Whites Creek Wetland

Whites Creek flows through the Inner Sydney Suburb of Annandale into Rozelle Bay, Sydney harbour. Total catchment area is 262 ha and the wetlands catchment is 161 ha. The creeks length is approximately 2.5 kilometres. The area is heavily built up, consisting mainly of terraced housing with some light industries. Whites Creek is now a concrete channel, the lower 1060 m is tidal and is an open concrete channel. The upper reach of the creek has a steeper slope and consists of a covered concrete channel.

A large proportion of the catchment is impervious. No natural drainage lines have survived. Also there are no ponds or swamps. Whites Creek has been constructed in straight lines with even gradients and all meanders have been eliminated. Mangrove swamps originally existed in the tidal zones. There is only a small area of open space in the catchment. Whites Creek Valley Park is on the banks of the lower reaches of the creek and is the largest park in the catchment.

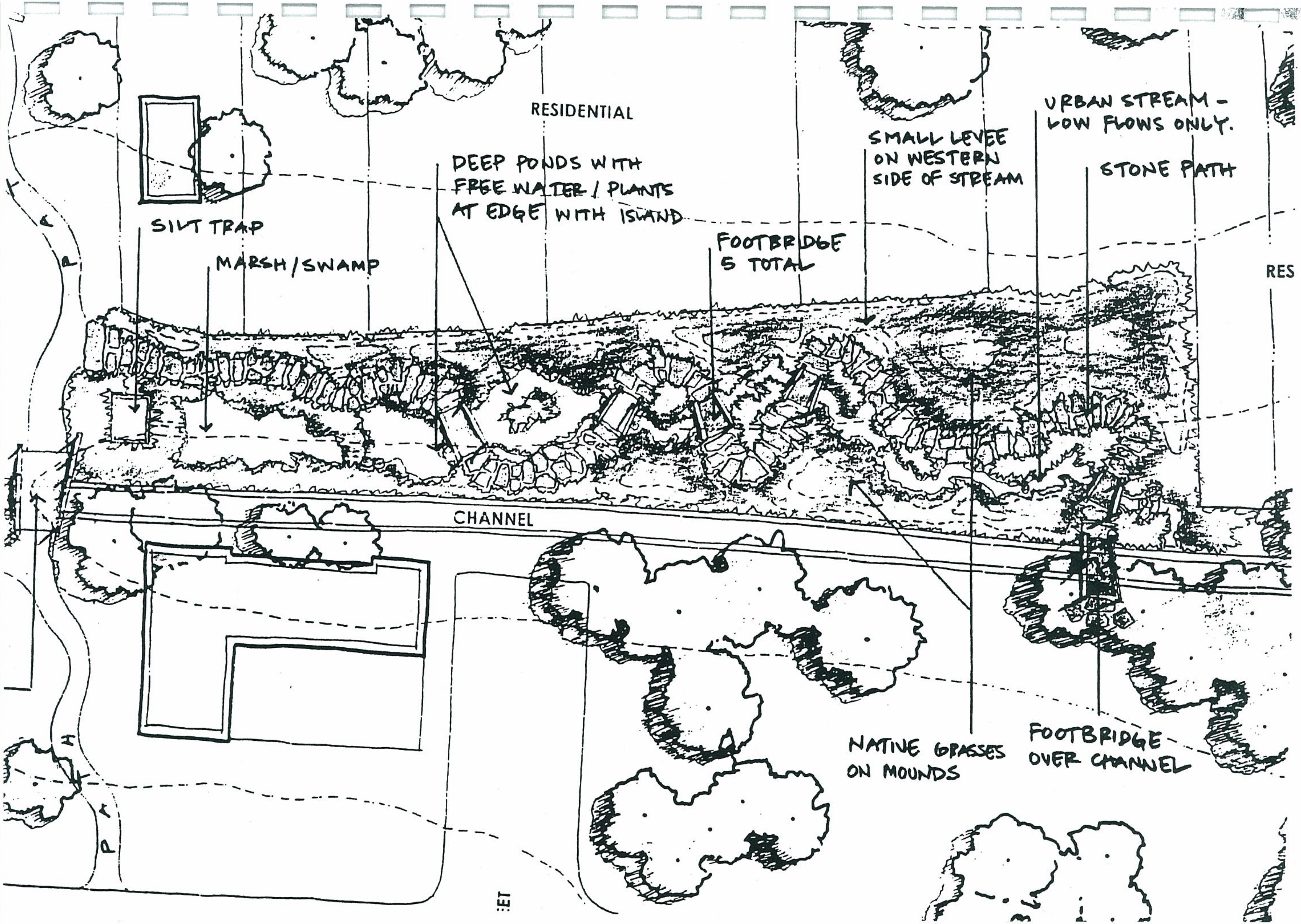
The upper reaches of the creek follows Whites Creek Lane and the land is developed on either side except for one park, Styles Street Playground. The proposed site for the wetlands is parallel to Whites Creek, between Booth and Piper Streets and on the Western banks of the Creek. The land is owned by Sydney Water, is level, and unused. The wetland site is 90 metres long and 10-20 m wide and covers an area of 1200 sq m.

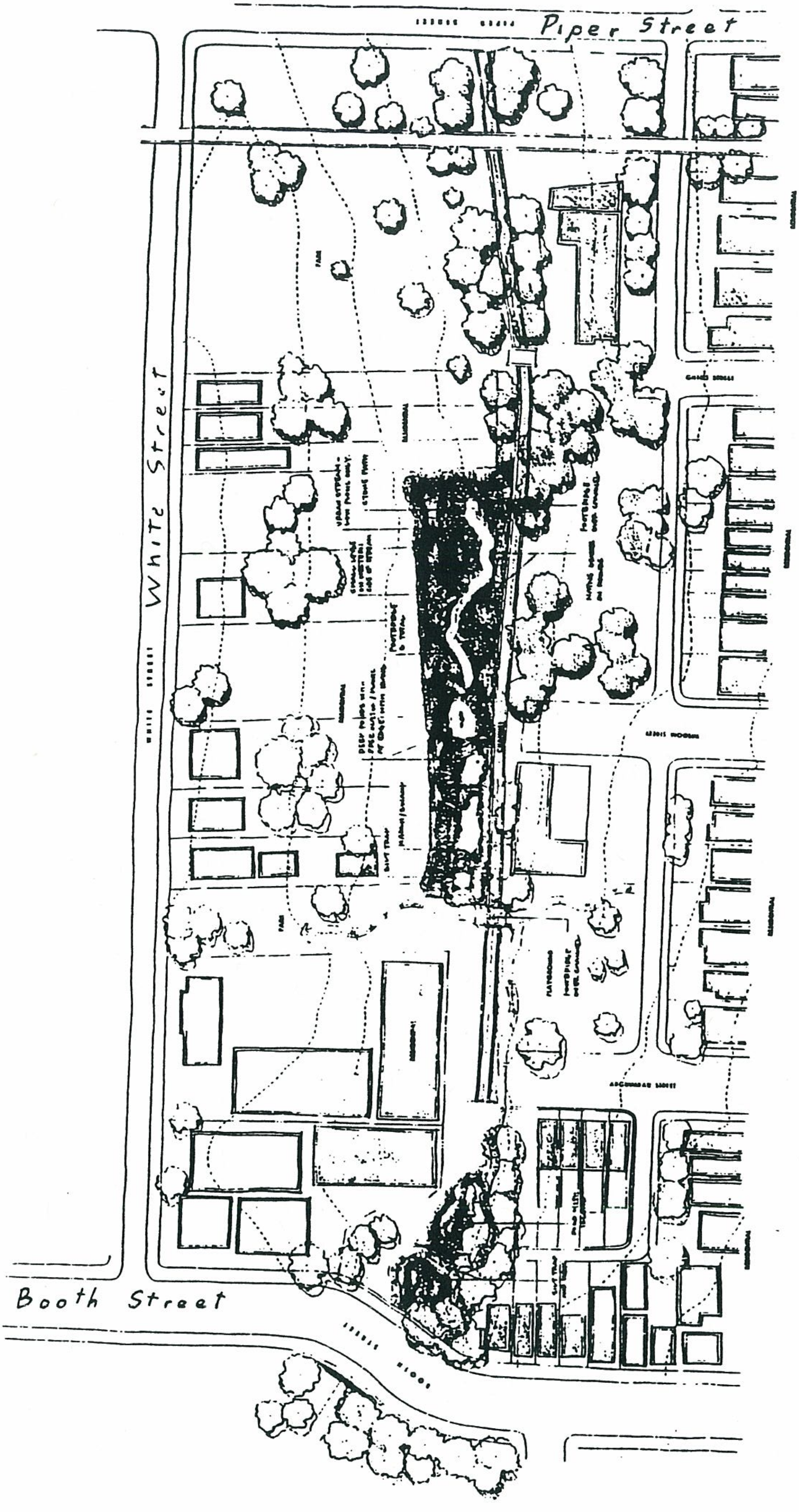
It is planned to divert water by pipe from the main channel into a series of constructed wetlands which will flow parallel to and then re-enter the main channel. The water surface in the wetlands will be approximately level with the bottom of the existing channel. The wetlands will only receive minor flows, and a small controlled proportion of major flows. The larger proportion of major flows will continue down the main channel. The wetlands will consist of: silt trap, gross pollution trap, shallow wetlands, lake, eco-engineered creek and an additional silt trap before the water re-enters the concrete channel. The creek bed and banks will need to be securely stabilised with rocks and vegetation.

Reasons for selection of the Whites Creek site:

- Fresh water flow
- Flat land available for wetland construction
- Wetland will add amenity to existing parkland
- Possible room for expansion if parkland expanded
- Whites Creek is polluted and flows into Sydney Harbour
- Flooding occurs downstream from wetland site

In the inner city areas of Sydney, it is difficult to find areas suitable for construction of fresh-water wetlands. This site is a window of opportunity in a densely populated area where vacant land occurs on the banks of a


RESIDENTIAL
SILT TRAP
MARSH/SWAMP
DEEP PONDS WITH FREE WATER / PLANTS AT EDGE WITH ISLAND
FOOTBRIDGE 5 TOTAL
SMALL LEVEE ON WESTERN SIDE OF STREAM
URBAN STREAM - LOW FLOWS ONLY.
STONE PATH
RES
CHANNEL
NATIVE GRASSES ON MOUNDS
FOOTBRIDGE OVER CHANNEL



Whites Creek Valley
Urban Stream Sketch
Friends of The Earth
OCULUS

freshwater stream. It is considered this is the most suitable site for freshwater wetlands in Leichhardt Municipality.

Wetlands Design

The design of the wetlands will not be finalised until feasibility studies are completed and detailed engineering design plans prepared. The wetlands will be designed off line to the existing channel. Minor flows and a small controlled proportion of major flows will enter the wetlands. During floods, the existing concrete channel will carry a large proportion of the water, while a smaller amount of flood water will travel through the wetlands parallel to the channel then re-enter the channel downstream. The creek has a continuous dry weather flow fed by artificial sources of water.

The system will act as a detention basin and as a by-pass channel, and the combined channels will increase total capacity. This design will help to decrease flood peaks.

Water will enter the wetlands from the base of the existing channel, through a pipe, into a silt trap and gross pollution trap. The pipe will be designed to divert a large proportion of the sediment from the channel, into the silt trap. A small weir about 20cm high and a shallow trench about 10cm deep will help to divert silt through the diversion pipe into the silt trap. A gross pollutant trap will be installed to capture larger and lighter objects which float on the surface especially litter and leaves.

Water from the silt trap will flow into shallow wetlands. Water plants will help to remove the nutrients nitrogen and phosphorus and reduce algae blooms. Some pollutants will be filtered out because they stick to the stems and leaves growing in the water. Oily pollutants which float on the waters surface tend to become attached to plant surfaces.

A small lake will be constructed below the shallow wetlands. Aquatic animals will be encouraged to use the lake. Suitable fish species and water birds can make their home in the lake. Protection from cats and dogs will be provided by building an island in the lake.

Water will overflow from the lake into a stream which will meander along a rocky bed. The banks of the stream will need to be well protected so as not to wash away during high flows. A grass cover will be established on the streams banks with trees and rocks stabilizing sensitive areas. Water flow between each section of the wetlands will be controlled and the water height adjusted by weirs.

The area surrounding the wetlands will be landscaped with native species. The soil removed during excavation will be integrated into the surrounding landscape plan. Direct access to the waters edge will be discouraged so as to improve safety for children and to protect aquatic flora and fauna.

Plantings of dense bushes and undergrowth will act as a barrier to the waters edge. A path will wind through the area with bridges, viewing platforms and jetties at suitable positions. People will be encouraged to visit and enjoy the area but people will be discouraged from interfering with the native plants and animals especially aquatic species. At the bottom of the wetlands the water will flow into a silt trap before it re-enters the original channel through a pipe.

After commissioning initially only small flows will be allowed to pass through the system. The growth and establishment of a vegetative cover which protects the banks will be monitored and when all earthworks are stabilised, larger volumes of water will be diverted into the system.

The design should ensure shallow dead ends, or backwaters do not occur where stagnant water accumulates with no flushing by flowing water. The bed of the shallow wetlands on the edges should be formed from soil with a high permeability. The edges of the wetland should have an even slope so as to drain freely preventing stagnant pools remaining when water recedes after heavy rain. The establishment of vigorous growing vegetation on the wetland edges will help soils to drain and dry out. Whites Creek has a continual dry weather flow of approximately 0.05 m^3/sec, which will help to maintain a steady flow through the system even during droughts.

Future possible extensions

The planned wetland scheme is surrounded by private property restricting the schemes size. This land is being purchased by government agencies and will be added to the existing Whites Creek Valley Park. In the future there is scope for extending the size of the wetlands. When access is available the constructed creek could be extended down to Piper Street. The existing concrete channel is old and will soon need rebuilding. In a later stage of development the channel could be rebuilt with natural features.

Near Piper Street a large aqueduct with sewer mains crosses the valley. The aqueduct is old and has heritage values. Water could be mined from the sewer main, appropriately treated and then diverted into the wetlands. The water quality of the sewage would be polished in the wetlands. The sewer mining would guarantee a constant supply of water to the wetlands, even during droughts. The sewer is a considerable height above the valley floor. A small waterfall could be incorporated as the water falls to the valley floor. Water stored in the wetlands could be used for irrigating the surrounding parkland. Sewer mining and irrigation both have financial benefits .

Whites Creek, Site Data

Geology: Quaternary sediments surrounded by
Hawkesbury Sandstone on valley slopes
Wianamatta Shales on upper reaches of catchment

Soils: Gymea Soil Landscape, Yellowearths, Hawkesbury Sandstone, on valley slopes.
Blacktown Soil Landscapes, Podzolics, Wianamatta Shales, upper catchment
Soils on site are artificial landfill

Plant communities:
Sydney sandstone ridgetop woodland, On Hawkesbury sandstone
Turpentine-ironbark forest, On Wianamatta shale
Very little original vegetation remains in local area

Rainfall data

Monthly Rainfall-means (mm)
(Observatory Hill)

Jan	Feb	March	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
102	113	135	124	121	131	100	77	69	78	81	78

Yearly mean 1213 mm

Evaporation (mm)
(Sydney Airport)

220	176	164	126	90	78	90	115	141	171	192	239

Yearly mean 1802 mm

P/E (precipitation/evaporation)

0.46	0.64	0.82	0.98	1.34	1.68	1.11	0.67	0.49	0.46	0.42	0.33

Yearly P/E 0.67

Average recurrence interval (ARI) years

Intensity frequency duration (IFD) rainfall data mm/hr

	2	5	10	20	50	100
1hr	40	53	61	71	85	96
2hr	26	34	39	45	54	60
5hr	15	20	23	26	31	35

Wetland plant species selection, propagation and establishment for a constructed wetlands ecosystem at Whites Creek, Annandale.

Scott Falconer

Background

It is now widely known that the diversion of stormwater through wetlands is one procedure within an integrated management approach which offers multiple benefits including water pollution control, (Lenehan 1992). Whites Creek is situated in a heavily built up area in the inner city of Sydney, and there is little doubt that constructed wetlands could significantly contribute to stormwater quality improvement, if sensitively designed and operated to cater for local conditions.

Freshwater Wetlands Complex

The topography and soils of the Sydney region consists of Holocene alluvium along rivers, streams and their floodplains, in particular the suspended dunes of the Eastern Suburbs are composed of Holocene marine sand and sandy peat, (Seidlich & Jardine 1997). The structure of the freshwater wetlands vegetation associated with these topography and soils can be classified into one of the following categories; Herbland, Reedland, Open-sedgeland, Sedgeland, Scrub, Low open-forest, Open-forest, (Seidlich & Jardine 1997).

Wetland Plants for Constructed Wetlands

Constructed wetlands consist of water saturated sediment with emergent vegetation, areas of open water with submerged vegetation and a range of wetland animal species, (Osborne & Adcock 1995). The design of constructed wetlands varies depending on site characteristics, which include; climate, land availability, native plant populations and local environmental regulations pertaining to the site. Within these parameters of the site, the design can maximise plant growth by considering; pond depth, soil conditions and water level controls, all of which will influence the type and range of species which will grow (Griffiths 1995). Designs can be categorised on the basis of the life form of the dominant vegetation (Osborne & Adcock 1995):

1. Free-floating plant systems
2. Emergent plant systems
    - Surface flow
    - Horizontal subsurface flow
    - Vertical subsurface flow
3. Submerged plant systems
4. Open water systems.

Designs are further refined to incorporate features that provide wetland wild-life habitat and passive recreational benefits. In terms of habitat, design factors to be considered include; edge design (with convoluted edge providing more littoral areas), inclusion of islands, pond depth, edge slope and terrestrial planting.

The Role of Plants in Constructed Wetlands

Within constructed wetlands, wetland plants have two important functions (Osborne & Adcock 1995):

1. In the water column, stems and leaves (live and dead) significantly increase surface area for the attachment of microbial populations (biofilms).
2. Wetland plants transport atmospheric gases, including oxygen, down into the roots and the sediments that surround them (rhizosphere).

Furthermore, wetland plants also require nutrients and trace elements and therefore play a direct role in nutrient removal, but this role may not be sustained unless plant harvesting is undertaken. Wetland plants also act as filters of pollution and reduce suspended solid loads as well as physically stabilising the sediments through root development.

Terrestrial plants also play an important role in constructed wetlands by stabilising banks against erosion with their root systems, reducing the flow velocity, removing nutrients and water from the soil and providing habitat for many organisms.

However wetland treatment of pollutants is principally undertaken through microbial transformations. The juxtaposition, on a microscopic scale, of an aerobic region surrounded by an anaerobic region is crucial to nitrification-denitrification and numerous other desirable pollutant transformations.

Plant species selection

Based on the Whites Creek design, it can principally be categorised as an emergent plant system with surface flow, and the type and range of wetland species will be chosen, based on; Pond depths, Soil conditions, Water level controls, availability of species, propagation techniques available and plant production rates.

Wetland plant species will include plants from freshwater herbaceous communities including:

1. Free floating plants, such as *Ceratophyllum demersum*.
2. Shallow water emergent vegetation, such as *Typha* (Cumbungi), *Phragmites* (Reeds), *Schoenoplectus* (Clubrushes).
3. Deep water submerged vegetation.

Terrestrial plant species will include plants from freshwater woody communities including the taller communities of *Melaleuca styphelioides* (Paperbark) and *Casuarina glauca* (Sheoak) as well as the shorter understorey species.

Wetland Plant Propagation and Establishment

Potentially useful species for propagation and establishment fall either into the class of 'sprouters' or 'seeders'. 'Sprouters', which are readily established by transplantation of rhizome segments but not by seed, are more desirable in the long term. However 'seeders', which can be readily germinated and established from seed but not by rhizome transplants, are useful for establishing large populations of opportunistic species over large areas after disturbance, as they do in natural ecosystems. Both 'sprouters' and 'seeders' are available from select nurseries in punnets which can be easily transplanted on site.

There are several factors which favour wetland plant establishment including sediment type and water level. Clay substrates and low rates of water movement are less suitable for plant establishment than are sands and higher rates of water movement. Wetland plants also grow best if the water level approximately coincides with the sediment surface. Rhizome transplants and seeds are significantly affected by water level and their proliferation and rate of increase in biomass is also determined by sediment type (Chambers & McComb 1992).

References

Chambers, J.M. & McComb, A.J. (1992). Establishing wetland plants in artificial systems. pp. 20.1-20.6. In: *Proceedings of the International Conference on Wetland Systems in Water Pollution Control.* University of New South Wales, Sydney.

Griffiths, E. (1995). Multiple use of urban waterways: A local government perspective of wetland rehabilitation and re-creation. *Wetlands* 14:26-36.

Lenehan, S.M. (1992). Wetland systems in stormwater pollution control. pp. 12.1-12.14. In: *Proceedings of the International Conference on Wetland Systems in Water Pollution Control.* University of New South Wales, Sydney.

Osborne, P.L. & Adcock, P.W. (1995). Creating environmental kidneys: Wetland ecosystems as pollution filters and habitat restoratives. *Wetlands* 14:37-42.

Seidlich, B. & Douglas, S. "Green Web-Sydney". Sydney Regional Councils.

Pest control measures for the proposed Whites Creek artificial wetland.

Lawrence Kurdi

When planning pest control the first step is to decide which are the target insects, usually flies and mosquitoes are the major pests in wetlands. It may not be necessary to totally eradicate mosquitoes, in fact to do so would be near impossible. A wetland is more than the water course. A complex web of plants and animals operates in any natural system. Thus designers of Whites Creek artificial wetland must take into account these food chains. At the same time the level of pest insects is controlled by these plant and animal interactions. Thus through clever design of the waterway, as well as the inclusion of appropriate plants and animals a pest free wetlands system can be maintained.

The methods to be applied to Whites Creek can be divided into three categories; structural, biological and botanical control methods.

Physical/Mechanical Control Agents

These can be either preventative or corrective measures and "are direct or indirect measures taken to destroy the insect outright, disrupt normal physiological activity by means other than chemical insecticides, or modify the environment to a degree that makes it unacceptable or unbearable to the insect"(NAOS). Environmental/physical conditions of the waterway are almost uncontrollable. Thus mechanical parameters come into play. Perhaps the single most important factor in the control of insects of the proposed wetland is the design of the watercourse. Mosquitoes and Flies require stagnant water to breed. It is in stagnant, nutrient rich waters that the larvae grow. Therefore any design of the waterway must aim to eliminate the possibility of stagnant water and reduce nutrient levels. Such pockets of slow moving water need to be eliminated through construction of rounded, even banks to create a smooth water flow. The flow of water through the system may be slow but it needs to be constant. If this is not possible then regular 'flushing' of the waterway will reduce insect larvae numbers. This regularly happens along Whites Creek after even moderate rain.

Sewage overflow and urban runoff add large amounts of nutrients to the waterway, enabling it to sustain large insect populations and spread disease. The growth of water plants will reduce phosphate and nitrate levels in the pond and this translates as a benefit for the entire catchment as well as Sydney Harbour.

Other mechanical control measures that may be used are light or sound baited traps. There are many varieties of traps. All attract insects through pulsing or flashing lights. Alternately some work has been done on using high frequency sound waves (above human hearing range) to repel insects.

Botanical Control Agents

Botanical control methods are those derived from or a result of the action of plants, for example eucalyptus oil. Most have little persistence in the environment so are safe and short lived. Often the plant needs regular pruning to release it's insect repelling oils. The most suitable plants depend on the insect involved and locally found natural plant species.

The most persistent pests are mosquitoes and flies. These may be controlled by the use of organic sprays. That is Citronella, Pyrethrum, Garlic, Castor and Lavender oils mixed (or used in combination) and sprayed around the area as conventional pesticides would be. Castor Oil trees are already prolific at the site and can be ground for use.

Alternately these oils are commercially available but Lavender, Pyrethrum, Tansy, Wormwood and many other plant species may be planted around the periphery of the wetland for their insect repelling properties. The oils released by these plants and carried on the breeze would also keep away moths, while the pyrethroids would keep away cockroaches and permethrin the Red Backed spiders.

If fish are introduced to the system then plants are necessary to stabilise the banks and provide egg laying habitat.

Biological Control Agents

Through the introduction of the target insects' natural enemies (competitors, parasites, predators or disease) numbers of target pest organisms can be controlled. The Whites Creek site is a small local area. Due to the size and nature of local insect infestations the most suitable of the afore mentioned is control through predators.

Many predator-prey relationships already exist, they only need fostering. Birds already visit the area but with minor provisions (such as suitable seed plants and nesting boxes or islands) bird numbers will increase and so keep insect numbers down.

Soldier Beetles are found in large groups and are large insect consumers and have been used commercially in southern Queensland. Other commercially grown species include Lady Beetles, used by organic farmers to control aphids on crops such as artichokes. So too spiders and the Praying Mantis can be cultivated and used to eat insects around the stream. Many insectivorous spider species exist that pose no risk to humans ,such as the Orb weaving spider are harmless to humans but trap flies. Even Dragon flies, traditionally associated with wetlands skim over the water eating mosquito larvae.

Frogs are endangered all over the globe. The Whites Creek wetland is an ideal habitat in which to build up frog numbers and they will help lower insect numbers.

Surface feeding species of fish such as Goldfish, Koi and other ornamental fish eat insect larvae that hang just below the surface of the water. Native species are usually bottom feeders but are opportunistic and will eat whatever they can get. Several native species may be used including Eels and Flathead (though Flathead are mainly fish eaters). Fish have the added advantage of providing a form of recreation.

Biological control methods have several advantages, not the least of which is economy. The cost of transporting the predator to the Whites Creek site is minor but ensures a safe and self replicating control measure. Legislation protects against development of non-native pest species. The relocation of native species from nearby areas, e.g. fish from Cooks River or George's River is however in keeping with conservation laws.

Predator numbers will rise and fall with the amount of prey and thus predator overpopulation should not be a problem. Oligophagous predators depend on a narrow range of food organisms and so are ideally suited to the task. Australian native species do exist which prey on flies and mosquitoes, providing a safe predator and conserving Australia's biodiversity. Finally some predators have an aesthetic or personal interest to park users.

A Complete System

No single method will control all pests. By predicting what species will become pests a system can be designed that combines all the resources available to us to produce a cheap, safe and perpetual method of insect control.

Feasibility study for the construction of artificial wetlands alongside Whites Creek, Annandale, Sydney.

Mark Cameron

INTRODUCTION

This preliminary report briefly outlines the proposal of constructing an artificial wetland alongside Whites Creek, Annandale.

The primary objective of the proposal (Friends of the Earth and the UTS Shopfront) is to treat stormwater from Whites Creek Catchment. The catchment area is approximately 262 hectares within the municipal Councils of Leichhardt and Marrickville. It is proposed the wetland will cater for low flow periods. Initial flow calculations are estimated at about 0.05 m^3/sec (dry weather flow).

There are also secondary benefits of constructed wetlands. These have a social focus that has the potential to involve and influence a number of community groups in the area. The proposed wetlands provide areas for 'green space', also an education tool for schools through programs such as Streamwatch. Wetlands on the proposed site can bring biodiversity into an area that has been neglected for a long time.

The subsequent information that has to be provided for a feasibility study is described in two parts; Hydrology and Water Pollution Monitoring.

OVERVIEW

In a project description provided by Friends of the Earth (FoE) "it is planned to divert water by pipe from the main channel into a series of constructed wetlands which will flow parallel to and then re-enter the main channel. The wetlands will only receive minor flows, major flows will continue to flow down the main channel. The wetlands will consist of : silt trap, gross pollution trap, shallow swamp like wetland and an additional silt trap before the water re-enters the concrete channel."

Whites Creek catchment is approximately 262 hectares. The land use is medium to high residential and light industry. The lower 1km of Whites Creek is an open concrete channel, whereas the upper creek is a covered concrete channel. The proposed area for development is owned by Sydney Water and is vacant and overgrown with weeds.

Kolar (1996), listed the advantages and disadvantages of 'Constructed Wetlands for the Treatment of Stormwater Runoff'. The arguments 'for' and 'against' wetlands are all in relation to conventional treatment wastewater rather than stormwater.

The advantages of constructed wetland systems (Hammer and Bastian, 1989), include:

1. they are relatively inexpensive to operate,
2. they are easy to maintain,
3. they provide effective and reliable wastewater treatment,
4. they are relatively tolerant of fluctuating hydrologic and contaminant loading rates,
5. they may provide indirect benefits such as green space, wildlife habitats, and recreational and educational areas.

The disadvantages of constructed wetland systems include:

1. they tend to require relatively large area requirements for advanced treatment,
2. their current imprecise design and operating criteria,
3. their biological and hydrological complexity and our lack of understanding of important process dynamics,
4. possible problems with pests.

Livingston (1992) also includes:

5. their relatively high construction costs,
6. their delayed efficiency until plants are well established,
7. public concern about nuisances that can develop.

Kolar (1996) reported the first stage of constructing a wetland is to determine its objectives. Hydrological and geophysical properties of the site should be investigated. A definitive area should be reserved for wetland purposes. Decisions on the maximum flow to be treated. Therefore a base flow is to be calculated, and a hydrological creek profile modelled to determine probable maximum flow through Whites Creek.

HYDROLOGY

Kolar (1996) lists the critical hydrological factors that have to be evaluated in the feasibility and design of constructed wetlands.

- velocity and flow rate,
- water depth fluctuation,
- detention time,
- circulation and distribution patterns,
- seasonal and climatic influences,
- groundwater influences,
- soil permeability.

WATER POLLUTION MONITORING

Another requirement of this study is water pollution monitoring. There are no specific standards in regard to the quality of stormwater runoff. Kolar (1996) states that "Wetlands constructed as part of a stormwater management regime may require EPA approval.". Constant water pollution monitoring of influent and effluent will 'increase local knowledge of the effectiveness of the wetland.' (EPA, 1995). However, the level and length of a monitoring program are often dependent on financial restrictions.

The EPA recommends that for stormwater treatment wetlands, the following procedures should be undertaken:

- continuous monitoring of flow volume,
- sampling of influent and effluent during and following storms,
- sampling of sediment and vegetation every six months,
- reporting of the daily fluctuations in water quality variables (perhaps every six months).

The monitoring should include :

For the influent and effluent

- Flow (kl/d),
- Non-filtrable residue (mg/l),
- Biochemical Oxygen Demand (mg/l),
- Conductivity (µS/cm),
- Acidity (pH),
- Total Phosphorous (mg/l),
- Total Kjeldahl nitrogen, ammonia, nitrate, nitrite (mg/l),
- Faecal coliforms (colony forming units per 100ml),
- Suspended solids (mg/l).

For the wetland sediments:

- Total Phosphorous (mg/l),
- Nitrate (mg/l),
- Sodium adsorption ratio,
- Phosphorous sorption capacity,
- Metals,
- Acidity.

For the water plants:

- Total Nitrogen (g/kg),
- Total Phosphorous (g/kg),
- Biomass load of Nitrogen and Phosphorus (kg/ha).

The Australian and New Zealand Environment and Conservation Council provide some guidelines on the 'acceptable' levels of pollution in stormwater runoff:

- Total Phosphorous (mg/l) = 0.01 - 0.1,
- Nitrate (mg/l) = 0.1 - 0.75.
- DO (mg/l) = > 6,
- Turbidity (NTU) = 15,
- Solids (mg/l) = < 10.

CONCLUSION

This project report describes a feasibility study for a Constructed Wetland alongside Whites Creek, Annandale. This study will determine the hydrological data required for such a proposal. The study will also determine the levels of stormwater pollution currently in the Whites Creek Catchment.

The proposer has to be aware there are legal implications when constructing 'artificial' wetlands. The legal implications have to be adressed before the proposal progresses to the design phase. The implementation of constructed wetlands has advantages and disadvantages that not only have economic , but also social costs and benefits. The economic analysis is relatively straightforward. For a system such as a constructed wetland the social benefits are more complex. In the case of a proposal that can increase the community's environmental awareness, or introduce problems such as mosquito infestation, the effects have to be discussed, and in some way justified.

REFERENCES

Australian & New Zealand Environment & Conservation Council (ANZECC), National Water Quality Management Strategy, Australian Water Quality Guidelines for Fresh and Marine Waters, 1992

EPA, Wetlands for Treating Wastewater from Environment Protection Manual for Authorised Officers, December, 1995

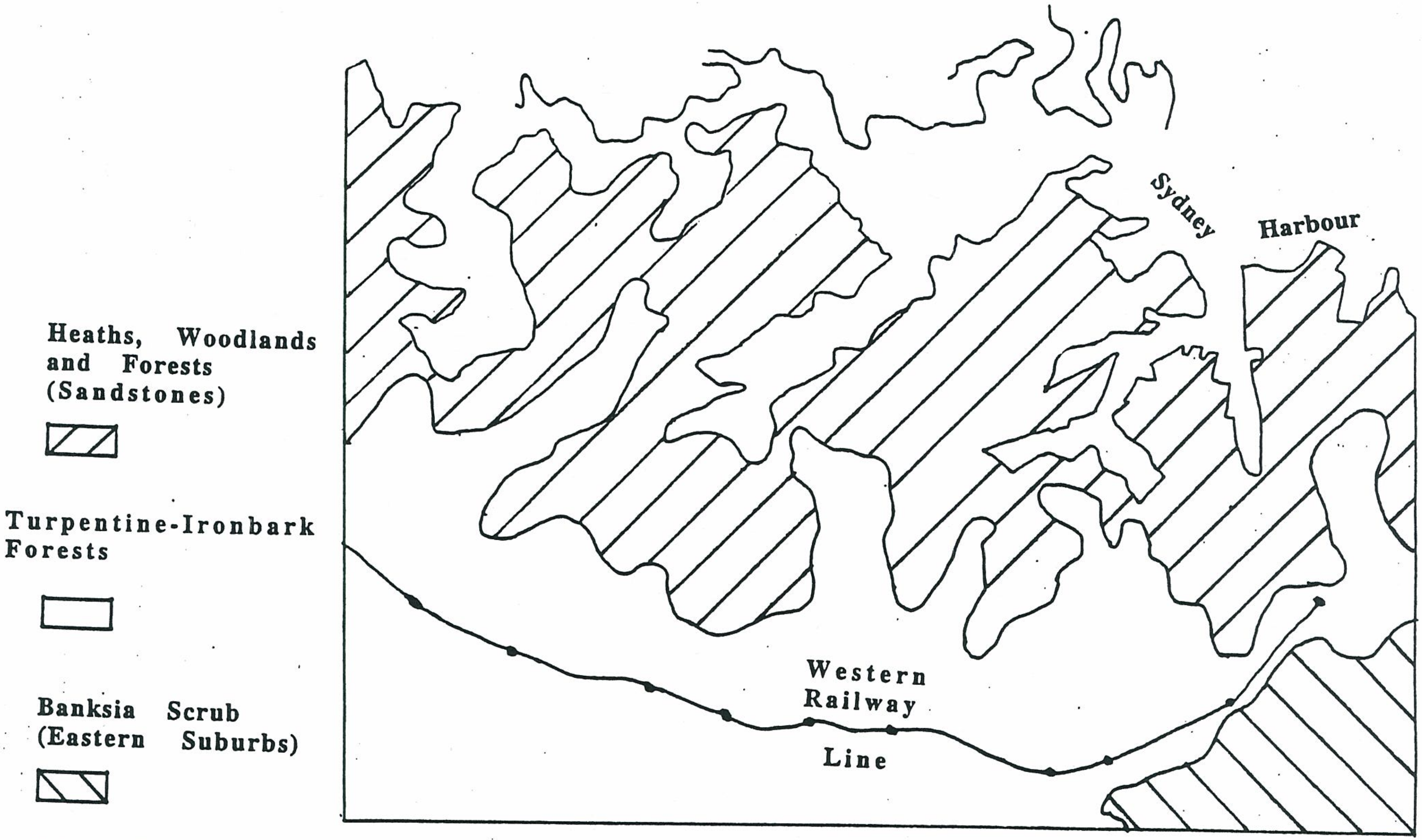
Hammer, D.A. and **Bastian,** R.K., Wetlands Ecosystems: Natural Water Purifiers? from Constructed Wetlands for Wastewater Treatment: Municipal, Industrial and Agricultural (ed. Donald A. Hammer), Lewis Publishers, 1989

Kolar, M., Constructed Wetlands for the Treatment of Stormwater Runoff (A review of the wetlands currently operating in and around the Sydney area), University of Technology, Sydney, 1996

Livingston, E.H., Use of Wetlands for Urban Stormwater Management from Constructed Wetlands for Wastewater Treatment: Municipal, Industrial and Agricultural (edited by Donald A. Hammer) Lewis Publishers, 1989

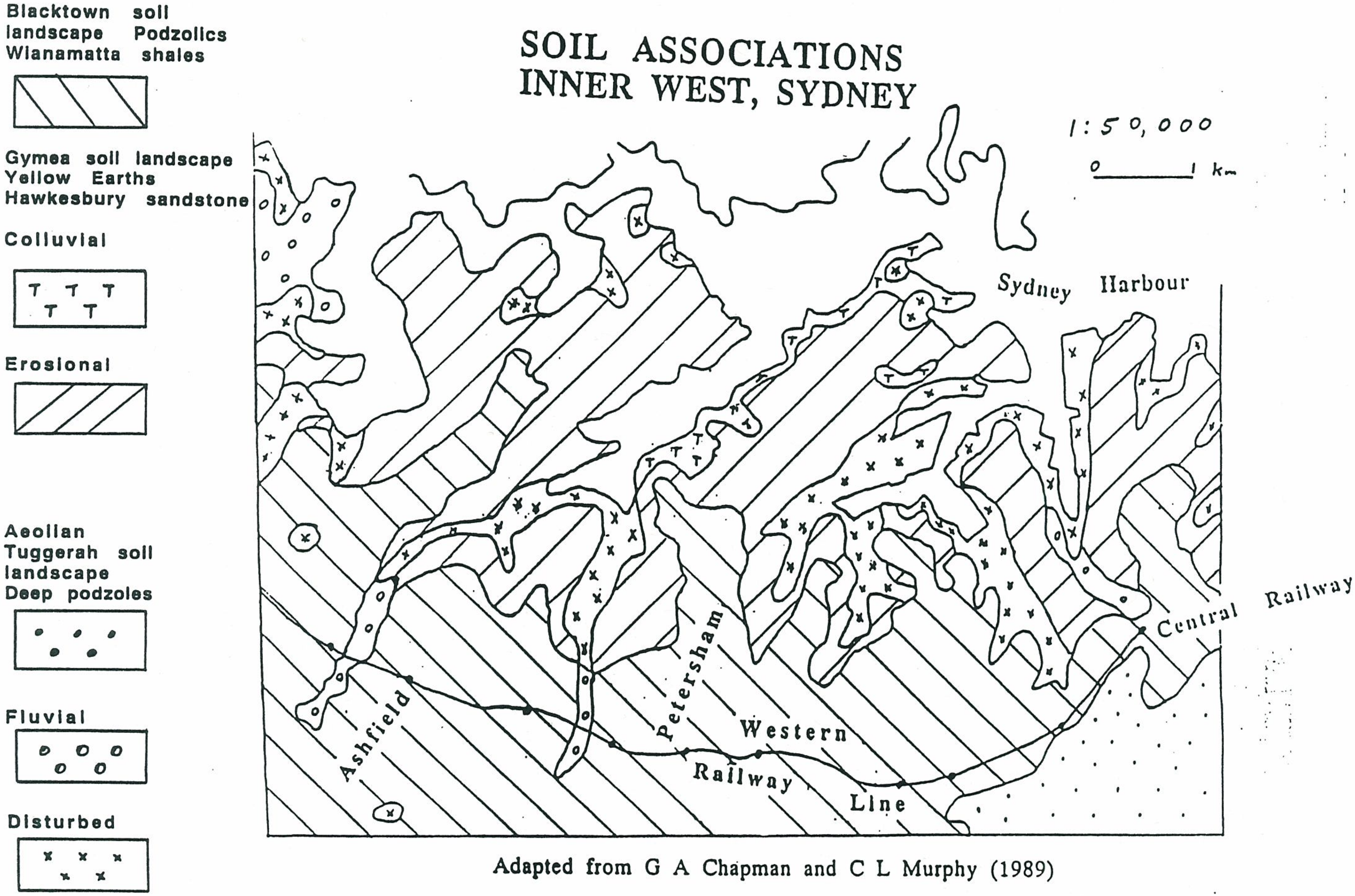
Livingston, E.H. (Florida Department of Environmental protection), Construction and Operation of Wet Detention and Wetland Stormwater Management Systems to Assure Their Proper Operation, 1989

VEGETATION
INNER WEST, SYDNEY



Adapted from D Benson and J Howell (1990)

SOIL ASSOCIATIONS INNER WEST, SYDNEY



Adapted from G A Chapman and C L Murphy (1989)