SPECIAL ENVIRONMENTAL PROGRAMME

CATCHMENT MANAGEMENT STUDY

WHITES CREEK SWC No 95

MAIN REPORT

AUGUST 1990

SPECIAL

ENVIRONMENTAL

PROGRAMME

WATER BOARD

THE NEW SOUTH WALES GOVERNMENT
Putting people first by managing better

WHITES CREEK SWC NO: 95

CATCHMENT MANAGEMENT STUDY

MAIN REPORT

August 1990

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INTRODUCTION

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1. INTRODUCTION

This report has been prepared in response to a brief and commissioning letter issued by the Water Board. The purpose of this report is to present a Catchment Management Plan for the Whites Creek Catchment (Figure 1.1). The purpose of the study, carried out over the period February to May 1990, as set out in the brief, was to:

> **"identify the physical characteristics of the catchment and its associated runoff regime and then establish a technical, planning and management framework within which the development of the catchment can be pursued to enhance the environmental, social and economic well-being of the local community"**

The study identifies and makes recommendations for works and measures aimed at:

- improving urban runoff water quality
- effective management of urban runoff flooding problems, and
- reducing environmental, social and economic costs of urban runoff.

Community input was sought during the study.

Whites Creek drains an area of 262 ha to Rozelle Bay as shown in Figure 2.1. The area is heavily built up, consisting mainly of semi-detached or terrace housing with some land used for commercial premises and light industries. The majority of the area (226ha or 86%) lies within Leichhardt Municipal Council, whilst the remainder (36ha or 14%), upstream of the Parramatta Road, lies within Marrickville Municipal Council.

The Board's drainage system consists of a 2300m length of main channel and four feeder pipelines, Piper St, Moore St, Styles St and Parramatta Road branches, with a total length of 1590m. The lower 1060 m length of the main channel consists of a reinforced concrete lined open channel with a bed width varying from 5m to 8m and depth between 1.4 and 2.0m. The upper reach of the channel consists of a covered concrete lined section with a bed width of 1.8 m to 2.5m and depth varying from 1.3 to 2.1m.

There is a limited system of Council drainage to the Board's system. Much of the stormwater runoff is conveyed in road side kerbs.

Computer modelling was used to establish flood flows for Average Recurrence Intervals (ARI) of 5, 20, 100 years and the Probable Maximum Flood (PMF) and determine the extent of flooding for each of these events.

These models were then used to evaluate various management options, based on approaches to urban drainage design established in the 1987 version of Australian Rainfall and Runoff (ARR), particularly in respect of capacity of drainage channels and overland flow paths. Computer modelling was also used to estimate the extent of pollutants transported by the stormwater system.

As it was shown during the course of the study that there was a significant overflow out of the northern part of the Whites Creek catchment into the Railway yards during major storm events (ie, ARI 5 years and above), a limited evaluation of runoff from an adjoining 65ha was carried out. This additional area is shown in Figure 2.1.

A damages analysis was carried out to determine the magnitude of losses sustained for each of the flood events.

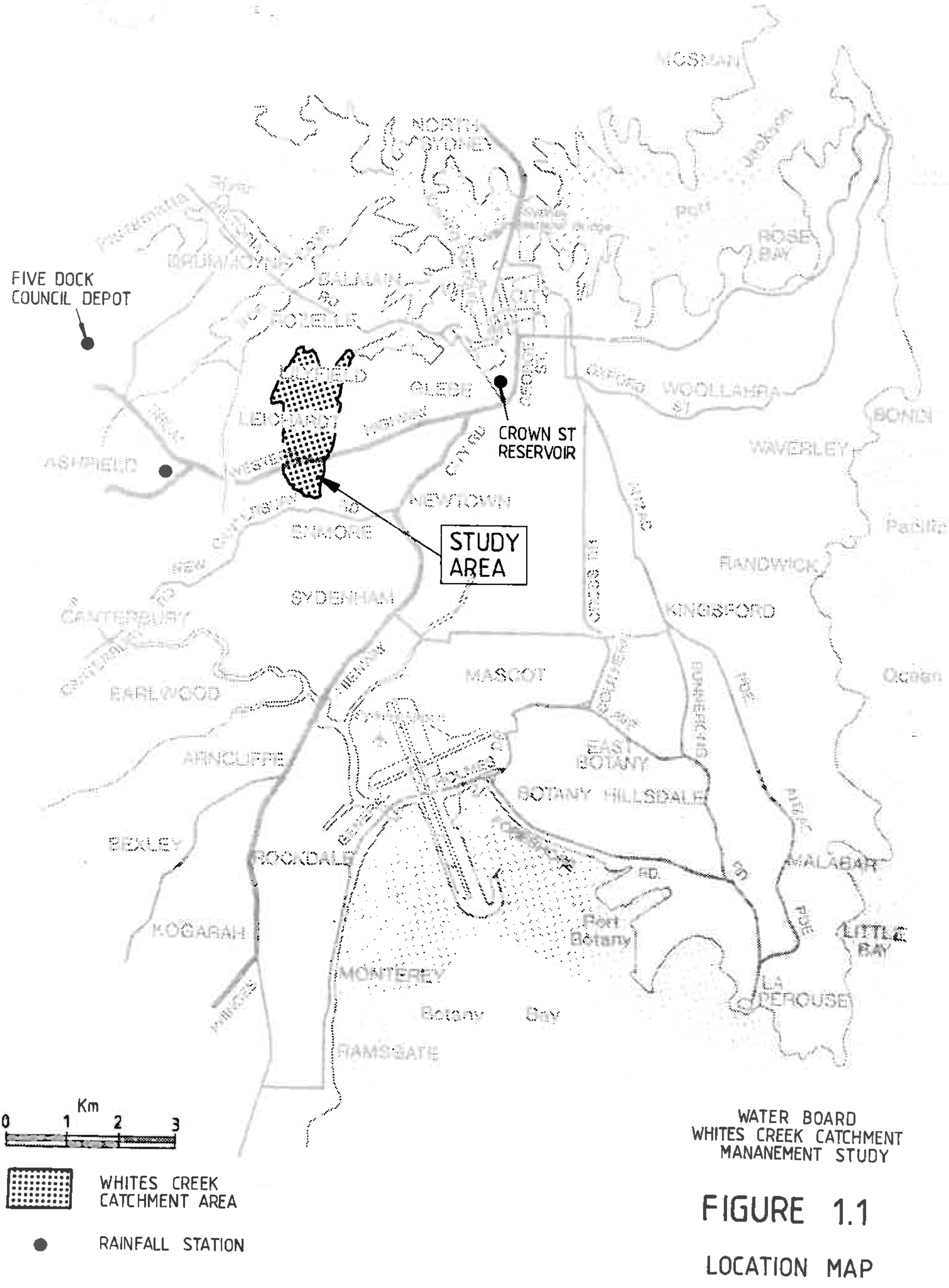
At the start of the study, data were collected on all aspects to be taken into account in formulating a catchment management plan and recommending improvement options. These included the environmental data such as flora and fauna, soils survey, land use and planning controls and proposals for future development, heritage and archaeological aspects, and existing drainage and sewer systems.

Contact was established with all public bodies which had an interest in the catchment, particularly the two Councils involved, to collate all relevant data, including proposals for developments within the catchment.

A key component of the study was to ensure public participation in the process of the study and obtain feedback to assist in the development of a Catchment Management Plan. To this end, at study commencement, a newsletter was delivered to all properties in the catchment area describing the study objectives and inviting comment. Subsequently, the major problem areas and public concerns were identified and meetings were arranged with small groups of concerned residents.

Towards the end of the study, two public meetings were held to inform residents and other interested parties of the preliminary study findings and obtain further input.

As the end result of the study, the recommended catchment management plan considers both structural and non–structural options and requirements for future management and maintenance of the drainage system.



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MANANEMENT STUDY

FIGURE 1.1

LOCATION MAP

SECTION 2

BASELINE DATA

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2. BASELINE DATA

In the early stages of the study data was collected from all available sources to provide the basis for the assessment of existing conditions and the formulation of improvement options.

2.1 Mapping and Topographic Data

Cadastral and topographic data is available for the study area at various scales and the coverage is shown in Figure 2.1.

Cadastral mapping at 1:2000 scale is available for the western and southern parts of the catchment. Leichhardt Council supplied cadastral mapping at 1:2500 scale for the remainder of the area. Cadastral mapping formed the basis for the figures in this report. Orthophoto mapping is available for all the catchment at 1:4000 scale, while most of the area is also available at 1:2000 scale.

The highest part of the catchment is just over RL 44 m (all elevations given in this report are to Australian Height Datum, AHD) at the southern end of the catchment in Temple Street, Marrickville.

The eastern boundary of the catchment runs along or close to Johnson St for much of its length with a maximum elevation of RL 28m. Land falls fairly steeply away from it to Whites Creek at slopes of from 1 in 12 to 1 in 15. Slopes on the western side of Whites Creek have slightly less steep slopes of from 1 in 15 to 1 in 20. Balmain Road runs parallel to, but within, the catchment boundary for much of its length, and the highest part of the boundary is just over RL 40m.

Flatter parts of the catchment are limited to the narrow strip adjoining the channel at its downstream end. The lowest part of the catchment is at RL 2 m beside the creek's outlet.

The north–western part of Whites Creek catchment is separated from the main part of the catchment by the railway.

During major storms, floodwaters by-pass the Whites Creek drainage system and drain directly to Rozelle Bay along the marshalling yards. This outlet collects runoff from a 65ha area as shown in Figure 2.1

2.2 Climate

Rainfall

The closest rainfall stations to the study area are shown in Figure 1.1 and are as follows:

Ashfield
Five Dock
Crown Street Reservoir

Humidity

Humidity is at a maximum near dawn but the minimum, which usually occurs at the time of maximum temperature, varies according to the season. In summer it is about noon, but in winter the minimum is two or three hours later (Bureau of Meteorology, 1979).

Wind

Within the region topographic relief and distance from the sea produce marked variations in wind speed and direction. The Sydney region's variation in average monthly wind speed throughout the year is small, ranging from 10.2 km/h in April to 12.4 km/h in November. The main wind direction at 9:00am and 3:00pm varies with season. In summer at 9:00am the main direction is northeast but in the other seasons, westerly or northwesterly winds predominate. At 3:00pm northeasterly or east–northeasterly winds predominate in all seasons, except winter when west–southwesterly winds are most frequent (Bureau of Meteorology, 1979).

2.3 Heritage

This component of the study was concerned with identification of significant environmental heritage items and precincts within the study area. The investigation made use of the two heritage studies commissioned by Leichhardt and Marrickville Municipal Councils as well as other register listings, for example, those by the National Trust. A comprehensive report on heritage issues is given in Appendix A.

The study area was first alienated in a series of land grants made between 1793 and 1819. They included small 15–30 acre farm allotments as well as the massive holdings of Major George Johnston's Annandale Estate, spanning both sides of Parramatta Road and encompassing most of the eastern portion of the study area.

During the 1820s a number of the earlier grants were consolidated and by the end of the decade the study area was primarily divided between the Annandale Estate, the Piperston Estate adjoining on the west, Hammond Hill Farm on the southern side of Parramatta Road and a few smaller, less significant allotments.

For most of the first half of the nineteenth century the study area was a country retreat for the wealthy landowners who established mansions and landscaped gardens on their properties. The distance from Sydney, the uncertainties of transport and the variable qualities of the land precluded other forms of more intensive settlement. However, during the economic crisis of the 1840s, the first subdivisions were made in the study area. The Piperston estate was put up for auction in forty–one allotments and was eventually bought largely by one man who renamed it Leichhardt. It was further subdivided in 1849.

The incorporation of the area as a municipality acted as a spur to closer and more intensive subdivision and settlement. The creation of new, reliable and improved transportation to and from the area made it viable as a dormitory suburb for Sydney and the area was rapidly sold and settled with villas, cottages and mansions, depending on the location of the property. The higher areas, the spines along which the principal streets of Annandale run for example, were favoured for the creation of wealthy villa developments. Lower down the slopes, towards the creeks, less opulent working class housing was established.

During the early years of the twentieth century, although land sales continued in the study area it, like the rest of the inner city suburbs, became stigmatised by deteriorating conditions and was labelled as a "slum". This tag remained until a revival of interest in the past heritage of the area was engendered by the arrival of a new population during the 1960s. The "gentrification" of the inner city encouraged the Councils to change their policies with respect to environmental planning and many older properties were saved and reused. During the 1980s a number of environmental studies were undertaken to systematically identify the heritage values of the area.

Investigations have identified large portions of the study areas as possible conservation areas, (Figure 2.2) particularly on the eastern side of White's Creek where the majority of Annandale has been incorporated in a conservation area listed in the LEP 20. The recent heritage study has proposed extending the boundaries of the conservation area though without formal ratification as yet. The entire eastern side of the White's Creek area has been identified as an Urban Conservation Zone by the National Trust of Australia (NSW).

A second conservation area has been recognised by the National Trust along Norton Street, Leichhardt, and the recent heritage study has also proposed to greatly extend the precinct to the north east. A third proposed conservation area exists in the extreme north–eastern portion of the study area.

On the southern side of Parramatta Road the National Trust has identified all of the western side of the study area up to Crystal Street but excluding the Parramatta Road frontage as an Urban Conservation area. The Marrickville Heritage Study recommended a number of conservation areas along Westbourne Street, Parramatta Road and in the same area as the National Trust. In addition, some outstanding streetscapes were recognised, generally within the conservation areas.

There are numerous individual items listed throughout the study area by the National Trust and the Heritage Studies, and some are listed within LEPs and the Register of the National Estate. A few are protected by instruments under the Heritage Act of NSW. The majority of these items occur along the major "spines" of the study area, in Annandale Street, Johnston Street and Catherine Street together with isolated examples throughout most of the study area. The items include houses, churches, schools, halls, fences, railings, hotels, industrial sites and soft landscape elements.

2.4 Land Use and Development Controls

The estimated resident population within Leichhardt at 30 June 1988 was 59,750. The average annual rate of population increase between 1981 and 1986 was 0.01%.

The estimated Marrickville resident population at 30 June 1988 was 85,750, and the average annual rate of decrease between 1981 and 1986 was 0.24% (Australian Bureau of Statistics, 1989).

Using the census districts that most approximate the Whites Creek catchment, the current total catchment population has been estimated at 13,300.

Land use in the two Council areas is shown in Table 2.1.

Leichhardt Planning Controls

The zoning controls in the Leichhardt Municipality are shown in Figure 2.3. The **residential** area is predominantly classified as "b2". According to the Municipality's Local Environmental Plan (LEP) this means that building or works on utility installations, drainage, open space and roads are only accepted on land Zoned Residential "b2" with development consent from the Council. Land zoned to **Special Uses** has the same restrictions. The area zoned **Open Space** requires development consent for any recreation area, roads and utility installations.

Areas stipulated as **Conservation** Areas (Figure 2.2) in the Leichhardt LEP require Council's consent before demolition, renovation or erection of a building or work where visible from a public place. The objective is to retain the existing late nineteenth and early twentieth century townscape by ensuring that any alterations are sympathetic with existing buildings.

TABLE 2.1

LAND USE

LAND USE	LEICHHARDT		MARRICKVILLE		TOTAL CATCHMENT	
	Area (ha)	% of total	Area (ha)	%	Area (ha)	%
Residential (houses)	113.1	50	19.7	55	132.8	51.0
Residential (units)	11.3	5	0.4	1	11.7	4.4
Commercial	11.3	5	3.6	10	14.9	5.7
Industrial	11.3	5	1.10	3	12.4	4.7
Roads	56.6	25	9.0	25	65.6	25.0
Open Space	9.0	4	0.4	<1	9.4	3.5
Special Uses	6.8	3	1.8	5	8.6	3.2
Railways	6.8	3			6.8	2.5
TOTAL:	226.2	100	36	100	262.2	100

Items of **Environmental Heritage** (Figure 2.2) are protected such that no one can demolish or renovate the building or work, nor damage the relic or any part of the relic without Council's approval such that the exterior appearance of the building or work must be sympathetic with the surroundings.

A building or work within the **Foreshore Scenic Protection Area** (Figure 2.2) is not allowed if visible from a public place unless it has consent from the Council.

Marrickville Planning Controls

The Marrickville Municipality Local Environmental Plan (LEP) also contains zoning controls and regulations that restrict development (Figure 2.3). Buildings or works of relevance such as roads, utilities, drainage facilities, parks and gardens, and recreation areas cannot be carried out without the consent of the responsible authority for Zone 2a – Dwelling Houses, Zone 2b2 – Dwelling Houses, Zone 3a – General Business and Zone 4c Local Industry.

The only relevant works or buildings that are allowed with consent from the responsible authority for Zone 3c – Automotive Business are recreation areas and utility installations. The special uses Zone – 5a allows roads and utility installation with consent but no others. Zone 6a – Open Space allows works for the purpose of gardening and landscaping without consent but for the purposes of drainage, recreation areas, roads and utility installations, consent is required.

Conservation areas are stated in the Marrickville Heritage Study and not in the LEP. After meeting with Council members it was concluded that these areas have statutory significance only but are still used in relation to development proposals.

A guideline to development proposals is given in the National Trust Conservation Area definition. A further restriction placed on development occurs with buildings or works classified as Items of Environmental Heritage. In all these items a person is not allowed to make alterations or additions to the land, building or work, or demolish a building or work without the consent of the responsible authority.

Future Development Proposals

When developing a catchment management plan that aims to mitigate flooding and improve quality of runoff, future development potential and proposals are of interest. After discussion with Council members and staff it was found that development of a few areas is being considered, as described below.

The potential for development suggested as being likely by both Municipalities would be small scale but still important to drainage. It includes public and private garden development and resurfacing, together with first floor additions, refurbishment, extensions, new garages and fence replacement.

It is still not known if and how the railway corridor in Leichhardt will develop. Leichhardt's SRA depot, to the south of the railway line, is a large area zoned for Special Use. It was suggested by Council members that the area has significant development potential; as well, some of the remaining isolated pockets of Leichhardt's industrial land where the industry is not concentrated may change to residential.

Leichhardt Council

In 1989 approximately 130 building applications were received by the Leichhardt Council for the Whites Creek area. Discussions with Council members revealed that first floor additions are the most common (60–70% of building applications are additions and ground floor alterations) while the addition of a garage (20–30% of building applications) and the alteration of dwellings into dual occupancy are also common. Councils have no control over resurfacing of land in private holdings as a building application is not required. A tree planting program existed between 1971–74 but since then trees have only been planted on the request of residents.

Current proposals submitted to the Leichhardt Municipal Council include the Italian Forum project, Whites Creek open space and the Link Road. The Italian Forum project is a 12,000m^2

commercial development situated off Balmain Road on the Water Board site. Vacant land has been proposed for rezoning to open space to include a pedestrian and cycle path and passive recreation area (attractive landscaping with toddlers' play area and paved area for skateboarding).

The proposed City West Link Road will be a major arterial raised road that generally parallels the Railway Parade and Brennan Street. Other proposals include a Motor Auctions site off Balmain Road, and Department of Housing Units along a portion of White's Creek Lane.

Marrickville Council

For parts of the Marrickville Municipality that fall within the catchment, Council members suggested that there was potential to redevelop Taverner's Hill Public School. There is also the possibility of a car park between Charles, Crystal and Margaret Streets.

Recent proposals submitted to the Marrickville Municipal Council include a 5,500m^2 development application for office blocks on the corner of Parramatta Road and Phillip Street and a 1,403m^3 development application for offices on the corner of Parramatta Road and Railway Street.

2.5 Drainage System

The system is depicted on Figure 2.4 and details are provided in Table 2.2. The Board's drainage system consists of a 2300 m length of main channel with four feeder pipelines, Piper St, Moore St, Styles St and Parramatta Road branches, with a total length of 1590m.

The lower 1060m length of the main channel consists of a reinforced concrete lined open channel with a bed width varying from 5m to 8m and depth between 1.4 and 2.0m. The upper reach of the channel consists of a covered concrete lined section with a bed width of 1.8 m to 2.5 m and depth varying from 1.3 to 2.1m.

The system was constructed in stages and completed in the late 1930's.

TABLE 2.2
DETAILS OF DRAINAGE SYSTEM

Line	Chainage m	Bed Width m	Depth m	Side Slope Vert:Hort	Pipe Diameter mm	
Open channel	0 - 510	8.3	1.37	5:1	-	
Open channel	510 - 876	7.0	1.37	5:1	-	
Open channel	876 - 1064	5.0	1.83	5:1	-	
Covered section	1064 - 1156	2.4	1.98	5:1	-	
"	1156 - 1212	1.8	2.06	5:1	-	
"	1212 - 1358	1.4	1.98	4:1	-	
"	1358 - 1545	2.3	2.13	24:1	-	
"	1545 - 1611	2.4	1.98	14:1	-	
"	1611 - 1741	1.9	1.83	26:1	-	
"	1741 - 1821	1.8	1.45	24:1	-	
"	1821 - 1855	2.1	1.75	110:1	-	
"	1855 - 2032	2.1	1.52	5:1	-	
"	2032 - 2156	2.1	1.32	5:1	-	
"	2156 - 2204	1.8	1.30	-	-	
"	2204 - 2291	1.8	1.30	-	-	
Piper Street Branch	0 - 54	-	-	-	600	
Moore Street Branch	0 - 73	-	-	-	1050	
	73 - 86	1.2	0.81	-		Box culvert
	86 - 111	-	-	-	1050	
	111 - 123	1.1	1.05	-	-	Box culvert
	123 - 352	-	-	-	1050	
	352 - 495	-	-	-	900	
Styles Street Branch	0 - 75	-	-	-	1050	
	75 - 88	1.2	1.07	-	-	Box culvert
	88 - 317	-	-	-	1200	
	317 - 412	-	-	-	1050	
	412 - 519	-	-	-	900	
	519 - 711	-	-	-	750	
Parramatta Rd Branch	0 - 310	-	-	-	450	
	310 - 333	-	-	-	400	

Open Channel

There is a limited floodplain adjoining the open channel section mainly allocated as recreational reserve, with a width varying up to a maximum of 75m at Cohen Park. The open channel is bridged at Piper St and Brennan Road and is confined on the left bank downstream of chainage 400m by the railway embankment, while at chainage 180m the channel passes through a tunnel under the railway. At this point the only passage available for overbank flood flows is Railway Parade where it passes under the railway bridge. Plate 2.1 shows the open channel near the downstream end and Plate 2.2 shows the tunnel under the railway line.

Modifications to the outlet to Rozelle Bay are being made as part of the works for the new City West Link Road being undertaken by the Roads and Traffic Authority. The works consist of providing a new section of channel of the same capacity as that existing, to discharge to Rozelle Bay some 13m south of the existing. The open channel section is subject to tidal flow. The concrete lining to the open section is in fair condition throughout with numerous cracks.

Covered Channel

The covered section is located under Whites Creek Lane, except for a length of 60 m which passes under private property. The channel cover forms part of the roadway for the upper section where the lane width is restricted to 6m. For the remainder, generally with a width of 10m, vehicular movement and parking is discouraged by the use of logs.

Plate 2.3 shows the covered channel and Plate 2.4 shows the junction of Clark Street and Whites Creek Lane (a drainage problem area – see Section 3).

Pipelines

The Piper Street branch is the shortest of the feeder pipelines being only 54m in length and 600mm in diameter.

The Moore St branch is 495m in length with a diameter varying from 900 to 1050mm. It commences at Ainsworth Road, passes along a short length of laneway, then under the War Memorial Park.

The Styles St branch consists of a 711m length of pipeline with a diameter varying from 750 to 1200mm diameter.

The Parramatta Road branch is 333m long and mostly 450 mm diameter.

Council Drainage System

There is a limited amount of Councils' drainage system discharging to the Board's system. Throughout much of the area stormwater runoff is conveyed in road side kerbs to the Board's system.

The underground drainage system in Marrickville collects stormwater north of the Parramatta Road and is connected to the Board's main drain and the Parramatta Road branch.

Within Leichhardt Municipality, the most extensive underground system connects with the Board's drain at the junction of Hearn Street and Albion Street. Another system drains the north-western part of the catchment under the SRA land (through a 1.5m diameter pipe) to discharge to the Board's system at the corners of Brennan Street and Railway Parade.

The remainder of Leichhardt's system consists for the most part of isolated short pipe lengths, generally less than 100m in length discharging at various points along the length of the Board's drains.

2.6 Sewer System

The major elements of the sewer system rising mains and overflow points are shown in Figure 2.4. The most notable feature of the system is the aqueduct which conveys the sewer line over Whites Creek near Piper Street. Local residents report leaks from this aqueduct.

2.7 Water Quality

Prior to the study commencement, no water quality data were available for the Whites Creek catchment. As part of this study, limited sampling and analysis was carried out at the points shown in Figure 2.4 at various stages of storm runoff and during dry conditions. The results are shown in Table 2.3, where the measured parameters are compared with typical urban values and desirable limits recommended by the State Pollution Control Commission (SPCC, 1989).

The results are in line with typical urban runoff concentrations, and higher than "desirable" dry weather quality. Generally, the concentrations of heavy metals are higher than typical values.

Four sewer overflow points have been identified by the Water Board and these are shown in Figure 2.4.

2.8 Refuse Collection and Street Cleaning

Leichhardt Council's Cleansing section services 240 km of streets and lanes with a complement of 42 employees. A statement of the current status of street cleansing in Leichhardt is given in Appendix B.

Marrickville Council's cleansing department services 247km of street with a complement of 80 staff, 2 street flushers and 3 mechanical cleaners and has won 2 awards in the "Keep Australia Beautiful" campaign. $5.7 million was spent on cleansing last year. 240L bins have been introduced (resulting in an increase of 36% in collection weight). Free collection of garbage is by request and results in 500–800 collections each week. There is also a weekly collection of recyclables, such as glass and paper.

2.9 Soil Survey

A soil map is shown in Figure 2.5, using information provided by the Soil Conservation Service.

TABLE 2.3
WATER QUALITY ANALYSIS

	Units	Desirable Dry Weather Quality	Typical Urban Runoff Concentrations	Site A 03.02.90 10.00 am	Site B 03.02.90 10.15 am	Site A 07.02.90 5.15 pm	Site B 07.02.90 5.30 pm	Site A 14.02.90 8.00 am	Site B 14.02.90 8.30 am	Site A 17.02.90 5.00 pm	Site B 17.02.90 5.25 pm	Piper St Bridge 07.02.90 5.00 pm	Site A 09.04.90 12.40 pm	Site B 09.04.90 12.20 pm
				During long duration storms				Dry Weather		First Flush			End of Storm	
Tot. Kjeldahl N.	mg/L					4.1	1.4			5.1	7.6	3.5	2.24	3.74
Ammonia	mgN/L					<0.05	<0.05	0.4	0.1	0.65	0.79	0.16	<0.05	0.09
Nitrate	mg/L					29.6	13	16.3	9.9	<0.2	<0.2	<0.2	8	4
BOD	mg/L	<2	10–60					5	4	30	47	98	1.5	<0.1
Suspended Solids	mg/L	(<10) (<50 wet)	150–650	71	76	31	25	42	7	285	145	1710	15	10
E. Coli	Count/ 100mL	<200	10^3–10^6			3600	4000	<1000	600	90000	1500		45000	>300
Faecal Streps	Count/ 100mL	1	1–10			70	50			>100	>100		39000	>300
Oil/Grease	mg/L	<1	1–10	8	8	5	4	18	55	8	8	5	<5	<5
Turbidity	NTU					27	16	27	6	32	5.2	25	6	6.5
Total Phosphorus	mg/L	<0.5	0.5–3.0			0.29	0.41	0.25	0.3	0.6	0.9	0.4	2.5	2
Copper	mg/L	<0.001	0.04			0.1	0.1	0.2	0.1	1.05	0.23			
Iron	mg/L					0.5	0.6	5.9	0.9	83	2.29			
Cadmium	mg/L	<0.0004	0.006			0.03	0.04	0.05	0.07	0.04	0.05			
Lead	mg/L	<0.025	0.2			0.3	0.2	0.3	0.2	1.22	0.35			
Chromium	mg/L	<0.001	0.17			0.1	0.1	0.1	0.1	0.08	0.15			
Zinc	mg/L	<0.125	0.2			0.5	0.4	0.4	1.9	4.75	3.95			
Nickel	mg/L					<0.2	<0.2	<0.2	<0.2	0.11	0.06			
Naphthalene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			

	Units	Desirable Dry Weather Quality	Typical Urban Runoff Concentrations	Site A 03.02.90 10.00 am	Site B 03.02.90 10.15 am	Site A 07.02.90 5.15 pm	Site B 07.02.90 5.30 pm	Site A 14.02.90 8.00 am	Site B 14.02.90 8.30 am	Site A 17.02.90 5.00 pm	Site B 17.02.90 5.25 pm	Piper St Bridge 07.02.90 5.00 pm	Site A 09.04.90 12.40 pm	Site B 09.04.90 12.20 pm
Acenaphthylene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Acenaphthene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Fluorane	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Phenanthrene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Anthracene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Fluoranthene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Pyrene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Benzo(a) anthrace ne	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Chrysene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Benzofluoranthene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Benzo(a)pyrene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Indeno(123-cd) pyrene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Dibenso(ah) anthracene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Benzo(ghi)perylene	ppm					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Total PAH's (poly-aromatic-hydrocarbons)						<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Endrin	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
Lindane	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
Methoxychlor	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
Dieldrin	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
Aldrin	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
BHC	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
Oxychlordane	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			

	Units	Desirable Dry Weather Quality	Typical Urban Runoff Concentrations	Site A 03.02.90 10.00 am	Site B 03.02.90 10.15 am	Site A 07.02.90 5.15 pm	Site B 07.02.90 5.30 pm	Site A 14.02.90 8.00 am	Site B 14.02.90 8.30 am	Site A 17.02.90 5.00 pm	Site B 17.02.90 5.25 pm	Piper St Bridge 07.02.90 5.00 pm	Site A 09.04.90 12.40 pm	Site B 09.04.90 12.20 pm
Heptachlor	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
Hept. Epox	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
HCB	mg/L					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			
DDD	mg/L					<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
DDE	mg/L					<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
DDT	mg/L					<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
Total PCB's						<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			

2.10 Flora and Fauna

The study area was assessed by combining information gained from a ground survey, consultation with National Parks and Wildlife Service, and consultation with the Parks Engineer from Leichhardt Council. The Whites Creek catchment is a very densely populated urban area with, approximately only 4% devoted to open space. The nature of the flora and fauna can be said to be typical of urban areas and vegetation within the catchment can be broken up into street vegetation, household vegetation and public parks or open spaces.

The street vegetation found along the side of the pavements and on the roads included Broad–leaved Ironbark *(Eucalyptus fibrosa)*, Brushbox *(Tristania conferta)*, Smooth Barked Apple *(Angophora costata)*, Bottlebrush *(Callistemon citrinus)*, Lombardy Poplar *(Populus nigra)*, Peppercorn *(Schinus molle)*, and a hybrid shrub Robyn Gordon Grevillea *(Grevillea x* Robyn Gordon). These play a role in the overall catchment drainage. The plants may take up large quantities of water and some nutrients but they can also have some detrimental affects. Leaf litter and twigs not cleaned up can add to the nutrient status of the receiving waters. The rootstock can also disrupt roads, pavements and underground services increasing Council maintenance costs.

Household vegetation in the form of residential gardens also plays an important role in the catchment drainage, although the area is very densely populated and as a consequence the number and size of the gardens is very small. Again leaf litter, grass clippings and other vegetative litter will add to the nutrient status of the receiving waters. Gardens have another important impact on the catchment in terms of the water quality, in that additions of pesticides, fertilisers and other chemicals eventually find their way into the watercourse thereby polluting the receiving waters. These residential gardens contain a very wide variety of species from the grasses for lawns to many different tree species.

The catchment contains few large areas of open space or parklands (Figure 2.3), the main ones being War Memorial Park on the corner of Catherine and Moore Street; Cohen Park on the corner of Hudson Street and Whites Creek stormwater channel; and between Whites Creek Lane and Styles Street. There are a number of smaller open spaces in the catchment which are concentrated around Whites Creek channel. The parks are used for residents' recreation and as a consequence have a large proportion of the area grassed with no more than 10% of each park consisting of landscaped garden. The species found include Blackbutt *(Eucalyptus pilularis)*, Red Bloodwood *(Eucalyptus gummifera)*, Tallowood *(Eucalyptus microcorys)*, Broad Leaved Ironbark *(Eucalyptus fibrosa)*, Forest Oak *(Casurina torulsa)*, Swamp Oak *(Casurina glauca)*, Brushbox *(Tristania conferta)*, Peppercorn *(Schinus molle)*, Gossamer Wattle *(Acacia floribunda)*, Green Wattle *(Acacia decurrens)*, Broad leaved Papperbark *(Melaleuca quinquenervia)*, Date Palm *(Phoenix canariensis)*, Lombardy Poplar *(Populus nigra)*, Port Jackson Fig *(Ficus rubiginosa)*, Common Red Bottlebrush *(Callistemon citrinus)*, and a prostrate hybrid Shrub Royal Mantle Grevillea (*Grevillea x* Royal Mantle).

The fauna of the area depict a typical disturbed urban site containing few residual native species. The mammals included the domestic dog (*Canis familiaris*) and cat (*Felis catus*), Black Rat (*Rattus rattus*), Brown Rat (*Rattus norvegicus*) and the House Mouse (*Mus musculus*). Following consultation with National Parks and Wildlife Service the site is not known to have any formal roosting sites or movement corridors for birds or bats. The Service did however suggest that there was a likelihood of movement corridors within the catchment. If the corridors did exist they would utilise that provided by the Whites Creek Channel and adjacent open space.

2.11 Archaeology

Dr Helen Brayshaw carried out a survey for aboriginal sites and reported that there is no record of any aboriginal sites being found within the Whites Creek catchment. The absence of any aboriginal sites was confirmed by Dr Val Attenbrow at the Australian Museum, whose current area of research includes the Whites Creek catchment. A copy of her letter is reproduced in Appendix B.

There will be no constraint on modifications to the drainage system arising from Aboriginal sites.

2.12 Flood Damages

No information was available on historical flood damages within the catchment. Therefore an analysis of potential damages was carried out and is described in Section 6.

PLATE 2.1 OPEN CHANNEL NEAR DOWNSTREAM END

PLATE 2.2 RAILWAY OVERPASS

PLATE 2.3 COVERED CHANNEL, WHITES LANE

PLATE 2.4 CLARKE STREET

SECTION 3

PARTICIPATION BY COMMUNITY & GOVERNMENT ORGANISATIONS

3. PARTICIPATION BY COMMUNITY AND GOVERNMENT ORGANISATIONS

3.1 Study Publicity

In order to ensure that community concerns were taken into account, publicity was arranged soon after study commencement. A Newsletter was prepared and distributed to households in the catchment area. The Newsletter included translations of a summary statement in 6 languages, Chinese, Italian, Greek, Arabic, Spanish and Vietnamese. The recipients were invited to return a form with their comments on the Whites Creek drainage system and its problems. A copy of the Newsletter is reproduced in Appendix C.

29 responses were received. From the responses to the initial Newsletter, five specific problem areas were identified:

Hearn Street – where frequent inundation of properties occurred due to inadequate drain and inlet capacity.

Clarke Street – where some houses were subject to frequent inundation due to a combination of their low elevation, inadequate drain and inlet capacity, lack of overland flow capacity and their location at the junction of the two drainage lines.

South Avenue – where property is subject to frequent inundation due to a combination of their low elevation and inadequate drain and inlet capacity.

White Street – where residents of the newly constructed Housing Commission unit blocks expressed concern about potential flooding, their children's safety and water quality.

Catherine St – where frequent inundation of properties occurs due to inadequate drain and inlet capacity.

These areas are identified in Figure 3.1 Responses with comments not related to these specific problem areas were spread over the catchment.

The most common issue mentioned by respondents was flooding, covering matters such as damage to property, effect on cars and access to cars, the expense of repairs to property, and general inconvenience. One half of the respondents mentioned flooding as a concern, and the large majority of these had been personally affected, often seriously.

3.2 Liaison With Government Organisations

The following organisations were contacted during the course of the study:

Leichhardt Council
Marrickville Council
State Rail Authority (SRA)
Road Transport Authority (RTA)
State Pollution Control Commission (SPCC)
Dept of Housing
Maritime Services Board (MSB)
Public Works Department (PWD)

These organisations were contacted in order to:

- familiarise them with the study objectives,
- collect from them information relevant to the study,
- ascertain the particular interest which they had in the catchment
- determine whether they had any future plans which ought to be taken into account in formulating the catchment management plan

Details of key contact personnel and others contacted as part of specialist study investigations described elsewhere in this report are given in Table 3.1.

Both Councils were very supportive of the study and provided information on their drainage systems, planning procedures, street cleansing and garbage collection procedures and also assisted with establishing contacts with the local community.

The **Roads and Traffic Authority's** City West Link Road, under construction during the currency of this study, involves alterations to the outlet of Whites Creek into Rozelle Bay. These alterations involve realigning the channel below the railway bridge with a new outlet and the width of the new channel is similar to that existing although it has a steeper slope. Railway Parade east of the railway bridge will become redundant.

The **State Pollution Control Commission** does not have any information on Whites Creek, although it is keen to see water quality monitoring programmes set up on urban drainage systems. The SPCC has recently produced the "Pollution Control Manual for Urban Stormwater" (1989) which provides guidelines for urban water quality (see Section 4.4).

The **Department of Housing** has an interest in the catchment by virtue of recent construction of a large block on Whites St. As discussed in Section 5, several residents of this development are concerned about a number of issues related to Whites Creek, including flooding. The land was previously used for industrial purposes.

The **Maritime Services Board** has responsibility for Rozelle Bay into which Whites Creek discharges. It, together with many other Government departments contacted and under the auspices of the Dept of State Development is participating in the development of a Regional Strategy for a wider area including Rozelle Bay. The Strategy is expected to be finalised later in the year and is likely to involve the use of the significant areas of foreshore presently owned by the Government.

The **Public Works Department** has been promoting a marina and associated recreational complex along the banks of Rozelle Bay and an Environmental Impact Statement has been prepared for it (PWD, 1987).

3.3 Public Meetings

Following the initial Newsletter, and meetings and contact with the various public authorities, work proceeded on computer modelling and estimation of damages in order to provide the background required for consideration of the problem areas in the catchment (described in later sections).

Subsequently a "Small Group" Meeting was held on the 18 April with representatives of specific problem areas identified from responses to the newsletter, to discuss their concerns and transfer to them some initial findings of the study and how they might affect their specific problems. Notes and attendance at this meeting are given in Appendix C.

TABLE 3.1
RELEVANT ORGANISATIONS & CONTACTS

ORGANISATION	KEY CONTACTS	POSITION
Leichhardt Municipal Council	Peter Head	Municipal Engineer
	Greg Walsh	Deputy Engineer
	Bruce Lay	Development Planner
	Steve Blaydon	Health & Building Surveyor
	Allan Coker	Town Planner
	Peter Cormican	Design Engineer
	Greg Hawken	Social Planning
	Tony Woodward	Town Clerk
Marrickville Municipal Council	R White	Municipal Engineer
	Bill Stewart	Deputy Engineer
	John Lee	Design Engineer
	Ken Francis	Senior Planner
	Murray Smith	Chief Health Inspector
	Greg Bull	Senior Community Worker
State Pollution Control Commission	Greg Muir	Manager, Water Branch
Roads Traffic Authority	Peter Sampson	Project Engineer, City West Link Road
Public Works Department	Mark Porter	
Maritime Services Board	Steve Simpson	Planning Manager
National Parks & Wildlife Service	Liz Ashley	Wildlife Ecologist
Soil Conservation Service	Casey Murphy	Co-author of "Soil Landscapes of Sydney"
Water Board	Richard Chin	Floodplain Managment Co-Ordinator, Southern Region
	John Webster	Project Manager, Stormwater, Urban Development Southern
	Fred Mattern	Sewer Business Manager, Southern Region

Site meetings were then held at Hearn St, South Avenue and Whites St to inspect the problem areas with the concerned residents. The purpose of the "Small Group" and site meetings was to ensure that the specific problem areas and resident's concerns were understood and could be incorporated in later assessments.

A Public Meeting was then scheduled for 7.30 pm on Monday 30 April at the Annandale Community Centre with the hope that a wider audience could be addressed. Advertisements were placed in the "Glebe and Western Weekly" and "Western Suburbs Courier". In addition handbill notices were distributed around the catchment in public places. A press release was issued to both local newspapers. Telephone calls were made to several residents and organisations to ensure that all interested parties were notified.

Specific invitations with a summary of the study progress to date were issued to the following:

- Leichhardt Council (Mayor, Alderman and Staff)
- Marrickville Council (Mayor, Alderman and Staff)
- Dawn Fraser (Independent Member for Balmain)
- State Pollution Control Commission
- Dept of Housing

A record of the meeting, attendees (and details of prior publicity) is given in Appendix C. The attendance at the meeting was disappointing. Of the 25 attendees, only 11 were residents in the catchment, the remainder consisting of Consultants, Staff and Water Board and other government organisation representatives. Most of the 11 residents had already attended the "Small Group" and site meetings and were therefore already familiar with the study objectives and approach.

It was resolved at the meeting that a further public meeting would be held to provide more details of the study findings.

The next public meeting was scheduled for Tuesday 22 May at the same venue. In order to ensure maximum publicity, an invitation was prepared (see Appendix C) and mailed to each household using the services of Australia Post. In addition, telephone calls were made to interested people as before.

The attendance at the meeting was slightly higher than before with 16 local people present. The presentation by the Project Manager went into considerable detail regarding the study findings and costs of the proposed works.

An important outcome of the meeting was the nomination of a Catchment Management Advisory Committee which would provide a forum with which the Water Board could liaise and seek local input into the future programme for improvements to the Whites Creek drainage system. It was considered that the Committee should represent interested residents, representatives of the local Councils and other relevant authorities in addition to the Water Board. Persons nominated for the Catchment Management Advisory Committee are given in Appendix C.

SECTION 4

COMPUTER MODELLING

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4. COMPUTER MODELLING

4.1 Selection of Models

Appropriate models for evaluation of flood flows and levels and water quality were selected and the concurrence of the Water Board was sought before proceeding. Design flood events specified by the Board were the floods with Average Recurrence Intervals (ARI) of 5, 20, 100 years and the Probable Maximum Flood (PMF).

4.2 Hydrologic Modelling

The ILSAX model was selected for hydrological analysis, with checks made on the results so derived by using the Rational Method and the RAFTS model.

The ILSAX model is widely used for analysis of urban drainage systems and has given good results when checked against measured rainfalls and runoffs on gauged urban catchments. Rainfall data in the form of a time series for either a recorded event or a design event provides input to the model, which then routes runoff through the drainage system to produce a hydrograph of flows at various points in the system.

The total catchment area is split into subcatchments as shown in Figure 4.1, based on the Water Board catchment subdivision. Times of concentration (ie, the time from the commencement of the storm to the peak flow observed at the point of interest) to each of the model nodes were calculated taking into account the overland flow path and distance.

An advantage of the ILSAX model is that it can be readily refined by subsequently increasing the number of sub-catchments. It therefore can be used in the future by Councils to evaluate and upgrade their drainage systems.

Rainfall intensity-frequency-duration data and temporal distribution input to the model were determined using ARR procedures, and are reproduced in Appendix B. Probable maximum precipitation was determined from Bureau of Meteorology (1984).

The model was run for a range of rainfall durations and the maximum flood peak was found for a time of concentration of 60 minutes. The results are shown in Table 4.1. Estimated flows for the design events at various parts of the system are then shown in Table 4.2.

The results of checks by the Rational Method and RAFTS are shown in Table 4.3. The results indicate that the ILSAX values are representative.

The ILSAX model was later used to evaluate the sizing and location of retarding basins and pipeline upgrading which would be required to reduce flood peaks throughout the drainage system and therefore reduce flood damages. The results of this analysis are discussed in Section 5.

The north western part of the catchment drains to Whites Creek by a pipeline under the railway marshalling yards. The pipe has limited capacity and floodwaters unable to enter it spill onto the marshalling yards and flow eastward to enter Rozelle Bay just downstream of the outlet of Whites Creek.

In order to assess the level of inundation across the yards, it was necessary to carry out ILSAX modelling of an additional area adjacent to Whites Creek catchment to estimate flood flows draining onto the yards. The depth of flooding across the yards was estimated to be as high as 2m for the PMF.

4.3 Hydraulic Modelling

The HEC 2 backwater model was selected for the definition of flood levels. It is widely used and model parameters used to simulate channel conveyance can be taken from technical literature and prior experience with the model. HEC 2 is suitable for Whites Creek because it does not have significant flood plain storage which would negate the steady flow assumptions inherent in the HEC 2 model formulation.

The basic input to the model consisted of cross–sections on average approximately 50m intervals at the locations shown in Figure 4.2. The cross–sections were derived from dimensions shown on Water Board drawings, verified in the field where necessary by measurement and some limited survey. Flood plain sections were derived from 1: 2000 scale orphophoto mapping, validated in

TABLE 4.1

VARIATION OF PEAK DISCHARGE WITH TIME OF CONCENTRATIONS
(5 year storm)

Storm Duration (min)	Outlet	Chainage 1050
20	56.3	39.4
25	57.4	41.3
30	56.6	41.2
45	56.5	40.7
60	58.7	42.8
90	57.0	40.4
180	49.3	32.9
360	35.3	23.2

TABLE 4.2

DESIGN FLOOD FLOWS IN SYSTEM

Section No	Chainage (m)	FLOWS (m^3/s)				
		ARI 5 years	ARI 20 years	ARI 100 years	PMF	
1	0	59	74	92	400	
14	484	47	61	80	358	d/s Brennan Street
22	865	45	59	76	331	d/s Piper St. Branch
30	1050	43	56	72	306	end of covered section
37	1210	36	47	61	251	u/s Moore St. Branch
46	1606	24	32	41	163	u/s Styles St. Branch
52	1972	18	24	30	120	Clarke St. u/s Parramatta Branch
54	2270	9.5	12.8	16.3	64	d/s Parramatta Road

TABLE 4.3

COMPARISON OF FLOWS

ILSAX RATIONAL METHOD - RAFTS

	ARI 5 YEARS	ARI 20 YEARS	ARI 100 YEARS	PMF
d/s end only				
ILSAX	59	74	92	400
RAFTS	63	78	104	466
RATIONAL	41	60	89	444

certain areas where there was a mismatch between the Board's drawings and map contours, by field measurement and survey.

Cross–sections at the downstream end of the Creek were modified to take into account alterations currently underway as part of the works for the City West Link Road.

As there are no gauging stations on Whites Creek it was not possible to calibrate the model, therefore the roughness factor, Mannings "n" was selected based on experience and published figures. An "n" value of 0.014 was selected for the channel and a value of 0.04 for grassed and overbank sections and 0.025 for roadways. The downstream boundary conditions for the model runs was taken as Mean High Water Springs (0.62m AHD). Sensitivity tests show that the flood profiles are not very sensitive to tidal levels.

The deisgn flows derived from the ILSAX model runs were input to the HEC 2 model and the corresponding flood profiles produced. It was found that fairly significant decreases in flood level of up to 0.5m were indicated by the model after the RTA works have been completed. This decrease is due to the steepening of the slope of the channel at the outlet and the removal of a bridge at the downstream end of the railway tunnel. The new outlet conditions were therefore adopted as the base case for assessment of channel improvement options. The flood levels are shown in Table 4.4.

The flood contours (in m AHD) taken from the HEC-2 model printout for each of the four design events are shown in Figures 4.3 to 4.6. Minor fluctuations in water levels are mainly due to variations in cross-sections. The capacity of the existing channel/pipe system was found to have an ARI of 3 years or less.

The HEC 2 model was then used to evaluate improvement options incorporating increased channel capacity as discussed in Section 5. Longitudinal flood profiles for existing and improved conditions are shown in Figures 5.2 and 5.3. Generally, channel and drainage improvements can tend to increase flood flows due to increases in velocity and reduction of temporary flood storage in the drainage system. However, in the case of Whites Creek, there is little temporary storage and existing overland flows tend to be concentrated on the road system which drains fairly steeply down to the Board's drainage system or parallel the Board's system on road surfaces. It is therefore considered that although there would be some change to the flows estimated by and described in the ILSAX model following channel improvements these changes would not be very significant and therefore the design flows shown in Table 4.2 are taken to be valid before and after improvement to the drainage system.

TABLE 4.4
FLOOD LEVELS

Section No*	Chainage (m)	FLOOD LEVELS (m AHD) 5 yr	20 yr	100 yr	PMF	Notes
1	0	0.89	1.16	1.46	4.19	
4	110	1.50	1.77	2.07	5.07	d/s Railway tunnel
8	147	1.77	2.27	3.16	5.62	u/s Railway tunnel
9	205	2.64	3.09	3.49	6.82	
11	305	2.73	3.13	3.52	6.87	
12	394	2.77	3.16	3.54	6.97	
14	484	2.74	3.07	3.38	7.24	d/s Brennan St
15	494	2.73	3.07	3.92	7.31	u/s Brennan St
17	587	2.84	3.32	4.04	7.38	
20	779	3.01	3.49	4.19	7.56	
22	865	2.78	3.43	4.21	7.60	d/s Piper St
23	875	3.51	5.25	6.35	7.62	u/s Piper St
28	970	4.10	5.29	6.36	7.77	
30	1050	4.06	5.21	6.27	6.68	
31	1052	4.27	5.34	6.37	7.42	
33	1144	4.90	5.28	6.37	8.66	
37	1210	6.09	6.61	7.17	13.25	
39	1318	8.45	8.72	9.00	12.73	
41	1424	10.44	10.71	10.99	13.44	
45	1536	12.11	12.35	12.54	15.21	
46	1606	12.15	12.41	12.64	15.27	
48	1720	14.19	14.42	14.65	16.81	
50	18.36	16.14	16.34	16.51	18.62	
52	1972	18.10	18.30	18.47	20.40	
54	2110	20.07	20.26	20.43	22.01	

Note: For conditions after completion of RTA works.

* For locations of sections see Figure 4.2

TABLE 4.5 Cont...

NITRATES LOADING (Kg)

	1968 (464mm)	1942 (1147mm)	1973 (1282mm)
Jan	1052	20.4	3660
Feb	15.6	3870	6440
Mar	824	22700	640
Apr	29.1	133	2870
May	834	450	1650
Jun	13	2220	1040
Jul	434	1040	9400
Aug	148	109	679
Sept	120	14600	9590
Oct	-	3130	4210
Nov	0.3	2280	1550
Dec	1000	1670	180
TOTAL	4469	52200	41909

SECTION 5

IMPROVEMENT OPTIONS

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5. IMPROVEMENT OPTIONS

A comprehensive discussion of all the issues involved in urban flood management is given in the Water Board report "Report of the Urban Flood Management Task Force" October 1988. Design Criteria and discussion is well defined in ARR (1987).

Both of these reports form a useful reference source for consideration of improvements options.

5.1 Desirable Objectives for Urban Runoff Control

Quantity

Current standards for design of urban drainage systems specify a drainage conduit for floods of a certain return period with an overland flow path to contain more extreme floods up to the 100 year ARI flood. The desirable objective is to ensure that dwellings, commercial and industrial premises remain flood free up to this event.

The appropriate return period for the drainage conduit can be 10 or 20 years depending upon the type of catchment. In view of the density of development in the Whites Creek catchment it is considered appropriate that the channel system be upgraded to the 1 in 20 flood (ie from its current capacity of 3 years or less).

Quality

Desirable objectives for various parameters of urban runoff quality have been established by the SPCC (1989) as described in Section 2.7. Desirable objectives are consistently lower than values from typical urban areas, including the results from Whites Creek sampling.

Control of water quality is much more difficult than control of water quantity. There are no guaranteed "quick fix" solutions. Solving the problem will take time and involve some structural works but also, more importantly, a joint commitment by the resident community, Water Board and local Councils to improve the situation, using a range of non–structural measures.

A "Catchment Management Advisory Committee" composed of the interested residents and representatives of the Water Board, Councils and other relevant organisations can play a useful role in terms of public education and indeed in all the planning procedures for catchment improvement.

5.2 Water Quantity Improvement Options

5.2.1 Structural Options

The range of options available for reduction of flood levels is as follows:

Channel improvements
Retarding Basins
Levees
By-pass Channels

Channel Improvements

In Section 4 the results of computer model runs evaluating the effects of channel widening were described. In order to meet the established objectives for the drainage system, (ie, a 20 year capacity) an increase in capacity of 75% is required overall and can be accomplished by increasing the width of the channel by the same 75% factor. An option of providing 10 year capacity was evaluated, but as the difference between the 10 and 20 year flows is fairly small cost savings to accommodate the 10 year rather than the 20 year flood would not be significant.

The increase in width can be accommodated within the recreational reserve bordering the open channel. However, bridges at Piper St and Brennan St would require widening or provision of supplementary capacity by means of a culvert. The Brennan St bridge has been reconstructed with provision for some channel widening, but not the full 75% proposed.

The tunnel section beneath the railway line near the mouth of the creek cannot readily be widened and therefore it would be necessary to provide the increase in channel capacity by means of a diversion beneath the present Railway Parade bridge and out to the mouth of the creek via a new channel. Fortuitously, the section of Railway Parade west of and under the railway bridge will become redundant once the RTA road works are completed, thus facilitating the provision of this additional channel capacity. Necessary channel improvements are shown in Figure 5.1, and the details, with cost estimates are given in Table 5.1. Longitudinal flood profiles for existing and improved conditions are shown in Figures 5.2 and 5.3.

The total cost of providing the additional capacity is estimated at $4.5 million.

The disadvantage of channel widening is that it would take up recreational reserves which are already very limited within the catchment area. A cross–section showing the improvement adjacent to Railway Parade is shown in Figure 5.4. Together with the channel widening upstream of Brennan Road, childproof fencing should be installed adjacent to the White Street Housing Commission units to allay safety concerns of the residents.

Provision of this additional capacity underground by, for example, using box culverts, and providing a grass cover is possible although at a considerable additional cost estimated at $1.7 million, to bring the total to $6.2 million.

For the covered section of channel the increase in capacity can be achieved by excavating in Whites Creek Lane and burying box culverts beneath the roadway and adjacent to the existing channel as indicated in Figure 5.6. For upper end of the drainage line and the three feeder drainage lines installation of additional pipes would be appropriate.

For the particular problem of Clarke Street and Hearn Street, sketches of proposed solutions are presented in Figures 5.7 and 5.8 respectively. Details of the cost estimates and proposals are shown in Table 5.1.

Retarding Basins

Retarding basins are used to store water during times of peak flood runoff, to be released after the flood peak has passed. In this way the peak flow rate for any given return period is reduced.

TABLE 5.1
RECOMMENDED IMPROVEMENTS

	CAPITAL COST	ANNUAL MAINTENANCE COST $
QUANTITY		
Widening open channel by 75% including increasing capacity at Piper St & Brennan St and new channel under Railway Parade	1,420,000	
Safety fencing	30,000	
Increasing capacity of 1230m length of covered channel by 100%	1,590,000	
Increased number/capacity of inlets to covered channel	140,000	
Install additional pipeline for 335m in length of Parramatta Rd drain, diameter 375–1350mm	355,000	
Install additional pipeline for 705m length of Styles St drain, diameter 600–1050mm	480,000	
Install additional pipeline for 495m length of Moore St drain, diameter 900–1050mm	500,000	
TOTAL	4,515,000	
QUALITY		
Construction of water quality control pond at creek outlet (Alternative minor gross pollutant traps)	250,000 (400,000)	25,000 (60,000)
Installation of automatic sampling station	10,000	12,000
Ongoing water quality monitoring programme		
Council review of cleansing and collection procedures	-	
Public awareness and publicity campaign		initial – 20,000 ongoing - 5,000
TOTAL	4,775,000	ongoing - 42,000 to 77,000

The ILSAX model was used to evaluate retarding basin requirements to reduce peak flows sufficiently to ensure accommodation of the 20 year flood event within the existing channel. These basins have to be distributed throughout the catchment to ensure that channel capacity is not exceeded at any point, and possible locations for the necessary basins are shown in Figure 5.5.

Preferred sites for retarding basins are on undeveloped land, particularly where dual usage can be achieved, ie, where recreation usage and retarding basin function can be combined. However, within the catchment non–developed land is so limited and restricted to recreational areas that land acquisition would be necessary to provide the required storage area making the cost of the option prohibitive. Estimated cost of construction is $2 million with $16 million required for land purchase. The total area required for retarding basins is 4.3ha.

A desirable feature of retarding basins is the maximisation of storage volume by constructing bunds to provide storage above normal ground levels although with the penalty of increased flood levels upstream. Because of the dense nature of development in the catchment bunding is not possible so that maximum water depths have to be limited to about 1.5 metres.

It is also possible to have a retarding basin as a "hole in the ground" where floodwaters are collected and pumped out after the storm has passed and there are examples in the Sydney area. However, cost considerations dictate that to be economically viable the hole has to be already available, as for example, in a disused quarry. It would not be possible to justify the cost of excavation and accordingly this option was not further developed.

An opportunity would exist for a retarding basin if there were to be significant redevelopment within the catchment as it is sometimes possible for significant storage to be provided within a re–development. Many Councils now insist on the incorporation of on–site retarding basins in redevelopment proposals usually establishing the criteria that the basin shall ensure that runoff from the site, typically the 20 year flood peak, should not be increased over that existing at present.

However, such an approach is only of value where low-density development is changed to high density development, thus increasing the proportion of impervious area. In the case of Whites Creek catchment, it would not be expected that such a strategy would achieve any benefits given the already high percentage of impervious area.

To be effective, a strategy of this nature would require developers to **reduce** the existing runoff by means of retarding basins.

However, there are no plans in existence at present for any such development and indeed a large proportion of the catchment, particularly on the eastern side of the catchment, is under various preservation orders. Therefore retarding basins on redevelopment sites does not seem practical at the present time, although this possibility could be reconsidered in the future depending upon the time frame for construction of the recommended improvement works.

In any event, it should be noted that any retarding basins should only be undertaken after consideration of the impact on the total catchment as it is sometimes possible to aggravate downstream flooding by the extension of the duration of flows caused by the basin.

During discussions at various meetings the possibility was raised of providing storage on each individual property to reduce flood peaks in the creek. This was investigated and it is calculated that, on average, 12 m^3 of storage would be required on each property, representing a space of 4m x 3m x 1m deep. Given the small plot sizes in most of the catchment, construction of such storages means that this cannot be considered a practical proposition.

Levees

The use of levees to protect areas from flooding is not a practical proposition in the Whites Creek catchment. Indeed, levees needed at the downstream end of the creek to contain flood flows would only increase flood levels at the upstream end of the works to the detriment of upstream property owners.

By-Pass Channels

There are no opportunities to divert flood waters from the catchment. The creek is confined by steep catchment slopes for most of its length, except at the downstream end where it is confined on the left bank not by natural ground but by the railway embankment to an elevation of RL 6.0m.

5.3 Non-structural Options

Non-structural options considered included the following:

- Flood proofing
- Zoning
- Flood forecasting and Warning

Flood Forecasting and Warning

With suitable flood forecasting and warning systems it is possible to reduce flood damages by warning property owners of an imminent flood. They are then able to move household effects from the ground floor to the first floor and replace them after the flood has passed. Estimates of the warning time necessary to achieve significant reductions of flood damages vary but it is generally accepted that it is measured in hours rather than minutes.

The computer model studies (Section 4) show that the time of concentration of the whole catchment is no more than one hour, ie, the time from the start of the storm until the peak flow is reached. However, for most of the catchment, the time of concentration is considerably less than one hour, due to the diminishing catchment area up the creek. Even notice of an approaching storm in the Sydney area outside of the catchment would not constitute an adequate warning system due to the unpredictability of intense rain "cells" which would be the cause of major flooding in the Whites Creek catchment.

For the above reasons a flood forecasting and warning system could not provide any benefit to the inhabitants of Whites Creek catchment area.

Zoning

In principle, land zoning can ensure that development is not allowed on flood prone land, usually by allocating the land for recreational use. In such a densely developed area such as the Whites Creek catchment and with no proposals for any significant redevelopment this option is not possible or viable.

Flood Proofing

Flood proofing has a role to play in flood mitigation and operates by preventing the entry of water into properties. Flood proofing includes raising the house and treatment of the house exterior by waterproofing, and by modifications to entry levels.

House raising is more appropriate for timber framed housing in rural areas and is not seen as having a major role to play in the study area. There is currently no technology for raising brick houses. Three houses in particular at Hearn St could warrant flood proofing treatment, however, the proposed augmentation of channel capacity would also reduce the problems.

5.4 Water Quality Improvement Options

Consideration of water quality issues relates to the form of pollution in the water.

Floating material
Suspended Material
Pollution within the water body

5.4.1 Floating Material

This material is conveyed at or near the surface of the flow. It can include cans, plastic, paper and other litter, usually washed off the streets or properties, although some can come from direct dumping in the creek.

There are two means of coping with this problem. One is to ensure that the material does not enter the creek system (which may be termed prevention) and the other is to ensure by suitable trapping procedures that it is not transported out into the Harbour and potentially onto the ocean beaches.

Prevention

Prevention involves a combination of factors, including Council street cleaning and refuse collection procedures and public education.

Both Councils devote considerable resources to street cleaning and refuse collection. However, it is recommended that Councils review their procedures to determine if improvements can be made.

Gross Pollutant Traps

There are two trap options. One is to trap the material at the various points of entry into the drainage system (Minor Gross Pollutant Traps) and the other is to collect it at the downstream end of the creek just before it discharges into Rozelle Bay (Major Gross Pollutant Trap). For either option the usual method of collection is by means of a series of vertical bars positioned across the channel. It is implicit that regular cleaning is essential as a blocked screen could very well cause flooding and negate the benefits of flood mitigation works.

Traps at individual entry points would mean enlarging and providing grilles at the inlets proposed as part of the improvement works. The cost of such works is estimated at $400,000.

Another option would be to install a major gross pollutant trap at the outlet to Rozelle Bay. It could be formed by building a rock wall out in the Bay, and fixing a trash rack on the top. The alternative would be to construct a pond on the alignment of the present Railway Parade which will be made redundant once the new roadworks are completed.

within the existing alignment of Railway Parade which will become unused once the RTA roadworks are completed. These two possible solutions are shown in Figures 5.9 and 5.10.

The retention pond can fulfil a number of functions including:

Collection of sediment
Water quality monitoring and treatment
Collection of floating material
Restriction of tidal flow in the creek

Suspended Sediment

The pond will only trap sand particles in suspended sediment and the quantities are expected to be low. Maintenance dredging would be able to periodically remove sediment by dredging with an excavator every few years.

Collection of Floating Material

Floating material can be collected by means of a grill, which would require regular cleaning and maintenance.

Water Quality Monitoring and Treatment

The pond affords the opportunity to regularly monitor water quality and provide the opportunity for treatment in the event of accidental or deliberate spillage within the catchment. A boom could collect oil and grease.

Because of the limited number of businesses in the catchment the nature of any pollution should enable any polluters to be identified from water quality analyses.

Restriction of Tidal Flow

Flooding associated with tidal inflow is of concern to residents at the lower end of the Creek. Tidal flow into the creek can exacerbate flooding problems for floods which are significantly less severe than the greater than 3 year floods which overflow the channel.

It would be possible to provide a weir at the lower end of the pond to limit tidal inflow, although this would require careful design to ensure that upstream flooding is not worsened.

5.5 Water Quality Measurement Programme

As the data base on water quality is limited to samples taken during the study it is recommended that an ongoing water quality measurement programme be instituted to adequately measure existing conditions and form the basis for comparison of improvement options. Measurements should be made of the following:

- suspended solids
- nutrients–nitrogen and phosphorus
- B.O.D.
- toxic trace metals
- oils and surfactants

It is proposed that samples be collected at the downstream end of Whites Creek with an automatic sampling station.

Experience is being gained by the Water Board following trial installation of floating booms to collect floating material. A trial installation of a floating boom at the outlet of the Creek over the same six month period will enable the extent of the problem to be gauged and help guide the designs of gross pollutant traps.

5.6 Public Education and Participation

A Public Education campaign should be directed toward developing a sense of "ownership" of the catchment, so that each individual by his or her own actions can contribute to improving the creek environment. A Catchment Management Advisory Committee has an important role to play here.

Nominations for the Committee were accepted at the last public meeting and the current membership is shown in Appendix C.

5.7 Implication of Preferred Options

5.7.1 Geotechnical

Open Channel

Based on the Soil Conservation Service (SCS) landscape boundaries the whole of the section of open channel will be contained in 'disturbed terrain' which most likely comprises old fill placed to create a level platform above the old creek bed.

On the assumption that the major part of the fill has only consolidated under its own weight and has not been structurally compacted, it is considered likely that all cuts will require shoring or need to be cut back at suitably flat batters which can be confirmed during opening up inspections on site.

Much of the line of the proposed extension will have already been surcharged by at least two metres of existing ground. Hence, after excavation for the new channel, net soil loadings will be less than previously experienced and any future settlement problems are likely to be small.

The subgrade along the route of the channel augmentation should be investigated by means of a programme of test pits possibly assisted by boreholes.

In addition, valuable information may possibly be obtained from the RTA which may have already commissioned geotechnical investigations for the proposed freeway and may have inspection records from piers which are currently being installed in the vicinity of the existing channel, near its exit into Rozelle Bay.

Covered Section

The SCS boundaries indicate that the major part of the covered section of channel is located in the sand or sandy formations, overlying Hawkesbury sandstone. However, it is considered probable that sections of ground adjacent to the existing carrier may contain fill in various forms as a legacy of earlier development.

It is noted that in much of Whites Creek Lane the construction of an additional culvert carrier will involve excavations very close to existing houses, garages, walls and fences. Where the original sand profile is intact or where fill has been loosely placed, the sides of open excavations will probably require careful shoring to avoid damage to existing structures.

As in the case of the open channel section it is unlikely that bearing capacity or settlement will be a problem with the new box culvert.

Because to the proposed box culvert route underlies an existing road over much of its length, it would be prudent to investigate subgrade soils by borehole rather than by test pits.

At the Booth Street bridge it is recommended that investigation also include careful examination of the bridge foundations and their design/construction documentation if they are available.

Piped Sections

Where existing flows are carried in piped sections, extra capacity will be provided in new pipes laid mainly alongside the existing ones.

In Moore Street and Parramatta Road sections, the new lines will be placed under roads, lanes and parks. However in Styles Street the existing line goes very close to existing houses and light industry. Options here may either comprise thrust boring adjacent to the existing line or rerouting of catch drains beneath streets away from the existing line.

Comments on trenching support and base preparation apply equally to piped sections as they did for the channel sections.

Future geotechnical investigations should be undertaken as described earlier, however, in order to assess ground conditions for any thrust boring work a denser cover of investigation points may be required than for open trenching methods.

Dewatering

Careful attention should be paid during all the investigation stages to measurement of existing groundwater levels, in order to establish whether or not dewatering is required for construction.

This is particularly important since, if installation of dewatering systems such as well points or deep wells is necessary, the ensuing drop in the standing water surface may result in surface settlement with ensuing damage to adjacent structures unless recharge wells are incorporated between well points and areas to be protected.

5.7.2 Community and Environmental Impact

Planning Aspects

The major impact of the preferred proposed improvements derives from the proposed widening of the existing Whites Creek drainage channel.

Widening of Whites Creek channel will require resolution of a number of matters prior to its acceptance. They include:

- Loss of open space in the Municipality of Leichhardt directly adjoining the existing channel alignment.

- Further segregation of open space areas north and south of the Whites Creek channel.

- Potential conflicts of access through open space to the upgraded channel for clearing and maintenance purposes.

- Security of the channel from adjoining recreation areas, in particular where children's playgrounds could be developed.

- The aesthetic impact of a widened concrete channel surrounded by security fencing in an open area.

- The potential to bridge the channel to provide for pedestrian and cyclist linkages between open space north and south of the channel.

- The reduction in possible development potential of areas directly adjoining the drainage channel or in areas which could overlook the channel.

- The potential to identify sections over the channel where air space could be developed for residential buildings or parking structures attached to residential areas.

- The acceptance of the preferred option by Leichhardt and Marrickville Councils, community groups, individual property owners within the catchment area, and statutory authorities.

- Planning controls are required to take flooding and water quality into consideration.

These matters will need to be resolved, possibly in the form of an environmental impact statement under Part 5 of the Environmental Planning and Assessment Act. The statement would need to meet the requirements of each Council and the Department of Planning. As well, detailed drawings would need to be prepared specifying all proposed drainage improvements and in particular the land take required for channel widening.

Flora and Fauna Aspects

The proposal to widen the Whites Creek Channel so as to mitigate flooding will have little impact on the flora and fauna of the area. The major impact of widening would be to significantly reduce the amount of open space and vegetation. The vegetation would be lost because the banks of the open section of Whites Creek Channel support many plants. As a result of reduced vegetation the viability of the area as a possible bird corridor would be reduced.

Safeguards against these impacts would involve intensive replanting programmes in the residual open spaces with existing plant species. There will be no impact on the flora and fauna due to the increase in size of the underground portion of the channel.

6. DAMAGES & SOCIAL IMPACT OF DRAINAGE PROBLEMS

A survey of residential, commercial and industrial properties within the Whites Creek stormwater drain catchment area was undertaken so that estimates of economic and social effects of flooding could be determined.

6.1 Methods

Existing buildings were surveyed and details recorded on computer, using a two phase approach.

Firstly, several industrial properties were visited by a loss adjuster to assess their susceptibility to flooding at different depths. The results from these surveys were translated into damages for different recurrence intervals and used in the calculation of Average Annual Damage (AAD).

The second phase included a more general survey of all properties within the limits of the Probable Maximum Flood. Data collected during this survey for each property included the type of house, shop or industry; construction material; condition; size; height raised and ground height. Ground heights were taken from the orthophoto map and floor levels were estimated on site. Some ground levels were also surveyed so that the accuracy of the orthophoto maps could be checked.

The economic effects of flooding were calculated using the ANUFLOOD computer program. ANUFLOOD bases its calculations on stage–damage curves which relate the amount of damage sustained to the depth of the flooding. The stage–damage curves used in this study have been developed from several studies including those carried out on the Sydney floods of August 1986 and April 1988 for the Department of Water Resources and the Public Works Department.

Flood level spot heights for both existing and improved conditions were obtained from the hydraulic modelling data for the flood–affected areas. These levels were then entered into the ANUGRID computer program which produces a flood surface for each of the return intervals. (This flood surface is generated from the spot heights and information on the direction and elevation of the drainage line). The flood surface was then used by ANUFLOOD in its calculation of flood damages.

Flood damages for the various return periods were then combined with the results of the loss adjuster surveys to calculate the AAD.

6.2 Results

6.2.1 Economic Damages

Existing Situation

The AAD for the residential properties were estimated at $86,000 (Table 6.1).

For the same discount rate, the commercial and industries properties incur an AAD of $139,000 This damage includes both the direct damage (damage to stock and fittings) and the indirect damage (loss of profit, cleanup, etc). The indirect damages were assumed to be 55% of the direct damages, based on earlier studies in similar situations.

Although the NSW Treasury recommends a uniform discount rate of 7%, a discount rate of around 5% may be more appropriate for residents and 10% for businesses because the latter usually seek quicker returns on investments. Present worths of AAD for these discount rates and for two other discount rates were calculated to assess the sensitivity of the analysis (Table 6.2). For the uniform 7% rate the total present worth is $3.1 million.

Damages were also assessed to evaluate the sensitivity of the estimated flood levels being half a metre higher or lower than the values adopted (Table 6.2).

Improved Conditions

The damages incurred after increasing the capacity of the channel to convey the 20 year flood are presented in Table 6.3. The present worth of AAD for the improved conditions is shown in

Table 6.4. The present worth of the average annual benefits of the improvements are shown in Table 6.5.

It can be seen that the overall benefit varies according to assumptions regarding the discount rate, but is in the range of 1.5 to 3.0 million dollars. This is less than the cost of the works which has been estimated at $4.5 million.

A summary of existing potential damages and damages after improvement for different industries is given in Table 6.6. These industries include a cardboard carton dealer, an electrical generating equipment hire company, a hair care products manufacturer, a paper recycler, a sheltered workshop, a shoe manufacturer, a supplier of moulded fibrous plasters and a wholesaler of truck parts.

Railways

The potential for flood damage to railway marshalling yards on the eastern side of the Catherine Street Bridge was also investigated. For the Probable Maximum Flood there would be up to 2 metres of water over the railway track with very low velocities for a period of perhaps 2 hours.

According to railway officials this should not cause too much damage. Loss of the use of the railway for two hours would result in no loss of freight revenue as the affected tracks are rarely used (perhaps once or twice a day). The Engineers Department of the State Rail Authority has suggested that as long as flow velocities were low, little gravel would be removed and little damage caused.

6.2.2 Social Impacts

The number of households flooded can be a useful measure of the social impacts of flooding. Table 6.7 shows the results of the number of residential households which are flooded above the ground or above the floor. A property flooded above the floor refers to the actual floor of the living area being inundated. Properties which have only garages, external buildings or other property flooded are classed as being flooded above the ground.

In the case of flats or townhouses a household refers to each individual unit, not each individual building. The number of households flooded with the enlarged channel is much less than now (Table 6.8).

6.2.3 Flood Insurance

The current flood cover available to the residents of the floodplain of Whites Creek varies. Although flood insurance is generally not available in NSW, much flood damage is still covered by insurance (Lustig, 1990).

This is because all insurance companies pay out for losses resulting from the overflow of a stormwater pipe, drain or gutter. Such an event is normally classified as "Storm" or "Escape of Water". If however, the waterway is still essentially a natural watercourse, any overflows are quite correctly classed as "Flood", and the insurance companies normally do not pay.

There are some situations however, where the responses of one insurance company can differ markedly from the next. This is where the flooding emanates from a large, modified watercourse such as a stormwater channel: some companies pay out on the claims while others refuse them. In the case of the Whites Creek floodplain, the watercourse has long been modified. Consequently, some insurance companies would pay out all flood losses. Others would refuse the claim where the watercourse was an open stormwater channel, but pay out where this stormwater channel was covered over.

The covered stormwater channel emerges to an open one between Armguimbau Street and Wisdom Street. Accordingly, all premises upstream of that point should be covered by insurance, while only some of those downstream of this point would be covered.

It is not known if those premises adjoining the open stormwater channel will ever be able to be covered by flood insurance. The NSW Government is currently examining the feasibility of instituting flood insurance. The reaction of the insurance industry however, remains largely sceptical that flood insurance could ever become viable (Brown, 1990).

It may be that if flood insurance were instituted in a form where the premium varied with the risk of the event, the only people who could afford to pay would be those well above the floodplain, and those already so high that the frequency of flooding would be low.

The dilemma which would arise from this however, would be that these people would be flooded so rarely that they would not bother to pay their low premiums, while those lower down who would be flooded frequently could not afford their high premiums (Brown, 1990).

TABLE 6.1
SUMMARY OF DAMAGE ESTIMATES FOR EXISTING SITUATION

ARI(yrs)	Potential Flood Damages(7% discount rate) Residential	Industrial/ Commercial	Total
5	131,987	69,750	201,737
20	435,235	834,635	1,269,870
100	840,239	1,128,182	1,986,422
PMF	2,802,719	5,718,921	8,009,748
AAD	**$86,266**	**$138,761**	**$225,027**

TABLE 6.2
SENSITIVITY OF PRESENT WORTH OF EXISTING AVERAGE ANNUAL DAMAGE

Sensitivity		Present Worth of Annual Average Damage: Adopted Flood Levels	Flood Level Variations: -0.5 metre	Flood Level Variations: +0.5 metre
Residential AAD		86,266	47,398	130,504
Discount Rate Over 50 Years	3%	2,200,000	1,200,000	3,400,000
	5%	1,600,000	870,000	2,400,000
	7%	1,200,000	660,000	1,800,000
Business AAD		138,761	131,748	150,323
Discount Rate Over 50 Years	7%	1,900,000	1,900,000	2,100,000
	10%	1,400,000	1,300,000	1,500,000
	13%	1,000,000	1,000,000	1,000,000
Total Present Worths	3% res/13% bus	3,100,000	2,200,000	5,600,000
	5% res/10% bus	3,000,000	2,170,000	3,900,000
	7%res/7% bus	3,100,000	2,460,000	3,900,000

TABLE 6.3
POTENTIAL FLOOD DAMAGE FOR IMPROVED CONDITIONS

	Potential Flood Damages		
ARI (yrs)	**Residential**	**Industrial/ Commercial**	**Total**
5	0	0	0
20	0	0	0
100	194,811	870,976	1,065,788
PMF	2,551,166	5,207,028	7,758,195
AAD	**$19,535**	**$47,810**	**$67,345**

TABLE 6.4
PRESENT WORTH OF ANNUAL AVERAGE DAMAGES FOR IMPROVED CONDITIONS

		Present Worth of Annual Average Damage		
Sensitivity		**Adopted Level**	**-0.5 metre**	**+0.5 metre**
Residential AAD		19,535	13,941	27,508
Discount	3%	500,000	360,000	700,000
Rate Over	5%	360,000	250,000	500,000
50 Years	7%	270,000	190,000	380,000
Commercial AAD		47,810	44,952	56,481
Discount	7%	660,000	360,000	780,000
Rate Over	10%	470,000	450,000	560,000
50 Years	13%	370,000	350,000	430,000
Total	r3/c13%	870,000	710,000	1,100,000
Present	r5/c10%	830,000	700,000	1,060,000
Worth	r7/c7%	930,000	550,000	1,100,000

TABLE 6.5
PRESENT WORTH OF ANNUAL AVERAGE BENEFITS OF THE IMPROVEMENTS

Sensitivity		Present Worth of Annual Average Damage Adopted Level	 -0.5 metre	 +0.5 metre
Residential AAB		66,731	33,457	102,996
Discount Rate Over 50 Years	3%	1,700,000	860,000	2,700,000
	5%	1,200,000	610,000	1,900,000
	7%	920,000	460,000	1,410,000
Commercial AAB		90,952	86,796	93,842
Discount Rate Over 50 Years	7%	1,300,000	1,200,000	1,300,000
	10%	900,000	860,000	930,000
	13%	700,000	670,000	720,000
Total Present Worth	r3/13%	2,400,000	1,500,000	3,400,000
	r5/10%	2,100,000	1,470,000	2,800,000
	r7/7%	2,200,000	1,700,000	2,700,000

TABLE 6.6
SUMMARY OF LOSS ADJUSTER SURVEYS OF INDUSTRY

INDUSTRY	ARI	EXISTING POTENTIAL DAMAGES/ LOSSES ($)	AFTER IMPROVEMENTS ($)
Industry 1	5	0	0
	20	84,000	0
	100	95,000	87,000
	PMF	107,000	107,000
Industry 2	5	0	0
	20	200,000	0
	100	257,000	180,000
	PMF	350,000	350,000
Industry 3	5	50,000	0
	20	70,000	0
	100	96,000	90,000
	PMF	136,000	136,000
Industry 4	5	0	0
	20	55,000	0
	100	65,000	60,000
	PMF	80,000	80,000
Industry 5	5	0	0
	20	150,000	0
	100	220,000	200,000
	PMF	300,000	30,000
Industry 6	PMF	10,000	10,000
Industry 7	PMF	1,074,000	1,074,000
Industry 8	PMF	820,000	82,000

TABLE 6.7
NUMBER OF HOUSEHOLDS FLOODED-EXISTING CONDITIONS

ARI (yrs)	Above Ground	Above Floor
5	50	18
20	140	75
100	173	90
PMF	426	386
Average Annual Number	24	13

TABLE 6.8
NUMBER OF HOUSEHOLDS FLOODED - IMPROVED CONDITIONS

ARI (yrs)	Above Ground	Above Floor
5	4	2
20	12	3
100	61	25
PMF	415	355
Average Annual Number	5	3

SECTION 7

CONCLUSIONS

7. CONCLUSIONS

The Study has found that there are problems associated with the Whites Creek Catchment drainage system. Improvement options are constrained by the heavily built up nature of the 262 ha catchment area and the limited amount of open space (only 4% of the total area). Responses from the community have shown that there are five major areas of concern, involving some dozen houses.

At Hearn St, Clarke St, South Avenue and a small section of Catherine St residents have been subjected to frequent flooding resulting from a combination of factors including houses located in a depression and inadequate inlets to the Board's drain, which is of itself of limited capacity. At Whites St a number of residents in the recently completed Department of Housing units are concerned about potential flooding problems and their children's safety.

There are wider concerns about pollution, particularly sewer overflows. It has been made known to residents that the Water Board will be carrying out an investigation programme to reduce this problem.

In considering the responses from the community it is important to bear in mind that less than 30 residents out of the estimated 13 300 population appear to be concerned about the drainage system.

Computer modelling has determined that the drainage system has a limited capacity and will convey less than the 3 year ARI flood, and that there is a significant flood risk for many properties along the main drain lines.

In order to upgrade the system to current design standards a drain capacity of 20 years is needed. This will require an increase in capacity of the main channel of approximately 75% by widening the open channel and provision of additional pipelines along Styles St, Moore St and the Parramatta Road branch. Current design standards also call for a floodway to convey the 100 year flood without inundation of property. Due to the dense nature of development within the catchment it is not practical to eliminate all house flooding for the 100 year flood although significant improvements can be made.

The problem areas are all located at the upper end of the catchment and it would not be practical to stage the works to benefit the upper end as a matter of priority as downstream flooding conditions could be made worse.

At present, the number of houses flooded ranges from 18 to 90 for the 5 year and 100 year flood respectively. The current estimated combined potential average annual damages for residential, commercial and industrial areas is around $225 000. After improvements, flood inundation and damages up to the 20 year event will be virtually eliminated, and the expected present worth of the improvements is around $2.2 million.

Commensurate with these works will be the requirement for improved inlets to the Board's drain. This is an area where the Councils can have a significant impact in mitigating current flooding problems.

These works, with the addition of child proof fencing alongside the Whites St units, would remove the concerns of residents in the problem areas and lower the risk of flooding along the whole length of the channel and tributaries.

The combined cost of these works is of the order of $4.6 million.

There are no viable alternatives to increasing the channel capacity. There are no opportunities for the use of levees or by-passes out of the catchment, and there is insufficient open space within the catchment for retarding basins. There are no plans for large scale development which might offer the opportunity of incorporating on-site retardation.

Because of the small size of the catchment, a flood warning system would not give sufficient notice to enable residents to reduce flood damages. Flood proofing of houses by raising them above floodprone land, (often possible in rural areas) is not seen as a viable option in the densely developed Whites Creek catchment, with brick housing construction.

For improvement of water quality a retention basin at the downstream end of the channel at the outlet to Rozelle Bay offers the possibility of trapping gross pollutants, sediment and oil and grease by a floating boom, and affords the opportunity of treatment of accidental or deliberate pollution before entering the Harbour.

The alternative is to construct a series of minor Gross Pollutant Traps distributed throughout the catchment, generally formed by enlarging inlets to the Board's channel system.

The basin could be formed by constructing a rock barrier within the Bay or by utilising the existing alignment of Railway Parade (which will be made redundant after completion of the RTA roadworks) upstream of the Crescent. The rock barrier, with the installation of a low flow piped outlet, offers the additional advantage of being able to exclude a significant part of the existing tidal inflow. The retention pond would, however, interfere with the proposal for development of the Bay put forward by PWD although it would fulfil an important role in minimising the043`outflow of pollution into proposed recreational areas.

The optimum choice of installation will require discussion and negotiation with PWD, the MSB and Council and require an Environmental Impact Assessment. The cost of providing such a facility is assessed at $250,000. With an ongoing maintenance estimated annual cost of $25,000, the option to construct minor Gross Pollutant Traps is estimated to cost $400,000 with an annual maintenance cost of $60,000

It is recommended that a water quality monitoring programme be instituted and that Councils review their street cleansing and garbage collection procedures.

The recommended Catchment Management Advisory Committee should ensure that future implementation of the catchment management programme fully considers community interests and has wide spread support.

SECTION 8

ACKNOWLEDGMENTS

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8. ACKNOWLEDGMENTS

The majority of the work was carried out by GHD staff with input from external specialist consultants as required. The study team is set out in Table 8.1.

The assistance rendered to the Consultants by staff of the Water Board, Councils, other Government bodies and members of the community during the course of the study has been very valuable and is gratefully acknowledged.

TABLE 1.1
STUDY TEAM

	Name	Company
Responsible Principal	Timothy Smyth	GHD
Project Manager	John Lawrence	GHD
Hydrology/Hydraulic Engineering	Mike Sharpin Tony Daley (Dr) Jim Ball	GHD GHD University of NSW
Planning	Vaughan McInnes	GHD
Environment	Andrew Morison	GHD
Geotechnical	Ken Boddie	GHD
Damages Assessment	(Dr) Terry Lustig	Environmental Management Pty Ltd
Heritage	Wendy Thorpe	External Consultant
Community Participation	Anne Gorman	Social Impacts
Archaeology	(Dr) Helen Brayshaw	Brayshaw McDonald Pty Ltd

SECTION 9

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