extraction	Annual Production	Truck Movements Per Day Weekday	Saturday
Current: west bank, west of road	1987-1998	266,667	110	86
East bank, west of road	1987-2010	220,833	90	72
South bank, road to Freeway	1989-2020	115,625	48	36
South (west) bank east of Freeway	1999-2020	22,727	9	8

Note that the figures given are for truck movements, which are truck loads multiplied by two.

For the current site of extraction, the projected average annual production is about 35% higher than the average between 1981 and 1986, and 25% higher than the 1986 production.

The projected average annual production of the east bank, west of road area is about 4% greater than the 1986 production.

The projected production - and hence truck trip generation - east of Menangle Road is substantially less than in the areas west of Menangle Road. The truck trip generation in the area east of the Freeway would average nine movements per weekday and six per Saturday.

Based on the trip distribution of current loads - as indicated in Section 2.3 - some 96% of truck movements would be expected to be to/from the North and 4% to/from the South.

Based on the current number of employees on the site and the current production level, we conclude that no additional employees would be based on the current site, that about 16 employees would be based on the east bank, west of Menangle Road site and about 10 employees would be based in the area east of Menangle Road. The total additional generation of light vehicles would thus be of the order of 52 vehicle movements per day. A first guess estimate is that about 75% of those movements would be to/from the North.

Table 3.3 summarises the current and projected traffic generation and distribution of the development.

TABLE 3.3

PROJECTED WEEKDAY TRAFFIC GENERATION AND DISTRIBUTION

Direction	Current (1986 avg)		1987-1998		1999-2020	
	Cars	Trucks	Cars	Trucks	Cars	Trucks
To North	24	84	64	238	40	141
To South	8	4	20	10	12	6
Total	32	88	84	248	52	147

Table 3.3 indicates that in the 1987-1988 period there would be an additional 160 truck movements per weekday and an additional 52 car movements per weekday, in comparison with the current site generation. Beyond 1998, the additional car and truck movements per weekday would be 20 and 59 respectively, the reduction due to the fact that the material on the current site of operations would have been exhausted.

4. TRAFFIC IMPACT OF PROPOSED DEVELOPMENT

4.1 Traffic Efficiency

Traffic efficiency principally relates to peak period congestion. For the projected traffic generation of the proposed development with the low level of flows on Menangle Road, this is of little consequence. The current weekday peak hour on Menangle Road occurs in the period 8.00-9.00 am. In this period most staff would already be on site so the only traffic movement would be the trucks. Their movements are generally not peaked so that site traffic generation would be daily truck movements divided by the hours of operation - 10 hours. To summarise for the peak hour and for daily flows on Menangle Road north of the site:

	Current	1987-1998	1999-2020 *
Peak hour flow (veh/hr)	282	297 (+15)	288 (+6)
Daily flow	3111	3305 (+194)	3184 (+73)

* assuming no base traffic growth.

We conclude that the proposed development will have little impact on traffic efficiency.

4.2 Traffic Safety

Traffic safety for this development principally relates to the safety of the access junctions. The current junction servicing the site had no accidents at it in the 1983-1985 period. Nevertheless, given the continuation of heavy vehicle movements up until about 1998, we recommend that this junction be reconstructed to provide improved sight distance to the South, to provide space to pass on the eastern shoulder of Menangle Road and to provide an additional lane on the western side to improve the separation between trucks egressing the site and northbound vehicles on Menangle Road. With these changes, as further discussed in Section 3.2, we consider that the traffic safety of the proposal is satisfactory.

For access into the site on the eastern side of the river, west of Menangle Road, the driveway currently being constructed is at the best location on the section of Menangle Road between the river and the railway underpass and is satisfactory for traffic safety.

For access into the site on the south side of the river east of Menangle Road there are a number of possible locations for safety site access. A point in the vicinity of the existing gate/driveway into the site would be good.

Access into the site east of the Freeway should preferably join the public road network at the access discussed above. While sight distance at the Gilbulla Road/Moreton Park Road is reasonable, this access has amenity disadvantages.

4.4 Transport Alternatives

In theory, an alternative means of transporting the material would be on the railway by constructing a loading facility at the siding at Menangle railway station. Apart from the initial construction cost of the loading facility, such a system would be uneconomic because of the relatively short distance that would be travelled on the rail network and the double handling involved. As indicated by the details of load destinations, material is transported to a wide range of suburbs in the Sydney region and in the south-west sub-region. The loading of material onto trucks, to move to the railway loading point and then be picked up by the trucks at the destination point would substantially add to the transport cost and convenience and could have an adverse amenity impact on Menangle village. Given that the proposed road transport system is directly onto the Main Road network and given the above comments, we conclude that the rail transport option is not acceptable.

4.5 Conclusion

We have assessed in detail the current and future traffic generation for the development and have compared those flows with base traffic flows on Menangle Road. We conclude that the development would not adversely affect traffic efficiency on the public road network.

Options for access into each of the extraction sites are assessed. With the recommended access options we conclude that the development would not significantly affect traffic safety. While any increase in flow theoretically has an impact, for the flows projected and for the access layouts proposed general guidelines on access design are met.

With direct access onto the Main Road network, the proposal does not adversely affect the amenity of the villages of Menangle or Menangle Park.

Figure 2

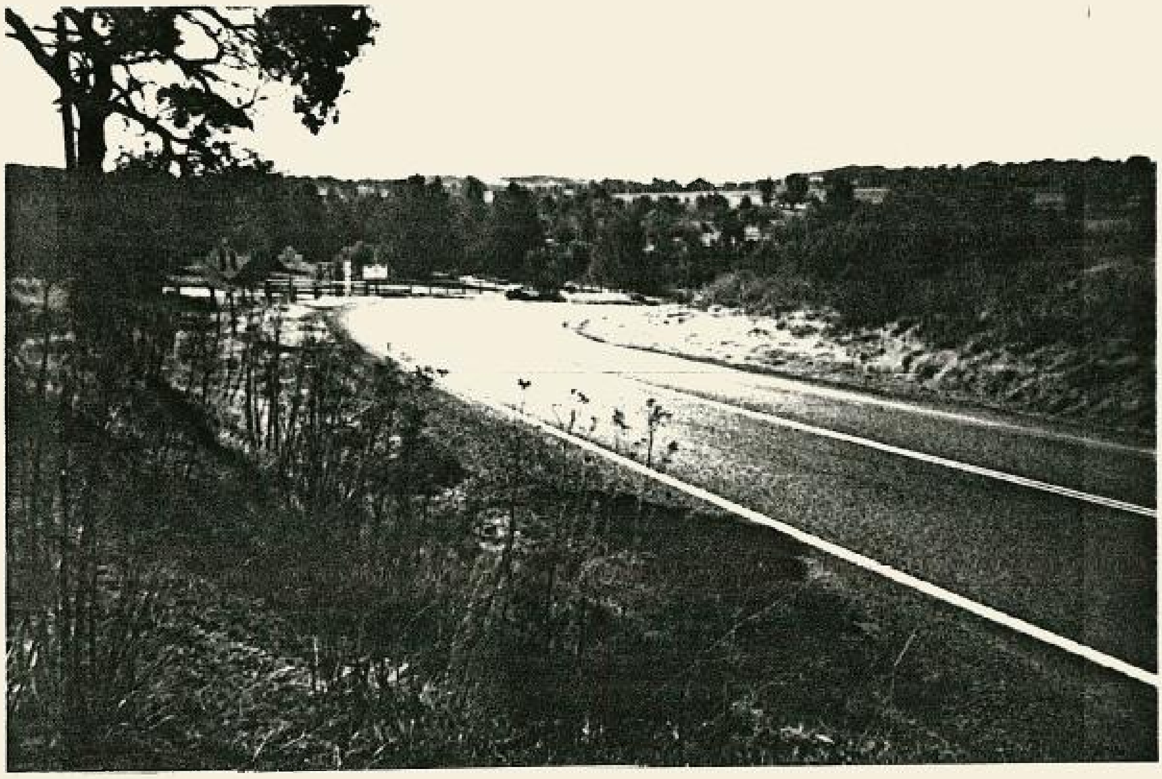


Figure 3

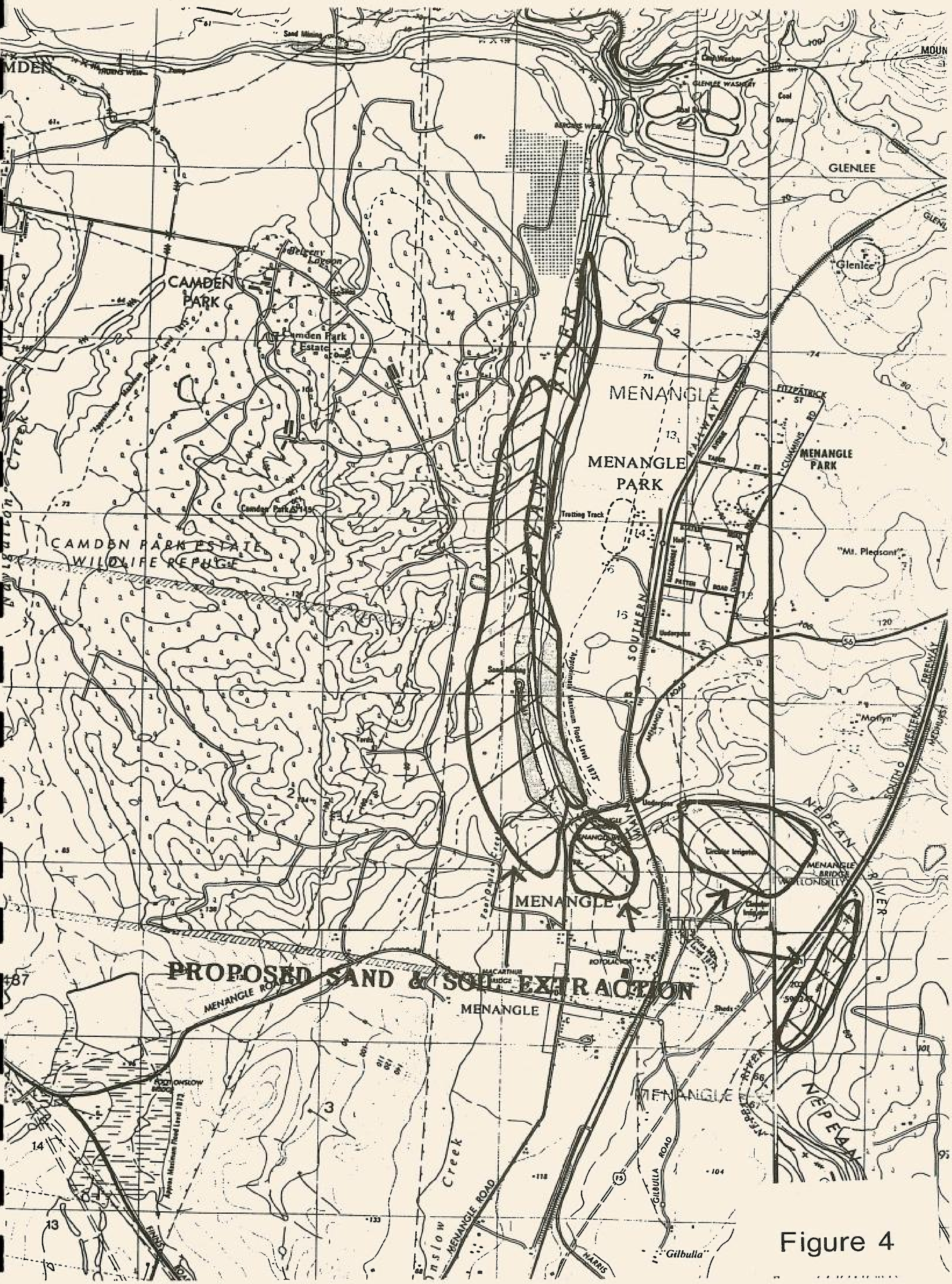

PROPOSED SAND & SOIL EXTRACTION
CAMDEN PARK
Camden Park Estate
CAMDEN PARK ESTATE WILDLIFE REFUGE
Belgenny Lagoon
MENANGLE
MENANGLE PARK
Trotting Track
SOUTHERN RAILWAY
FITZPATRICK ST
CUMMINS RD
GLENLEE
Glenlee
GLENLEE WASHERY
Coal Washer
"Mt. Pleasant"
"Marlyn"
NEPEAN RIVER
NEPEAN
MENANGLE BRIDGE
WOLLONDILLY
MENANGLE ROAD
GILBULLA ROAD
"Gilbulla"
Onslow Creek
Sand Mining
Circular Irrigator
Underpass
Approximate Maximum Flood Level 1873
SOUTH WESTERN FREEWAY

Figure 4


SITE
INCREASED RADIUS
MENANGLE ROAD
NEW LANE
NEW LANE
CUT BACK BATTER

Figure 5

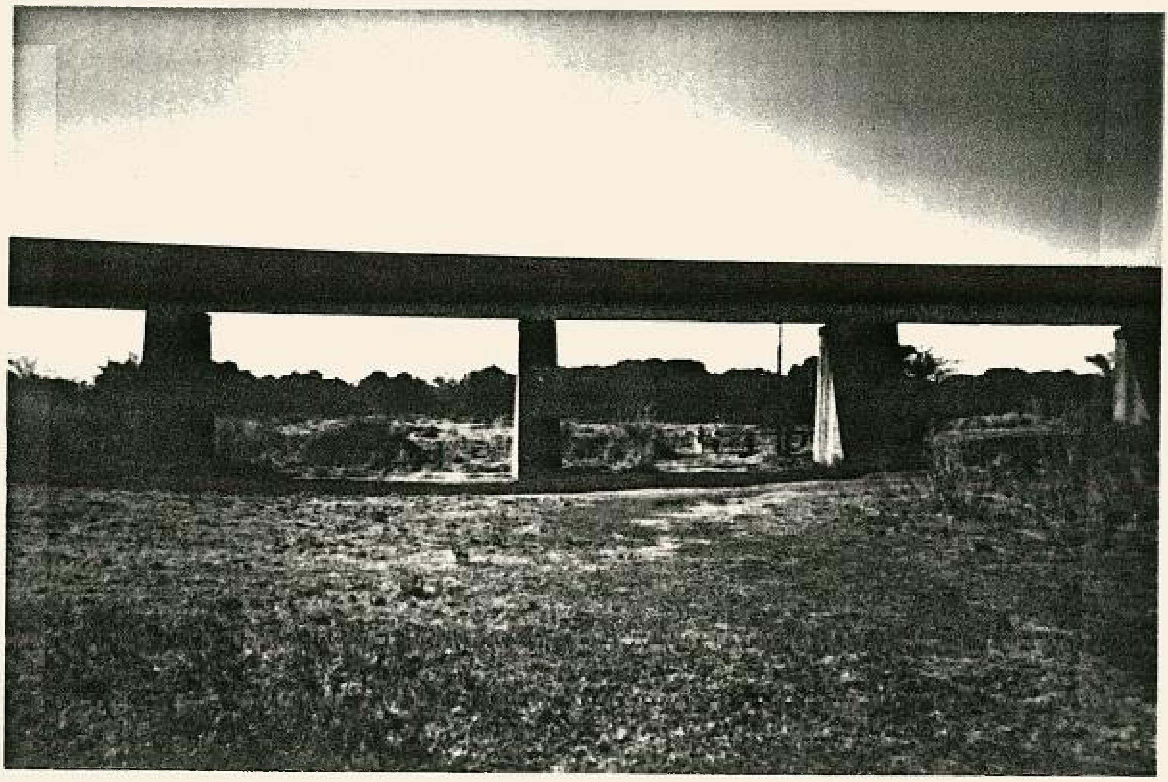


Figure 6

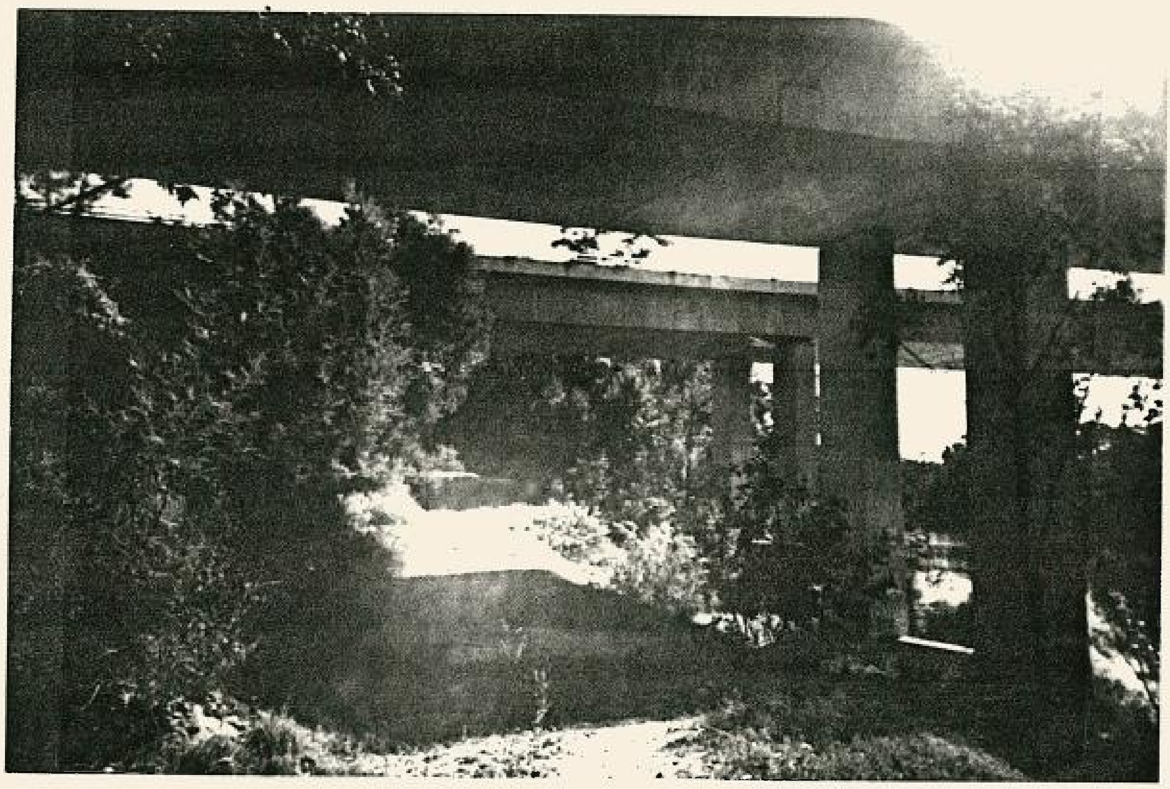


Figure 7

APPENDIX VII

Archaeological Survey

ARCHAEOLOGICAL SURVEY OF PROPOSED SAND AND SOIL EXTRACTION SITES ON THE NEPEAN RIVER, MENANGLE PARK, NSW

by

Helen Brayshaw

July 1987

Report Menangle River Sand & Soil Supplies Pty Ltd
through Planning Workshop

BRAYSHAW MCDONALD PTY LTD
CONSULTANT ARCHAEOLOGISTS
51 THOMPSON ST DRUMMOYNE 2047

CONTENTS

FIGURES

PLATES

1 INTRODUCTION

The archaeological study detailed in this report was commissioned by Planning Workshop, who were engaged by Menangle River Sand and Soil Supplies Pty Ltd to prepare a report supplementary to the EIS on proposed Nepean River extraction at Menangle prepared by Don Fox Planning Pty Ltd [1987].

The objectives of the study were to identify areas of archaeological and Aboriginal significance which would be affected by the development proposal, including:

* location and significance of archaeological sites or relics encountered or likely to be encountered on site;
* likely impacts associated with the development;
* measures to mitigate likely impacts.

The conclusion of this report, after consultation with the local Aboriginal community and a comprehensive field survey in which no archaeological sites were located, is that there is no archaeological constraint upon the development proposal or Aboriginal interest in the area to be affected.

2 ENVIRONMENTAL SETTING

The study area consists of three sections, the largest extending about 3km north from Menangle Weir, another between the Main Southern Railway and the South Western Freeway, and the third extending about 800m upstream from the South Western Freeway. A significant proportion of the northern section is currently being mined. The proposed maximum extent of mining is 350m from the river, principally on the western side.

Bedrock in the Menangle Park area is of the Wianamatta Group - specifically the Liverpool Sub-group, consisting predominantly of shale and some sandstone beds. The soil found in the study area is a fine sand alluvium deposited by the river system.

The land surrounding the Nepean River in the vicinity of the site is characterized by undulating topography. The river passes through predominantly open terrain and is mostly adjoined by an alluvial flood plain. The riverine environment has formed mainly through deposition processes and consists of levees, remnant alluvial terraces and the flood plain. Within the study area the flood plain is generally less than 300m wide, although elsewhere it extends to more than 1km. It is characterized by lagoons developing at the base of the adjacent hills which are filled by river flooding, which is often extensive; several such bodies of water, including Barragul Lagoon and Menangle Pond, are situated along the western edge of the northern study area. Some areas have suffered degradation from activities such as resource extraction and stock access.

Away from the river the study area is predominantly open grassland which has probably been cleared for agricultural purposes. The river itself is lined on both sides with sparse to medium timber. Species occurring include River Oak [**Casuarina cunninghamiana**], River Peppermint [**Eucalyptus elata**], Corkwood [**Duboisia myoporoides**], Wattles [**Acacia** spp], Tea Tree [**Leptospermum flavescens**] and Bottlebrush [**Callistemon** sp]. Various introduced species are also present, including Wandering Jew [**Tradescantia** sp] and Privet [**Ligistrum** sp].

To the west of this section of the river is Camden Park Estate, granted to John Macarthur in 1805 and retained by his family until 1973. It is an area of undoubted historical and cultural importance which has long been used for pastoral activities. Within the study area no visible historic remains were identifiable. As most of the study area is susceptible to floods it is unlikely that any relics more than 50 years old [and therefore covered by the Heritage Amendment Bill of 1987] would remain intact.

3 ARCHAEOLOGICAL CONTEXT

The Cumberland Plain is known to have been occupied for at least 7,000 years. Jamisons Creek, an open site located on an alluvial terrace near Emu Plains, has a basal date of 7,010 ± 110 BP [SUA 1233] and was occupied until European contact. However, the artefactual status and contextual integrity of postulated Aboriginal relics located in the 40,000 year old Nepean gravels on the Cranebrook Terrace near Penrith have yet to be conclusively demonstrated. Other excavated sites in the northern half of the Cumberland Plain have all yielded dates of less than 4,000 BP. A rock shelter site known as Bull Cave, situated east of Campbelltown, yielded a basal date of 1,820 ± 90 BP [SUA 2106] [Koettig 1985].

A number of archaeological surveys have been undertaken in the region as part of environmental impact assessments. The nearest archaeological site is an open site located only 2km north east of the study area at Mt Annan by Haglund [1985]. Eight artefacts of mudstone, silcrete, chert and quartzite were identified widely scattered near a farm dam, and a further 6 isolated artefacts were identified during her sample survey of the proposed botanic garden and native arboretum. Adjoining Haglund's study area to the west Hanrahan [1981a, 1982a and 1982b] undertook a series of surveys associated with urban development being considered by the Macarthur Development Board. She identified nine open sites and three isolated artefacts. Raw materials included silcrete, quartz and chert. Most of these sites were small surface scatters of artefacts, but subsequent testing [Bonhomme 1986] indicated that two contained undisturbed subsurface deposit. These sites have not been excavated.

Other surveys have been conducted in the Campbelltown area. At Bow Bowing Hanrahan [1981b] surveyed an area for the Housing

Commission without identifying any sites. Du Cros [1985] recorded a small scatter of silcrete and quartz artefacts during a short line survey at St Helens, and also at St Helens Dallas [1986] located one scatter of 15 artefacts, mostly of quartz and silcrete, on a graded fire trail. At Glen Alpine, 2km north east of Menangle Park, Dallas [1985] found no sites during a survey on behalf of the Housing Commission, as had Hanrahan [1981c] for the same client at Elderslie, downstream on the Nepean near Camden.

The route of the natural gas pipeline, which passes east of the river within 2km of the present study area, was surveyed by Haglund [1974]. Three shelter sites were located to the south east, on Hawkesbury sandstone formation, but no sites were located in the vicinity of the study area, a thick covering of grass reducing ground visibility to a minimum.

Along the banks of Nepean itself several systematic archaeological surveys have now been undertaken in the Menangle/Camden area, all associated with soil and sand mining. Minimal ground visibility and the effect of flooding, either in washing away material or covering it with layers of alluvial deposit, has resulted in the identification of very little evidence of Aboriginal occupation. On a section of the eastern floodplain adjacent to the Menangle Park Paceway, only one isolated stone artefact was found [McDonald and Brayshaw 1983]. Immediately upstream of the southernmost section of the present study area Greer and McIntyre [1983] found no artefacts. Rich [1985a, 1985b] surveyed two areas to the east of South Camden with the same negative result. Earlier this year Byrne looked at a small section of the northern study area during his study of the Camden Park Estate, and although his report is not yet available for public perusal, it is known that he identified no sites.

Although few archaeological relics have been located along the banks of this section of the Nepean, on the basis of the environmental setting and site types known to occur in the region, the following site types could be expected to occur within the study area:

Open Occupation Sites
These occur on well drained landforms, such as hill tops or on creek flats. They contain archaeological remains in the form of stone artefacts and sometimes also hearths, usually occurring as

surface scatters of artefacts or embedded in deposit in areas where the ground surface is exposed because of lack of vegetation or where it has been lowered by erosion or disturbance, for example by ploughing. The type and proportion of raw materials present in these sites tend to reflect proximity to their sources. Thus cherts, tuffs and fine-grained siliceous materials are plentiful in Nepean River gravels, while the major known source of silcrete is further north on the Cumberland Plain.

Scarred Trees
These are so called when the scar is the result of the removal of bark or wood for the production of items such as shields, water containers, canoes and roofing for shelters. Scars may also result from the extraction of possums or honey from trees, and be in the form of toe holds in the trunk or larger branches. Many layers of bark have grown on these trees since they were cut by Aborigines, so that the margins of the scars tend to be deep and rounded. In this area unless the tree is at least 170 years old scarring is not likely to be of Aboriginal origin. Bush fires, timber clearing and the passage of time have resulted in very few surviving to the present day.

Axe Grinding Grooves
These are produced during the manufacture or resharpening of stone artefacts, particularly edge ground hatchets. They occur on flat areas of sandstone and are generally in or adjacent to river or creek beds, as water is essential to the grinding process. These sites are common along the Nepean and Hawkesbury Rivers, occurring predominantly on Hawkesbury sandstones, but also occasionally on sandstones of the Wianamatta Group.

4 ABORIGINAL CONSULTATION

The study area falls within the territory of the Tharawal Local Aboriginal Land Council. Prior to the survey contact was made with Mr Gavin Andrews, regional representative of Tharawal. Mr Andrews was sent a map of the proposed study area and indicated that no sites were known to the Aborigines in the area. It was arranged that a copy of the archaeological report should be forwarded to the Tharawal Local Aboriginal Land Council.

5 THE SURVEY

5.1 Procedure

Prior to the fieldwork being undertaken the NSW National Parks & Wildlife Service register of sites, archaeological reports and associated documents were inspected. Additionally, discussion was had with Ms Bronwyn Conyers, Acting Regional Archaeologist in the Central Regional Office of the National parks & Wildlife Service, and Dr Anne Ross, Research Archaeologist of the National Parks & Wildlife Service, Head Office.

Maps of 1:25,000 scale were used in the field.

The survey was conducted by two archaeologists, Helen Brayshaw and Laurajane Smith. The weather was fine with good visibility, although grass cover was such that ground visibility was generally 0-5%.

5.2 Results

No archaeological sites or relics were identified during the field survey.

In the southernmost section of the study area thick grass cover resulted in 0% ground visibility. The central section had been cleared and ploughed, ground visibility was <5% and small scale extraction revealed alluvial deposit of >2m. A vehicle track and cattle tracks provided some ground exposure. Areas of sandstone, rough surfaced and generally less than $1m^2$, outcropped on a low ridge, but were devoid of engravings or tool sharpening grooves. There was some ground exposure in the northern section, but very little stone and no artefacts were observed on the alluvial deposit, which is currently being mined in some areas and in others revegetated.

It was concluded that archaeological sites were most likely to occur beyond the western boundary of the northern section of the study area, on higher ground around the bodies of water, in particular Barragul Lagoon. Here, however, as elsewhere along the Nepean, without erosion or other sources of ground exposure, such sites are unlikely to be found.

6 RECOMMENDATIONS

These recommendations are made on the basis of the National Parks & Wildlife Act of 1974 [as amended], whereby it is illegal to damage, deface or destroy a relic without written permission of the Director. In view of this legislation, should any relics be identified during the course of mining, officers of the National Parks and Wildlife Service should be informed without delay.

1. No constraint be placed on the proposed development on archaeological grounds.

2. Three copies of this report be forwarded to

   Ms Bronwyn Conyers,
   Acting Regional Archaeologist,
   National Parks & Wildlife Service,
   PO Box 95,
   PARRAMATTA, 2150.

3. One copy of this report be forwarded to

   Mr Gavin Andrews
   Tharawal Local Aboriginal Land Council,
   PO Box 145,
   PICTON, 2571.

7 REFERENCES

Bonhomme T.	1986	An assessment of archaeological sites at Narellan near Campbelltown, New South Wales. Report to the Department of Housing through Landcom [Project 144].
Dallas M.	1985	Archaeological survey of Glen Alpine Campbelltown, NSW. Report to Lend Lease Homes Pty Ltd.
	1986	Archaeological survey of the Land and Housing Corporation Project 217 - St Helens Park south of Campbelltown NSW.
Don Fox Planning P/L	1987	Proposed sand and soil extraction Nepean River Menangle.
Greer S. & McIntyre S.	1983	An archaeological survey of a proposed sand extraction site at Mt Gilead, Menangle NSW. Report to O'Donnell & Associates Pty Ltd.
Haglund L.	1974	Archaeological survey of Natural Gas Pipeline Moomba-Sydney-Newcastle: Bowral-Wilton section. Report to NPWS.
	1985	Preliminary archaeological assessment of area proposed for Mt Annan Botanic garden and Arboretum. Report to Public Works Department of NSW.
Hanrahan J.	1981a	Report of archaeological survey of Stage 1 of development of an area in Currans Hill/Menangle Park as part of EIS requirement for its proposed release for residential development. Report to the Macarthur Development Board.
	1981b	Archaeological survey of proposed subdivision at Bow Bowing near Campbelltown. Report to the Housing Commission of NSW.

Hanrahan J.	1981c	Report on archaeological survey of 25ha at Elderslie near Camden. Report to the Housing Commission of NSW.
	1982a	Stage 2 - report of an archaeological survey of an area in Currans Hill/Menangle Park. Report to the Macarthur Development Board.
	1982b	Report on an archaeological survey of Stage 3 of a development in Currans Hill/Menangle Park. Report to the Macarthur Development Board.
Koettig M.	1985	Archaeological investigation of three sites on Upper Mill Creek, near Lucas Heights, Sydney. Report to the Metropolitan Waste Disposal Authority.
McDonald J. & Brayshaw H.	1983	Archaeological survey of proposed soil extraction site at Menangle Park. Report to T.J. O'Donnell & Associates Pty Ltd.
Rich E.	1985a	An archaeological survey of proposed sand extraction Somerset Park Estate, Camden. Report to the Macarthur Development Board.
	1985b	An archaeological survey of proposed top soil extraction part Portion 17, Parish of Narellan, County of Cumberland. Report to M. Collins & Sons Pty Ltd.

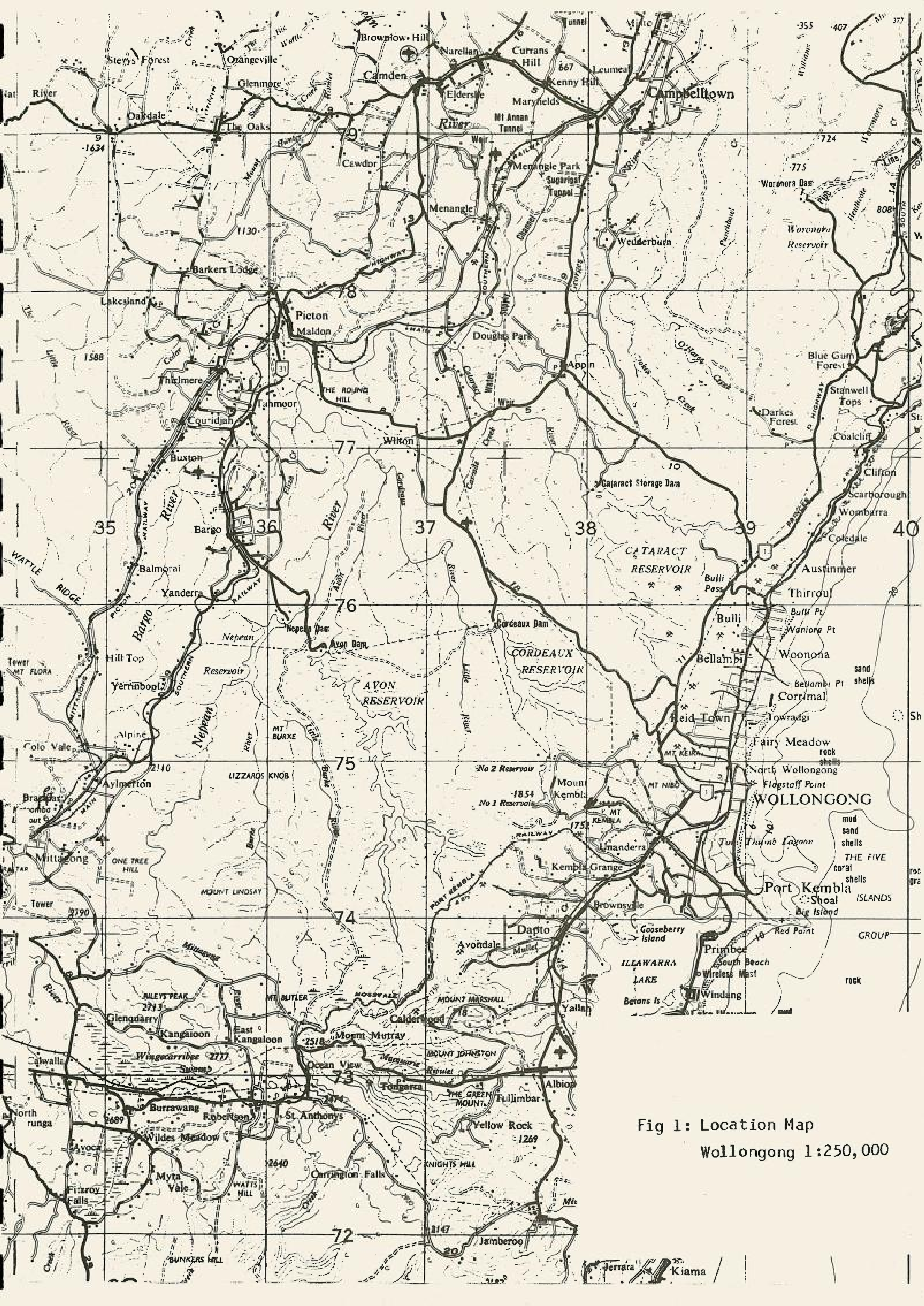


Fig 1: Location Map
Wollongong 1:250,000

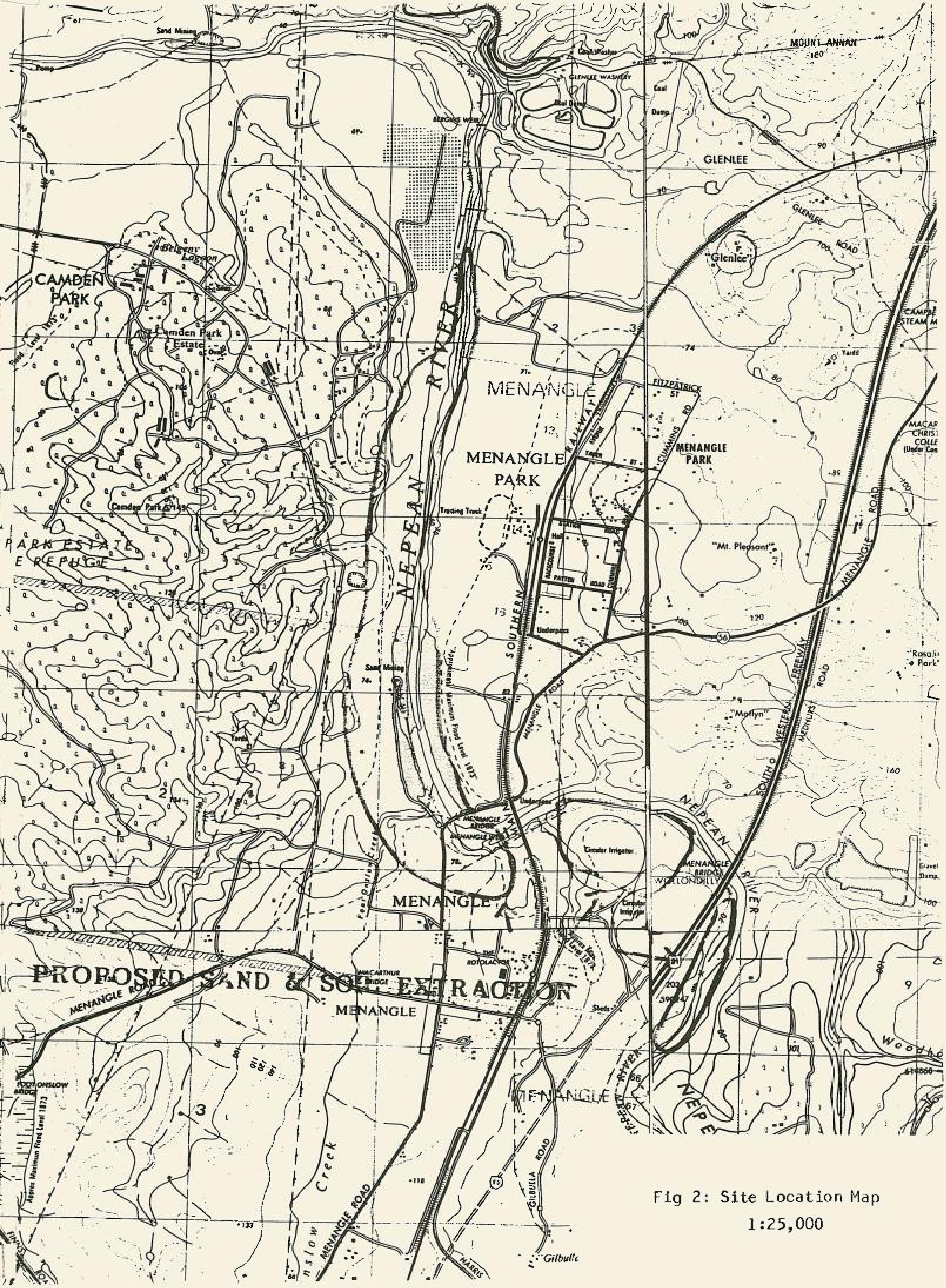


Fig 2: Site Location Map
1:25,000

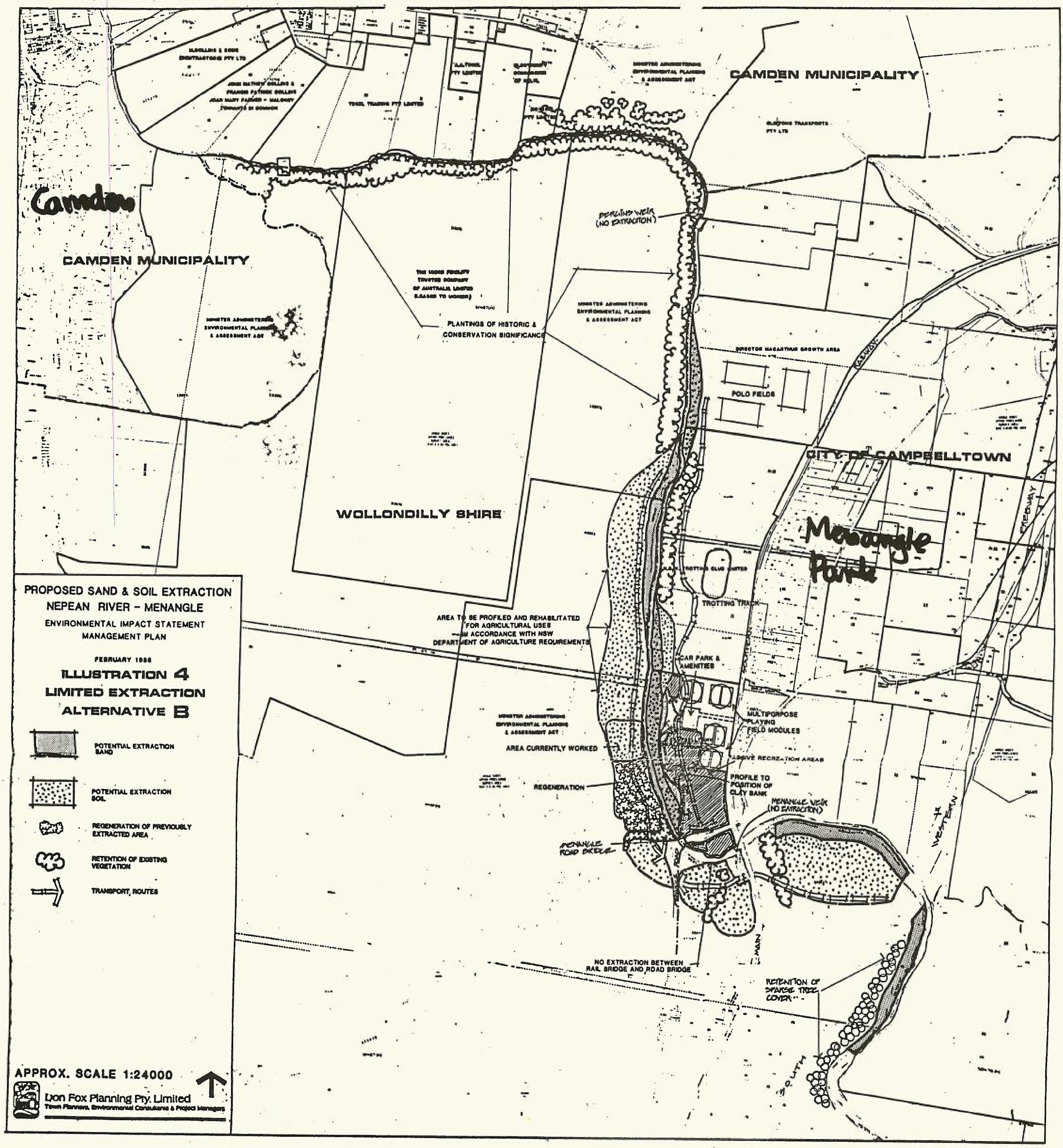


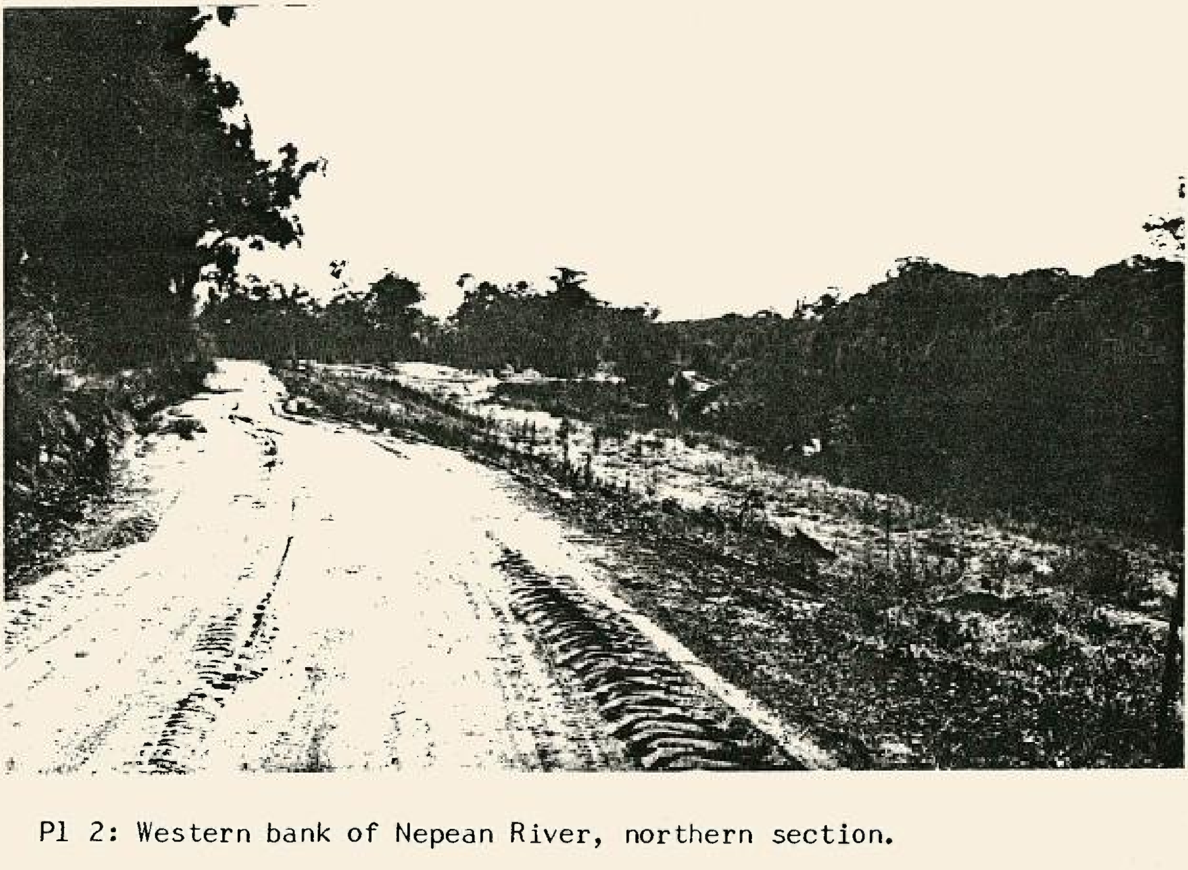
Fig 3: Areas of Proposed Extraction

planning workshop

APPENDIX VIII

Extraction and Rehabilitation Report

Pl 1: View south east of northern section of study area.



Pl 2: Western bank of Nepean River, northern section.

Pl 3: View north west, central section of study area.

REPORT ON EXTRACTION OPERATIONS AND
REHABILITATION AT THE
MENANGLE SAND AND SOIL SITE
FOR
MENANGLE SAND AND SOIL PTY LTD

Dames & Moore

TABLE OF CONTENTS

LIST OF FIGURES

REPORT ON EXTRACTION OPERATIONS AND REHABILITATION AT THE MENANGLE SAND AND SOIL SITE FOR MENANGLE SAND AND SOIL PTY LTD

1.0 INTRODUCTION

This report describes the proposed methods of operation and rehabilitation of the sand and soil sites operated by Menangle Sand & Soil Pty Ltd. It is based on information supplied by the Company, plus site inspections and discussions which several government departments and authorities, including the Department of Agriculture, Soil Conservation Services, Water Resources Department and Department of Environment. Submissions arising from a previous Environmental Impact Statement prepared by the Company have also been taken into account.

1.2 OBJECTIVES OF PROPOSAL

The purpose of the project is to continue exploitation of the soil and sand resources in the floodplain and bed of the Nepean River both upstream and downstream from the Menangle Bridge. The location of current and proposed operations is shown in Figure 1. The objective of the Company is to conduct extraction operations in an environmentally sensitive manner. The Company already operates soil and sand extraction operations on the site and has lease and other agreements to continue extraction.

Extraction operations have been undertaken on the site for many years. The current operators have consolidated various extraction agreements, cleaned up much of the previously extracted areas, and have instituted rehabilitation procedures aimed at producing a high standard of restored land in keeping with the local environment and historical significance of Camden Park Estate.

The rehabilitation objectives of the extraction operations are to restore the flood plain for agricultural uses, develop stable, attractive river banks in keeping with the surrounding area, and develop a clear, 50 m wide (average) stretch of the Nepean river.

1.3 OUTLINE OF THE PROPOSED DEVELOPMENT

The proposed operations will be conducted in several stages in different parts of the area. This is necessary to meet product specifications as well as lease conditions. The locations of the various stages are shown in Figure 1. Staged operations are already underway, and 'dry' extraction is proceeding in Stage 2. The stages are:

Stage 2	-	at present, on west flood plain of river
Stage 3	-	dredging operations
Stage 1	-	bridge area- dry extraction near gate to site
Campbelltown Council /Trotting Club	-	dry extraction on east side of river
Stage 6	-	dry extraction east of Menangle Road, south of river
Stage 7	-	dry extraction between railway line and freeway. (includes dredging)
Organimix site	-	relocation to near Stage 7.

Full details of extraction operations and rehabilitation measures are given in the following sections.

2.0 EXTRACTION OPERATIONS

2.1 INTRODUCTION

Two types of sand and soil extraction will be used in the recovery of the deposit. These are "wet" dredging in the river for sand and "dry" excavation for soil and minor sand production on the adjoining floodplains of the river.

Figure 1 shows the locations of the 'dry' extraction areas and locations for the 'wet' sand washing plant. The dredge will operate up to 600 m upstream and downstream from each wash plant site.

Soil is defined as all material ranging from black silty organic loam to fine dirty sand. There are minor quantities of fine to medium sand in banks which are readily identifiable as sand and can be extracted separately. All materials grade into each other.

2.2 WET EXTRACTION

Wet extraction is by means of dredging operations where a cutter suction dredge floats in the river.

The dredge is a purpose-designed pontoon fitted with a 120 kw diesel motor which operates the suction pump, cutter head, and other equipment. The cutter section head is lowered by wire rope to the river bottom and pumps water containing sand and other small debris laid down with the sand via a floating pipeline to an on-shore wash plant.

As part of the dredging process, and required as a condition of dredging by the licencing authorities, the river is 'de-snagged'. In this operation, large snags (tree trunk size) are hauled from the river by dozer (or equivalent) for on-shore disposal. It is estimated that 30% of timber is removed while the smaller snags remain at the bottom of the river as the suction action of the dredge cannot lift them. The dredge operator removes sand around these and they criss-cross on the bottom of the excavated channel.

In principle, the suction dredge operates somewhat like a large vacuum cleaner. All material that is large enough to be lifted by the pump is 'sucked' to the surface. Larger debris remains on a newly formed river bottom. In the process, there is disturbance of fines and waterlogged debris, which is not sucked into the dredge pipe, but settles out or is suspended in the river.

Once pumped ashore, sand is separated from debris and fines in an electric powered wet washing plant. A 134 kw Caterpillar diesel motor drives a generator which provides power for the plant. The main components of the plant are two wet screens to remove debris greater than 1/8" size. The -1/8" underflow passes into a box, where the sand/water mixture is agitated to separate the fines from the sand. The overflow containing fines is pumped to tailings ponds while the underflow containing the product sand is dewatered through two cyclones. The sand is then delivered to stockpiles, while the water is pumped to the tailings ponds.

The wastes from the washing plant, described above, consist of wood debris, and fines (very fine sand, silt, clay particles) in water. The wood debris is re-used in various organic mixers or soil/fills by the Company, and the wet fines disposed in the tailings ponds.

The tailings ponds consist of three small dams in series, approximately 10 m x 10 m x 2 m each in size. The first pond is cleaned out twice per week on average and the material blended with various products. The second pond is cleaned out at 6-12 month intervals, while the third at about 18 - 24 month intervals. The material is backfilled into dry excavated areas.

Water from the ponds cannot be discharged to the river. However make-up water is required for the wash plant, and waste water from the third pond is used. In some pond locations, water filters through the base of the ponds, is cleaned of suspended solids while filtering through floodplain deposits, and re-enters the hydrological system as clean water.

About 8% of water is incorporated with the product sand - a normal, commercially required and accepted practice. The remainder is recycled, eventually rejoins the river system as clean water, or is evaporated.

The life of a dredging set-up is about two years. The dredge and land-based wash plant is then moved to a new locality, and the surface site completely rehabilitated.

The reasons for the short life of each site are the relatively small sand reserves, the small capacity of the dredge at 400 tonnes per day average (maximum pump capacity is 600 tonnes per day), and limitation on pumpable distance between the dredge and wash plant of around 600 m maximum.

2.3 DRY EXTRACTION

Dry extraction occurs almost exclusively on the floodplain of the present water filled channel of the river. Several areas will be extracted simultaneously in order to produce the required soil blends. The locations of the extraction areas are shown in Figure 1.

Dry extraction is a sequential strip mining operation with four stages which progressively move across the selected mining area.

The four stages are:

1. Removal of top soil over a strip approximately 200 m along and 50 m wide.

2. Extraction of soil down to a pre-planned level, within a 50 m x 200 m strip.

3. Establishment of the final land profile by any combination of dozing, cutting and filling and grading on the previously worked out strip.

4. Establishment of ground cover two strips behind the working strip.

This form of operation means that at any one extraction site there is normally a moving area of disturbed ground up to 200 m x 200 m or 4 ha, depending on the state of re-growth on the last strip, and timing of top soil stripping ahead of excavation. Additional details are given below.

Prestripping

Topsoil is dozed off ahead of mining and stored in stockpiles for replacement in mined out areas. Topsoil is not sold. Experience with long term stockpiling to date has shown that seeds in the topsoil remain alive for periods considerably longer than three months. This is probably due to the porous nature of the topsoil, allowing air and water to move through the stockpiles, which do not compact excessively.

The normal pre-strip area is about 50 m by 200 m. This is sometimes reduced depending on the shape of the area to be mined, but is not exceeded. The topsoil is usually pushed into heaps by a dozer or similar equipment. It is not run over nor is it compacted by mobile plant.

Soil Extraction

A dozer or similar equipment pushes soil into a heap where a front end loader dumps it through a power screen to remove timber and other rubbish. The mobile stacker attached to the screen dumps screened soil into a product stockpile for sale or blending. As the operations advance, the mobile power screen and stacker are moved along the site.

Re-Profiling

The worked out areas need to be profiled in order to return the land to the designated final land-use. In some areas the final extracted surface will be the chosen profile. However in other areas, soil will be extracted from below the final profile and such areas will require backfilling. Backfill material will be weathered shales from the underlying Wianamatta Shale. This material will be stripped from designated areas within working strips. This is shown in Sections 11 (Stage 2) and 425 (Campbelltown Council) for example (Figures 3 and 6 respectively).

In Stage 2, additional shale will be stockpiled for use in backfilling strips further to the north. Quantities required have been calculated from sections drawn at 50 m intervals so that cut and fill quantities balance.

Once an area has been stripped and backfilled, as the case may be it will be prepared for revegetation.

Revegetation

This operation is explained in more detail in the following Chapter. As it is the last stage of the mining cycle, general comments are included here.

After the final profile is established, topsoil is respread and the site deep ripped across the slope. Banks will be constructed at the river side of the site to direct storm water to a prepared waterway.

The area is then disc ploughed and seeded with the appropriate mixture (see next Chapter). The preferred re-seeding time is Autumn to minimise the need for irrigation. While grasses are re-establishing, areas will be fenced to keep out stok and vehicles.

When the area has been re-established to the standard judged as satisfactory by the Agricultural Department and Soil Conservation Service, the land will become the responsibility of the Department of Agriculture.

2.4 STAGING OF OPERATIONS

The basic operating cell size is 50 m x 200 m as described above, and within each cell, one cycle of the mining process occurs. Actual operations have been designed to meet a number of criteria which include:

- The need to market saleable products from the resource
- The need to minimise temporary land disturbance during the mining cycle
- The need to preserve the existing river banks and vegetation as much as possible
- The need to improve the river channel in accordance with the requirements of the Department of Water Resources
- The need to minimise the visual impact both during and after mining
- The need to re-establish an agricultural land use and river environment consistent with the surrounding environment
- The need to avoid destruction of areas of historical significance.

These requirements are met with the operating plans developed for the six extraction areas. Details are explained below.

The Company must operate several sites simultaneously because different materials occur in each and many products are produced. The various areas, as shown in Figure 1 are separated from each other, and can each involve an area of disturbance of up to 4 ha at any one time. In mitigation, each operation is self-contained and small in extent so that there is no significant cumulative impact.

2.4.1 Current Operations

These are in Stage 2 and the Campbelltown Council/Trotting Club areas on the west and east banks respectively of the downstream part of the holdings.

2.4.2 Stage 2 Area

The Stage 2 operations plan is shown in Figure 2A, and two cross sections through the site in Figures 3 and 4.

Particular requirements of Stage 2 are to protect Barragal Lagoon, protect the west bank of the Nepean River, and minimise visual impact of operations viewed from Camden Estate.

Hydrological studies indicate that Barragal Lagoon does not have a hydraulic connection to the River through the soil deposit. Thus operations will not drain it. In addition, operations will encroach no closer than 50 m from the high water level mark, and the final profile will grade gently away from the lagoon to the river.

The present overflow channel is man-made according to old records, and the original channel around an adjacent hill to the next dry lagoon area north (and downstream) of Barragal Lagoon will restore the original drainage.

A river bank protection zone is planned along the west bank of the present water channel. This not only accommodates the requirements of the Water Resources Department for bank stability, but minimises visual impact, and helps screen operations.

Weathered shale will be stockpiled during Stage 2 for backfilling in the latter part of Stage 2. The stockpile, located as shown in Figure 2, will be built at a rate of 10,000 cubic metres per year for three years before being progressively removed for backfilling.

The shale has been selected for backfill because it is a more erosion resistant material than sand or loam in the event of a very big flood.

Backfilling is required because soil extraction is permitted to within one metre of the average low water level behind the bank. After extraction such excavation will be backfilled within a 4 week period, on average, to build the required bank height and profile.

The requirements for the finished banks are for a bank slope no steeper than 1:3 to three metres above low water level, then as a minimum, a slope as flat as 1:50 behind the bank and no steeper than 1:3.

With the Company's plan to preserve a buffer zone of the existing bank, these requirements will be met.

In addition as part of the rehabilitation process, drainage channels will be constructed along the boundary of worked areas to prevent water flow over the banks and erosion. Drains will feed to a concrete head and a pipe will direct run-off into the river. The porous nature of the soil means that there is little runoff during normal rain. The gradient of the channels will minimise channel erosion.

Properly constructed channels require minimal maintenance, and once areas are revegetated they will form the natural channels.

During extraction, banks and channels will prevent runoff entering the river. The final contours for the Stage II area are indicated in Figure 2B.

Stage 2 will be worked intensively while the Campbelltown Council/Trotting Club area will be worked at a slower rate in the years up to 1995. This will maximise retention of vegetation along the East bank of the Nepean River at a time when Stage 2 workings would otherwise be more exposed. This is because a section of the Stage 2 riverbank has very little vegetation that can act to screen operations. Stage II extraction will continue until around 1995.

2.4.3 Campbelltown Council/Trotting Club Area

This area is on the east bank of the river north of Menangle Bridge. A zone close to the river was worked some years ago and part of the area, rehabilitated. Other parts have natural re-generation over them. The area contains premium material and will be worked at a slower rate than Stage 2. The east bank contains much more vegetation close to the river bank, and it is also higher than the west bank.

Operations, while nominally able to proceed to within 3 m of the average low water level, will be limited to 5 m and on occasions more, in order to maximise the number of large trees that can be preserved. The self-imposed riverbank buffer zone will also apply.

Extraction has commenced in the Campbelltown Council/Trotting Club area around an eroded drainage channel from a pond, as required under conditions of the extraction agreement. This channel is being re-constructed by the Company. The pond overflow has been replaced by a concrete drop box and pipework to lead overflow under the site access road. On completion of the channel, extraction will proceed away from the channel as shown in Figure 5A, in both directions. This is necessary to satisfy extraction conditions. It is estimated that the site will be extracted and restored by around the year 2005 with most extraction between 1995 and 2005. The expected final profile is shown in Figure 5B.

The planned end use of the Campbelltown Council area has not yet been confirmed by Council. As a consequence the Company will restore a profile suitable for passive recreation and stabilise the surface with vegetation suitable for agriculture, as well as planting trees, which would be in accord with a possible passive recreation use.
The access road will remain for public access. The new profile, shown in Figure 6, provides for construction of a bank at 1:3 slope in resistant weathered shale down to the gently graded, restored surface which slopes at 1:40 to the river bank. Banks and drains will be constructed to prevent river bank erosion.

2.4.4 Stage 1 - Bridge Area

This deposit, previously unworked, adjoins a restored extraction area adjacent to the main gate and access road. Operations will commence on the west side away from view from the main road, and proceed through the hill, as shown in Figure 7A. The operations will leave a vegetation zone on a 7 metre high bank of Foot-Overlow Creek. The restored profile is designed to blend with the adjoining paddock, and slope down away from the main road. This is shown in Figure 7B. This deposit will not be worked in summer months if there is perceived to be a public reaction against extraction operations particularly during summer holidays. This proposal is to ensure that visitors to the nearby picnic area are not inconvenienced. Disturbed areas will be temporarily stabilised by grass cover during such periods.

It is anticipated that this area will be worked between 1988 and 1990.

2.4.5. Stage 3 Area

This is primarily a dredging operation commencing downstream of the Stage II dry extraction area and continuing downstream for 1160 metres to within about 200 metres of Bergins Weir.
In general the river will be widened to 50 metres while the bend near the end of Stage II will be straightened, giving a short length of river 60 metres wide.

New banks will be constructed by dredging and dozing in sand, and slopes will be 1:4 for the first 3 metres, then 1:5 above this. There will be minor cut and fill of the bank as the dredge line is laid along the bottom of the bank, but this will be re-shaped on completion.

Figure 13 shows a typical profile of the existing bank and the planned final profile. this indicates also the extent of sand above water level which will be excavated rather than dredging.

There is a requirement for the dredge to pass no closer than 18 m from the East bank.

The first site for the wash plant is shown in Figure 1. Former lagoons (now drained) will be the sites for the settling ponds. The access road will be constructed through the trees adjacent to the river, with priority given to preserving mature trees.

Dredging operations will commence in 1990-91 and continue until 1994.

2.4.6 Stage 6 Area

This area is on the east side of Menangle Road and adjacent to the picnic area on the river. It adjoins a newly built house, the owner of whom has indicated that operations will not unduly disturb him.

Operations will be set back 50 m from the main road, will work behind a high river bank and a bank protection zone. Operations are designed to avoid breaking through the bank until most of the deposit is extracted. When breakthrough does occur it will not affect the lower 7 m of bank. This will not only serve to protect the pool in the river, and the banks, but will retain the existing vegetation. Operations will be worked of a small scale during the period 1988 to 1966.

The operations plan is shown in Figure 9A, while final contours are illustrated in Figure 9B. Figure 10 is a cross section through the site, indicating the bank protection zone.

2.4.7 Stage 7 Area

This area adjoins the Nepean River between the Southern Railway and the South Western Freeway, and contains a significant resource of soil and sand.

The main activity will be soil extraction on the flood plain along with dredging of sand from the southern side of the river. The wash plant site is indicated on Figure 1.

As with other areas, a protection zone will be left along the river bank. A minimum bank height of 3 m will protect the existing bank, where sand is not to be extracted. The width of the protection zone will vary usually between 5 m and 15 m, depending on the steepness of the bank. The principle of increasing bank height where practicable, to preserve large trees will be applied.

The extraction plan is shown in Figure 11A. Operations will commence in the southwestern corner and will work northeast and east. This will minimise visual impact, protect the river, and provide a suitable range of materials for blending.

It is anticipated that operations will commence in the area around 1988, with maximum extraction in the years 1996 to 2020. Final contours are indicated in Figure 11B, while a profile through the deposit is shown in Figure 12.

The Company will transfer its Organimix blending site to the gently sloping hill along the southern edge of the area. Access will be via the Stage 6 and 7 access road. Two bridges, built to Council requirements will be constructed over two creek crossings.

3.0 MACHINERY AND EQUIPMENT

The following machinery and equipment will be used for extraction operations:

Wet Extraction

Dredge - diesel powered
Sand Plant (movable) - diesel/electric powered
Aquamator - portable sand washing plant diesel/hydraulic

This equipment is currently operating at the Company's Camden site, and will be transferred in 1990-91.

Dry Extraction

4 Wheeled Loaders
2 Wheeled Loaders to be transferred in 1990-91
1 Water truck (Second truck in 1990-91)
1 Farm tractor with attachments
3 Mobile power screen/stacker units
2 Mobile power screen/stacker units to be transfered to site in 1990-91.

Contract Equipment

Used on a casual basis for about one month per year.

1 Caterpillar D7 H series dozer
3 Dump trucks (25 tonne)
2 Excavators

The contract equipment is used to dig and move weathered shale.

4.0 QUANTITY OF MATERIAL TO BE EXTRACTED

Current annual production is approximately 220,000 tonnes. It is anticipated that production will increase to 400,000 tpa, with the transfer of equipment from the Camden site in 1990/91. The expected breakdown of products will be :

- 300,000 to 350,000 tonnes of soil and bank sand.
- 50,000 to 100,000 tonnes of dredged sand.

The total resource is approximately 7.7 million tonnes. This is made up of 5.9 million tonnes of soil and 1.8 million tonnes of sand. Further details are shown in Table 1.

TABLE 1
SOIL AND SAND RESERVES CONTROLLED BY
MENANGLE SAND & SOIL PTY LTD

BLACK, ORGANIC SANDY SILT	ORGANIC SILTY SAND	FINE TO MEDIUM GRAINED SAND	MEDIUM TO RIVER SAND
3.4 M Tonnes	2.5 M Tonnes	1.2 M Tonnes	0.6 M Tonnes

5.0 EXPECTED LIFE OF THE OPERATION

The reserves are expected to be largely worked out after 30 years.

6.0 DISPOSAL OF WASTE

Vegetation removed ahead of extraction operations or in river de-snagging will be windrowed and burnt when dry. Smaller organic material, screened from the raw product streams will be stockpiled and blended into the various mixtures produced by the Organimix operations.

Worn out equipment and similar materials will be removed from the site to an approved disposal tip.

Workshop wastes are removed by a garbage disposal service, while bath house wastes are directed to a septic disposal system.

No waste materials are buried on-site with the exception of some fines from the sand plant settling ponds which are used as backfill.

7.0 TRANSPORT OF MATERIALS AND ACCESS

All products and materials are brought on and taken off site by road transport. Access to the site is from the Menangle - Campbelltown road. The main access gate is beside the bridge over the Nepean River. Access to the East bank deposits is from the Campbelltown Road between the Nepean River and the railway line, while access to Stage 6 and 7 will be approximately 300 metres south of the main access gate, on the Menangle Road.

8.0 NUMBER OF PERSONS EMPLOYED

The present workforce comprises 16 personnel, including sales and office staff.

Contracting personnel numbers range between one and six for periods of one to three months.

9.0 HOURS OF OPERATION

It is intended that existing hours of operation will be retained, that is, 6:00 am to 5:00 pm (west and south side of the river) and 7:00 am to 6:00 pm (east side of the river).

10.0 STOCKPILING

The small scale of mining operations and the nature and variety of products created means that there is little scope for generating large stockpiles.

Occasionally the dozer may push up a raw soil stockpile of around 50,000 tonnes. This is damp material that is quickly screened and sold. The power screen/stacker stockpiles can reach 5,000 tonnes, but this is quickly sold. This means stockpiles rarely build to a size which could cause dust problems or be visually intrusive.

11.0 MANAGEMENT AND REHABILITATION

11.1 INTRODUCTION AND OBJECTIVES

The rehabilitation aspects of the project will be discussed in sequence from Stage 1 to Stage 7. It is not proposed that mining will follow sequentially from Stage 1 through to Stage 7. However, areas to be mined have been described and referred to elsewhere in the document by this nomenclature, so the practise will be continued.

The mining operation will remove substantial quantities of sand and soil from the bed and banks of the Nepean River. The rehabilitation of the mined areas will be undertaken progressively as each area is worked out.

The rehabilitation plan has a five fold purpose.

1. To rehabilitate land such that it may be returned to productive agricultural use. The policy which the Company has decided to adopt is that which applies to mining sites generally in New South Wales. That is that land should be rehabilitated to a standard so that its value to agriculture will be at least equal to that prior to mining.

2. To rehabilitate the mined land so that the soil surface is stable and erosion and pollution is minimised.

3. To rehabilitate the area such that the aesthetics of the site are not reduced in quality. This includes the removal from the site of all items of mining equipment and rubbish.

4. To rehabilitate with sensitivity for the historic nature of the property, Camden Park.

5. To forward plan the mining operation and the rehabilitation procedure so that potential problems are discussed and solved before they are allowed to develop.

The Company and its consultants believe these objections can be achieved.

The Company does not wish to alienate its neighbours or the citizens of the district and as such, intends to ensure its standard of rehabilitation is second to none.

11.2 STANDARD REHABILITATION PROCEDURE

Many practices are standard to all areas to be mined.

1. It is virtually known now each and every tree and shrub which will need to be removed prior to mining. An application will be submitted to the Catchment Areas Protection Board under Section 26D of the Water Act if any trees in the river bed or within 20 metres of the banks of the Nepean River are destroyed.

2. Trees and shrubs on land to be mined will be dozed out and wind rowed to allow complete destruction by burning when it is dry.

3. Topsoil to a depth of 200 mm will be dozed off the site and stockpiled.

4. After mining, the area will be reshaped to the planned landform (see cross sections).

5. Topsoil will be respread.

6. The site will be deep ripped across the slope to increase infiltration and reduce soil erosion.

7. On average two broad based graded banks will be constructed across the slope. These will direct storm water to a prepared waterway for discharge into the River. The banks will have a constant grade of 0.4%, a flat channel and adequate cross sectional area. Specific design criteria will be sought from the Soil Conservation Service prior to construction.

8. The area will be ploughed with disc harrows to achieve a fine seed bed and final land surface.

9. The area will be broadcast sown with a standard mixture of seed and fertilizer. There will be two periods in the year for sowing - spring and autumn. With this in mind (and considering seasonal conditions) the Company will forward plan areas to be revegetated to tie in with these periods. Autumn is the preferred season for sowing as a pasture sown in spring will probably require irrigation.

10. The rehabilitated areas will be fenced to exclude stock and unauthorised Company personnel and vehicles. Notices will be erected and staff encouraged to take an interest in progress.

11. After 12 months the area will be inspected by officers from the Soil Conservation Service of N.S.W. and the N.S.W Department of Agriculture. The success of the rehabilitation will be discussed

and the Company will undertake any further work deemed necessary, e.g. areas to be resown, topdressing, erosion control, weed control.

12. If after 12 months the standard of rehabilitation is judged satisfactory, in the case of Stages 1, 2 and 3, the land will become the responsibility of the owners of Camden Park Estate. No further mining of that area will be permitted.

These are the general procedures which will be adopted by the Company.

11.3 STAGING

11.3.1 Stage 1

A significant area of Stage 1 has been mined and rehabilitated. A crop of oats is flourishing and the land is ready for final inspection. The crop will be grazed and then sown with permanent pasture mixture in autumn 1988.

Erosion Control

A broadbased graded bank has been constructed at the change of slope. It discharges into a prepared waterway which has eroded in one section. This will be reshaped and couch turf laid to protect the soil.

The land between the graded bank and the river will be ploughed and resown in autumn as the proportion of weeds is unacceptably high. Tree planting by the company in this area has been successful; the trees will blend in with existing trees on the river bank.

The standard being aimed at for Stage 1 is agricultural land rated as Class 2 from Camden Park Estate through to the change of slope and Class 3 to the river bank. (Land class definitions have been taken from the Rural Land Evaluation Manual) i.e. land to the change of slope is suited to regular cultivation with a pasture rotation. The steeper land is suited to permanent improved pasture with occasional cultivation.

Part Stage 1 off Menangle Road

The high bank of soil to the west of Menangle Road and adjacent to the Company entrance will be mined in the future. This area is the only part of Stage 1 which has not yet been mined.

The bed of the creek which flows into the River will not be disturbed but the high banks will be reduced to a height of 3 metres.

The mining operation will extend about 150 metres into a paddock used by the Department of Agriculture. The rehabilitated landform will result in a more level land surface than presently exists. It will be suitable for cropping (Class 2) and will blend in aesthetically with the existing land form.

11.3.2 Stage 2

Stage 2 includes the area currently being worked.

The strip of vegetation approximately 20 metres wide along the river bank will be preserved. Topsoil has been stockpiled to a depth of several metres. The stockpile quickly revegetates and is respread when required. Because of the high sand content, infiltration is high and no surface sealing results. The Company is reluctant to carry the topsoil to areas undergoing rehabilitation for immediate respreading as stockpiles were successful in Stage 1.

The standard being aimed at for Stag 2 is Class 3. It is a relatively narrow strip of land (100 metres in places) and adjoins land being quarried by the Department of Agriculture and Barragal Lagoon. With a final slope of 2-3% and sufficient topsoil to apply a 200 mm layer, a high standard of rehabilitation will be easily achieved.

Barragal Lagoon

It is not intended to disturb any land within at least 50 metres of Barragal Lagoon. The Lagoon itself will not be affected in any way by the mining operation.

However, it is planned to construct a new spillway for the Lagoon around the side of the hill. This spillway will commence at the same point and be the same height as the existing spillway so that water levels will remain unchanged. The reason for a new spillway is that the present man made channel interferes with the proposed mine site, is ineffective and has no historic significance whatsoever.

Settling Ponds

The old settling ponds near the Lagoon spillway will be rebuilt for the proposed sand dredging operation in the river.

They are well sited on high ground with no potential problems from run off water or flooding.

Three ponds will be utilised - each being of 300 m^3 capacity. Pond No. 1. will be cleaned out twice weekly, No. 2. twice yearly and No. 3. every 2 years. Water from No. 3. will be used in the sluicing operation.

Material cleaned out of the settling ponds will be used for landfill in low areas after it has dried out.

11.3.3 Stage 3

Stage 3 entails a continuation of Stage 2 to the north for about 150 metres to a dense clump of trees. This timber will not be disturbed.

A small area near the river has been mined and rehabilitation has commenced. This is a short term stabilisation operation and is not intended to represent the final landform.

The bulk of Stages 3 and 4 entails dredging operations in the river, north to within 400 metres of Bergin's Weir.

11.3.4 Campbelltown Council/Trotting Club Area

This area is on the eastern side of the rive opposite Stages 1 and 2.

Soil was quarried from the area in the 1970's and rehabilitation was not undertaken with the degree of planning seen in Stage 1. The site illustrates a contrast in standards between what was acceptable in the 1970's and the 1980's (represented by Stage 1).

In the 1970's the aims of rehabilitation were to achieve an acceptable landform and stabilise the soil surface. These are still important aims today but with the additional factor of achieving pre-mine land capability.

The result is that this area has had little topsoil replaced and it is being used for low intensity grazing. The site is affected by moderately severe sheet erosion.

The consultants feel that by careful placement of topsoil together with strategically located erosion control works (especially graded banks), the area can be mined and rehabilitated to the upgraded Class 3 status.

The final landform will be a 2-3% slope towards the river with a short 1:3 slope (3 metres high minimum) along the eastern edge of the site.

Further to the east (towards the railway) tree planting will be undertaken to act as a visual screen from several houses beyond the railway.

Existing trees will be retained in a protection zone along the riverbank as discussed above.

11.3.5 Stages 6 & 7

These areas are located on the eastern side of Menangle Road to the south of the river. Mining will not encroach within 50 metres of Menangle Road.

The soil is deep, fertile alluvium well suited to growing improved pasture and crops for a dairy farming enterprise. As this is the case, the rehabilitation will be to a high standard. The most common final slope will be about 3% with two short batters of 6% and 10% around the margins.

It is anticipated that a Class 2 end product can be achieved by stockpiling sufficient topsoil and using techniques already explained.

11.4 REVEGETATION

For those areas to be restored to Class 2 status, a green manure crop will be planted initially. The aim of this is to build up soil organic matter, soil structure and fertility.

Sowing will take place as soon as practicable after final seedbed preparation, having regard to prevailing seasonal conditions. With a spring sowing, Cowpeas will be used. With an autumn sowing, oats or red clover will be sown.

At maturity, the green manure crop is ploughed back into the soil and a pasture mixture sown, preferable in autumn.

Recommended seed mixture:

Phalaris	2kg/ha
Rhodes grass	2kg/ha
Woogenellup sub clover	4kg/ha
Red clover	4kg/ha
White clover	2kg/ha
Kangaroo Valley rye grass	4kg/ha

Fertilizer - 250 kg/ha Grower 11

On areas where soil erosion may be a problem, a pasture mixture will be sown without a green manure crop. This will include the Campbelltown Council Area.

Recommended seed mixture:

Phalaris	2kg/ha
Rhodes grass	6kg/ha
Cough	1kg/ha
Sub clover	4kg/ha
White clover	2kg/ha

Fertilizer - 400kg/ha Grower 11 is applied as split applications 6 months apart.

Routine soil testing will be carried out to determine any specific deficiencies. Maintenance fertilizer will be applied after 12 months.

Critical Areas

Waterways, flumes and other critical areas will receive special attention. After shaping and topsoiling, couch runners will be planted and watered to obtain a quick soil cover. Water will not be discharged onto these areas until they are well vegetated.

Tree Plantings

The Company has an open mind on the re-establishment of trees.

While it may not be in the long term interest to plant trees on the Class 2 agricultural land, the wishes of the Department of Agriculture will be followed. The Company does intend to concentrate tree plantings along the river bank to reduce streambank erosion and to act as a visual screen from the river.

In the Stage 1 area which has been rehabilitated, 440 tree seedlings have been planted. The species include: River Oak, Bangalay, Cabbage Gum, Weeping River Gum, Blue Gum, Ribbon Gum, White Bottlebrush, Myall Wattle and Black Wattle.

12.0 ENERGY REQUIREMENTS

The operation of the existing facilities and proposed additional plant requires inputs of energy to power equipment and plant necessary for extraction and processing.

The main energy input is diesel fuel and oils for plant. Electrical consumption for office, workshop and freshwater pump is low.

Petrol consumption is limited to Company cars and is minor relative to diesel usage.

The current annual diesel fuel requirement will be approximately 468,000 Litres per annum when the dredge and sand washing plant is operational.

G E Holt

Peter Cowman & Associates

Dames And Moore

MENANGLE SAND AND SOIL PTY LTD

EIS 508

Proposed sand and soil extraction, Nepean River, Menangle

Borrower's name	Date	Ext

MENANGLE SAND AND SOIL PTY LTD EIS 508

Proposed sand and soil extraction,
Nepean River, Menangle