Napier Park Stormwater Reuse Project

Concept Design Report

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Prepared for

Moonee Valley City Council

Prepared by

AECOM Australia Pty Ltd
Level 45, 80 Collins Street, VIC 3000, Australia
T +61 3 9653 8222 F +61 3 9653 8299 www.aecom.com
ABN 20 093 846 925

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1.0 Introduction

1.1 Background

The Napier Park site is a public park in the suburb of Strathmore, City of Moonee Valley to the north west of Melbourne CBD. The park has an area of approximately 4.2ha. The park is bounded by Woodland Street, Napier Street, Glenbervie Road and Noble Avenue. The surrounding area comprises residential dwellings. Figure 1 shows the general location of the Napier Park site and the surrounding residential development.

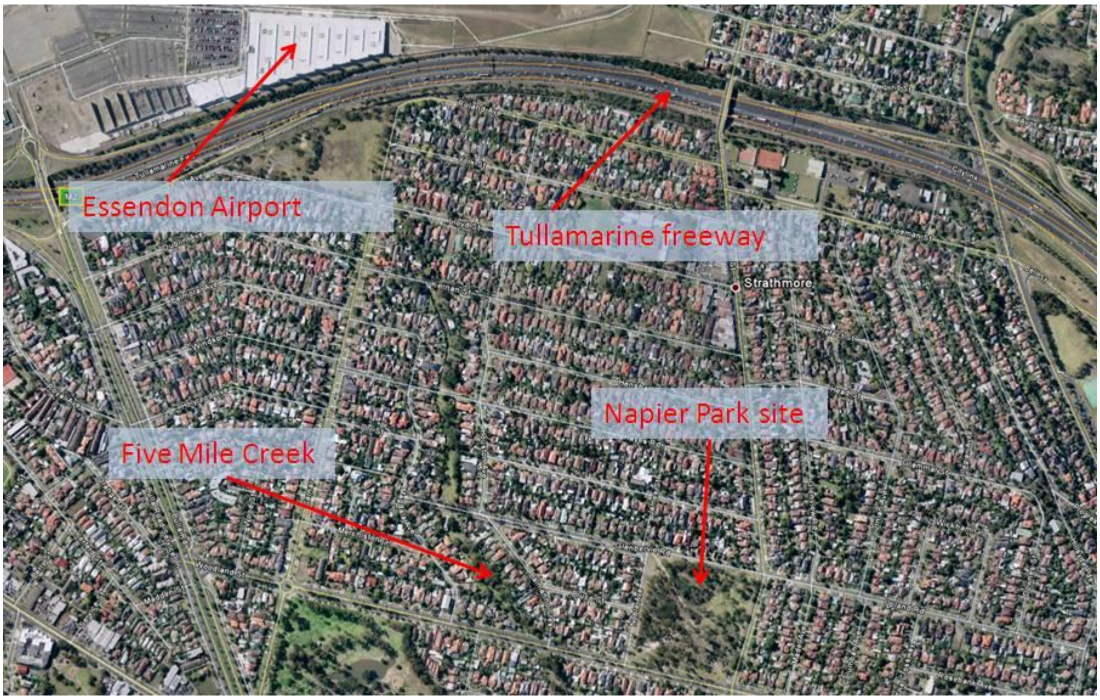


Figure 1 Napier Park, Strathmore

The park is characterised by remnant plains grassy woodland vegetation and was gifted to the Moonee Valley City Council for preservation and protection of this landscape character. Remnant River Red Gums *(Eucalyptus Camaldulensis)* dominate the open space and are distributed across the site with numerous self seeded juveniles present. The Napier Park specimens are protected under the National Heritage Register of significant trees and are recognised as one of only two significant stands of remnant river red gum dominated plains grassy woodlands in the Melbourne area. The preservation and protection of these trees is instrumental in the management of the park and has been supported by the formation of The Friends of Napier Park in 1986. The Friends of Napier Park have been actively involved in the management and preservation of the park in recent years and are considered to be instrumental stakeholders in the long term viability of the existing landscape character and ongoing preservation efforts. Figures 2 to 4 provide character images of the existing vegetation within the Napier Park site.

Figure 2 Typical grassy plain woodlands vegetation forming understorey to remnant and juvenile Red Gums.

Figure 3 Large Red Gums in area of maintained grass adjacent to play equipment in north west of Napier Park

Figure 4 Large remnant Red Gums dead or with visible signs of stress

Development changes within the catchment and the increasing occurrence of prolonged periods of below average rainfall have resulted in stress on the existing vegetation. A number of large remnant red gums have died in recent years and other specimens show significant signs of poor health. Moonee Valley City Council have pursued a number of strategies to alleviate the decline in vegetation health within the park with limited success. It is hoped that through the reinstatement of the overland flow path once present on the site and harvesting a proportion of water for irrigation use the long term viability of the park (in its present form) can be achieved.

Concurrent to this individual project, the Moonee Valley City Council is presently developing an integrated management strategy to establish goals and targets for water management including potable water use, sewage and stormwater discharges. The outcomes of this Napier Park project are consistent with and will contribute to this municipality wide project through reduced reliance on potable irrigation water, reduced overall nutrient loadings into Port Phillip Bay, improved water quality in stormwater runoff and the preservation of an existing green space with associated environmental and social benefits. The preservation of existing areas of native vegetation such as Napier Park through initiatives such as stormwater harvest provides an innovative response to a changing climate and its influence on already modified urban landscapes.

1.2 Project Objectives

The primary objective of the project is to address the ongoing decline in the health of the existing remnant native vegetation within Napier Park. Inspection and discussion with Council representatives has identified the lack of water as being the main contributing factor in the current poor health of the trees. Therefore a design response to support on site irrigation of the vegetation that provides an acceptable reliability of supply is required.

Water quality data from stormwater discharges into Moonee Ponds Creek from the Five Mile Creek catchment indicate high levels of phosphorous and turbidity. Through providing passive treatment of flows through the Napier Park reach, improvements in water quality from the contributing upstream catchment will ultimately result in proportionate improvements to the downstream receiving environments. Event flow stormwater will have improved water quality and the extraction of a proportion of flows will effectively further remove the contaminant loading from the downstream receiving environment. The re-establishment of an overland flow path through the park will also re-establish the community’s connection with the relic hydrology of the area and provide habitat for indigenous flora and fauna.

The objectives will be met through re-establishing the overland flow path along the eastern boundary of the park, which originally provided a tributary to the Five Mile Creek system, and providing for underground storage in the south east of the site for irrigation reuse. The existing and future landscape of the Park will be a key consideration with the proposed water course integrated within the context of the Napier Park setting. A conceptual design has been developed for the site which is based on dynamic hydrologic modelling, hydraulic analysis and landscape integration. The concept design is intended to inform the proposed stakeholder consultation prior to functional/detailed design stages and identify the critical steps required to further develop the concept towards a functional/detailed design.

This project represents one of the first stormwater harvesting projects where the re-captured stormwater is for irrigation of remnant native vegetation. This is likely to be an early response to climate change.

1.3 Overview of Napier Park Site

The park has a total area of approximately 4.2ha. A number of granitic sand pathways intersect the site with areas of remnant bushland interspersed with mowed open grass and a children's playground in the northwest. The park topography is defined by a moderate slope towards the south east with a high point in the northwest of the site adjacent to the intersection of Glenbervie Road and Noble Ave. The western extent of the park is approximately aligned with a ridge crest running north south (defined by Noble Ave) with fall in the park to the east. The eastern boundary of the park (Napier Street) forms the low point of the site and has been identified as the approximate location of an ephemeral watercourse prior to drainage works. This watercourse contributed to the upper reaches of Five Mile Creek. Drainage works have subsequently diverted these ephemeral flows into underground culverts, conveying flows downstream to the Moonee Valley Creek. The drain conveying flows from the north of the site intersects in the northeast corner of the site with a secondary connection joining from the north east (see figure 6). There is an existing roadside sump and connection with the drainage network in the south east corner of the site. Figure 5 provides an image of the junction pit in the north east of the site (where flows are proposed to be diverted from).

Figure 5 Stormwater Drain junction pit adjacent to soft path in north west of Napier Park

Preliminary review of geological records indicates that there was substantial volcanic activity, to the north of Melbourne during the Pleistocene era (2 million years ago). These eruptions extruded flows that filled the valleys of the Moonee Ponds, Merri and Darebin creeks. Due to the elevation of the land which comprises Napier Park, it is considered unlikely to have been influenced by these eruption events.

Information provided by Moonee Valley City Council describes the park as having a gentle south facing slope with the underlying rocks being portions of the marine or estuarine tertiary sandstones of the Brighton group (2-65 million years ago). The sedimentary parent rock gives rise to a duplex soil with a brown clay loam A horizon and a yellow clay B horizon. The soils are moderately permeable and relatively fertile. The subsoil structure of the park site will have a direct influence on the movement of infiltration water and its interaction with the vegetation on the site. The presence of the Red Gums on the ridges and upper slopes on the site is contrary to their typical habitat of low lying flood prone riverside environments. It is considered likely that the geological landform is preventing deep infiltration and allowing the surface soils to be saturated during localised rainfall events (moderate to heavy). This saturation mimics the flood conditions experienced in typical Red Gum habitat and is likely to have been instrumental in the establishment of the trees in the area. In addressing the particular irrigation requirements of the existing Red Gums, further geotechnical investigations should be undertaken to verify the sub surface profile. This knowledge will inform the refinement of the irrigation strategy and the functional design of an appropriate distribution system.

Figure 6 shows the area of Napier Park with the existing drainage in the northeast corner of the site.

Figure 6; Napier Park site with existing drainage and proposed diversion point in north east corner (image courtesy Nearmap)

The existing contributing catchment (at the T-junction in the North East of park) has been calculated based on drainage plans provided by Moonee Valley City Council. The catchment has a total area of 16.29ha consisting of medium density residential land and roads. Flows from the residential roof areas and impervious land cover (primarily roads) contributes to these stormwater flows. The existing drainage asset has been designed based on the 5 year ARI event with larger events to be contained within the park. Figure 7 shows the extent of the contributing catchment north of Napier Park.

Figure 7; Contributing stormwater drainage catchment north of Napier Park

2.0 Concept Design

2.1 Site Inspection

A site inspection was conducted on 29 September 2009. The inspection was attended by Moonee Valley City Council personnel representing engineering services, landscape and conservation along with Stuart Farrant (Engineer) and Peter Breen (Ecologist) from AECOM. A subsequent site inspection was undertaken on 27th November with Jo Bush (AECOM Landscape Architect) to specifically look at the site specific landscape issues.

Based on discussion with Council and assessment of the site constraints and opportunities a preferred design approach has been developed. The design responds to the existing topography of the site, the original inferred alignment of the Five Mile Creek, minimising disruption to the existing vegetation and the spatial requirements of key system components.

An unlined vegetated swale is proposed to convey flows from the junction pit in the north east of the park towards the south east corner. The alignment of the swale has been based on the existing ground profile on the site, minimising earthworks close to trees (and primary roots) and connectivity with the drains for extraction and return of excess flows at the lower end.

2.2 Design Methodology

Hydrologic modelling to estimate the catchment water balance and temporal fluctuations has been undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). Modelling has been used to assess the expected performance and reliability of the scheme averaged over a 10 year period (1996-2005) as well as looking at identified high (2005) and low (1997) rainfall years within the time series. Climatic data has been taken from the Melbourne Airport rain gauge (86282) with models run on 6 minute time steps. An average impervious fraction of 65% has been assumed for the site which reflects the medium density of the residential dwellings and carriageways within the catchment.

The proposed ‘day lighting’ of the existing culvert has been modelled as a vegetated swale with moderate infiltration of 3.6mm/hr. At the downstream end of the swale a 200kL storage has been modelled based on the available area in the southeast and a 2m depth of underground storage. Inflows into the storage have been extracted from MUSIC and used to estimate reliability of irrigation supply.

Design of the swale allows the conveyance of the 5 year storm event. Calculation of the Q^5 (discharge) is estimated to 3.0 cumecs based on the rationale method with a 300m longest catchment drainage length and IFD tables for the area of Napier Park,

$$Q = C\,i\,A$$

Where C = Runoff coefficient =0.75 (conservative)

i = rainfall intensity =87.9 mm/hr (2.44 x 10^{-5} m/s)

A = Catchment area =16.29 Ha (162,900 m^2)

Q = ~3m/s based on 1 in 5 year storm event

The swale channel has been designed to pass up to $3.0m^3/s$ before the banks are breached using PC-Convey V5.31. Flows above this will be contained in the existing park flood route which is understood to presently form part of the major drainage for the area.

2.3 Irrigation Strategy

Irrigation within the Napier Park area needs to respond to the specific requirements of the remnant Red Gums within the park. Red Gums typically occur in areas subject to intermittent flooding and can withstand significant dry spells between saturation events. The majority of the Napier Park site however, is not in an area likely to have been flood prone (other than the creek channel and small ponded water body on east side of park) being in the upper portion of a catchment with significant fall across the site. Interflow in the subsoils is likely to have contributed to sustaining the trees with tree roots intercepting subterranean water conveyed on the interface with the underlying bedrock. Widespread development within the catchment has reduced the percolation of rainfall into underlying soils and therefore reduced the interflow available to vegetation.

Based on the specific irrigation demands for the Red Gums (and other remnant vegetation) an irrigation strategy has been developed for the park. The strategy is based on 50mm irrigation applications applied to mimic flooding whilst promoting infiltration. The strategy allows for irrigation of 50% of the total park area and allows for 6 annual applications across the park. This is summarised as follows;

- Total park area ~42,000m^2
- 50% of park to be irrigated ~21,000m^2
- Based on 50mm application, total park application volume ~1 ML/irrigation cycle
- Assuming 200kL storage, park area to be separated into 5 application zone
- Each zone receives 200kL over 5 hour period at 11l/s to drain storage
- Optimum frequency of 6 applications over entire park per year (30 individual applications)
- Total annual irrigation demand of ~6ML/yr

This projected demand of 6ML/yr is consistent with the estimates provided by Mark Douglas from *Bushland Recovery* of 6 – 12 ML/yr.

The functional design of the irrigation reticulation and distribution will need to be verified and refined at later stages of the project. Geotechnical investigations should be undertaken to confirm the sub surface conditions which have supported the establishment of the Red Gums and ensure that the irrigation application method best mimics this natural hydrology of the site.

In designing the proposed irrigation strategy for the Napier Park site, consideration has been given to climate change and an appropriate response to it. One of the critical implications of climate change on Melbourne is a predicted reduction in rainfall with models suggesting annual average precipitation changes of -4% (-9% to 1%) by 2030, and -6 to -11% (-25% to +3%) by 2070 (CSIRO and BoM, 2007). Based on information from the Bureau of Meteorology the long term average (based on 39 years) for the Melbourne Airport rain gauge is 533mm/yr. The rainfall data set used in the modelling of the Napier Park site (1996-2005) had a mean average annual rainfall of 410mm. This represents a 123mm/yr reduction from the long term average. A further 4% reduction from the 410mm/yr average would further reduce the mean annual rainfall to 393mm/yr. This represents an overall total reduction from the long term average of 140mm/yr. Based on the 6ML/yr irrigation application over the 4.2ha Napier Park site, the proposed irrigation strategy will provide 143mm/yr supplementary water. This can be used to further validate the strategy by harvesting stormwater to mimic the long term historical rainfall for the area. This is an important consideration in responding to the incremental deterioration of the health of remnant native vegetation. The harvesting and irrigation scheme can therefore provide resilience to the impact of both development within the catchment and climate change.

3.0 Modelling Results

3.1 Volumetric Flow Analysis

Based on MUSIC models for the catchment and site the following mean annual flows have been determined. Table 1 summarises estimated catchment runoff volumes based on MUSIC modelling.

Table 1 rainfall runoff relationship for modelled years

Time series of analysis	Mean annual rainfall (mm/yr)	Mean annual flows (ML/yr)
1996-2005	410	35.5
2005	546	52.6
1997	254	19.1

These results show the potential for significant variation in the mean annual catchment discharges with a range of up to 300mm in the 10 year period analysed. Whilst this variation is significant, the proposed irrigation demand of 6ML/yr is exceeded even in the 1997 low rain fall year and should be attainable with appropriate storage provision to improve reliability. Figures 8 and 9 graphical represent the temporal storage inflow patterns for the two extreme event years.

Modelling results indicate that there is sufficient rainfall runoff to meet the annual volumetric irrigation demands within the Napier Park site. The hydraulic aspects of capturing this in buffer storage for the application strategy as specified in 2 .3 has also been considered. The temporal variation in the annual rainfall will impact on the reliability of the irrigation scheme. Individual high intensity events with high volumes will not always be able to be fully captured due to storage restrictions. Further works will be required at the functional/detailed design stage to confirm the preferred irrigation strategy and to refine the modelling to reflect the projected demand patterns and supply reliability. It is also likely that it will be feasible to harvest additional water for refill of council water tanks. The availability of this will depend slightly on annual rainfall patterns and capitalising on instances where rainfall occurs following a park wide irrigation cycle. Provision shall be made in the functional design to accommodate this refill of tankers directly from the underground storage.

To validate the proposed irrigation strategy the number of individual days where 200kL of inflow was likely was determined to ascertain whether the proposed irrigation scheme is feasible. This preliminary analysis found that in 2005 there were 34 days where daily inflow exceeded 200kL whereas in 1997 there were 16. These events are fairly uniformly distributed across the year.

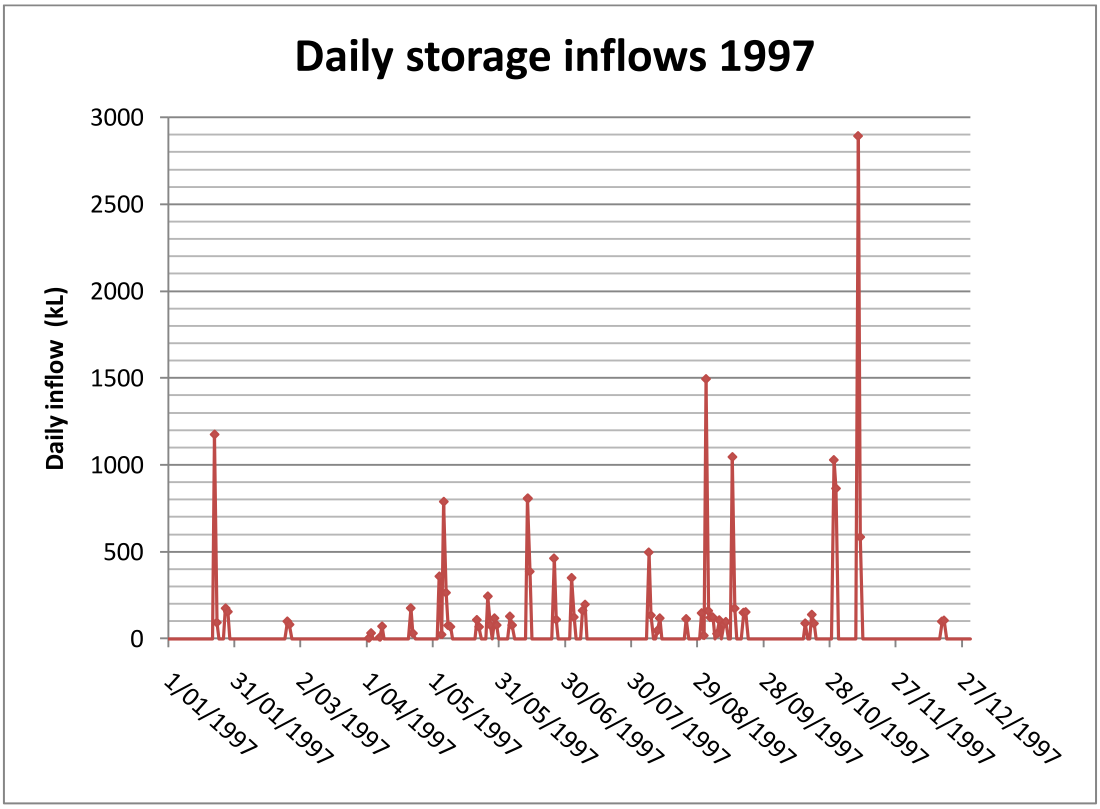


Figure 8 Modelled storage inflows for 1997 (low rainfall year)

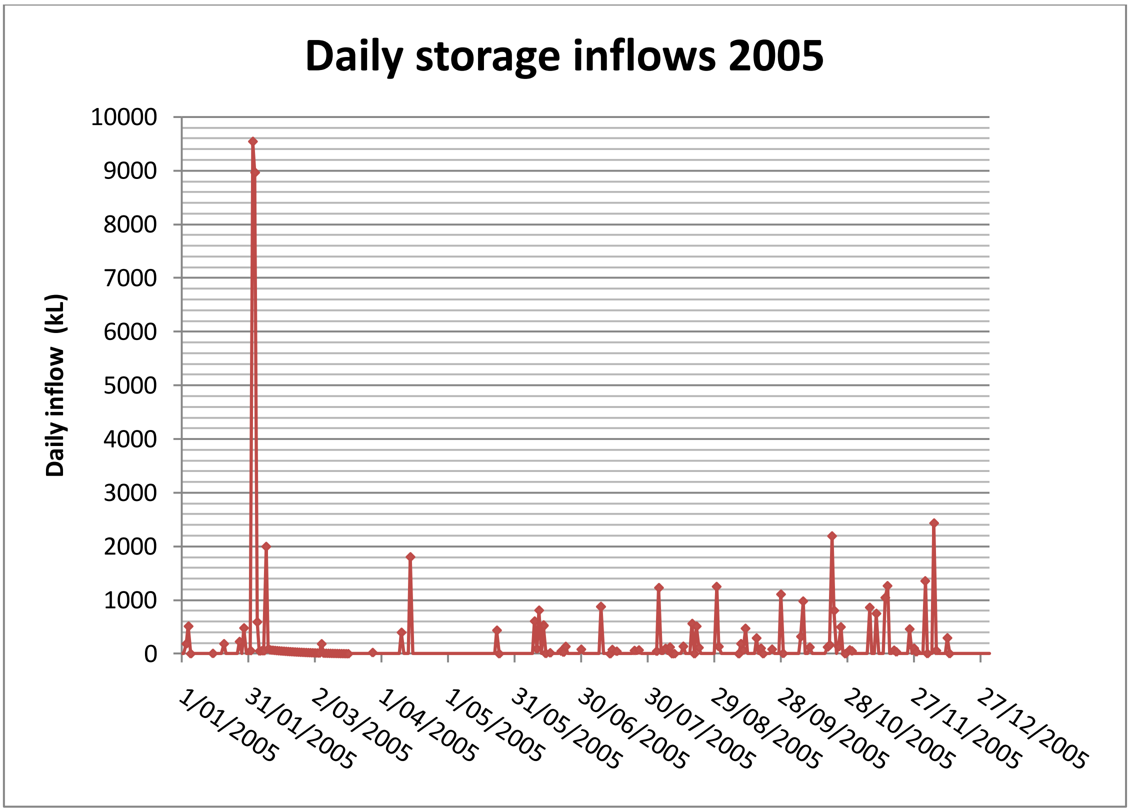


Figure 9 Modelled storage inflows for 2005 (high rainfall year)

This preliminary analysis does not consider the combined effect of preceeding low flow days. Based on this it is considered likely that the 30 applications per year irrigation strategy outlined in section 2.3 should be achievable with an acceptable level of reliability. It is also considered likely that the Red Gums will be resiliant to periodic dry years (where full application over summer months) assuming that they still achieve a number of saturation watering events through the remainder of the year. The operational framework of this strategy to define the timing of irrigation release (in relation to the filling of the storage) shall be refined in the detailed design phase of works. This is likely to be based on water level telemetry whereby the full storage volume will be released (with an overnight application cycle) once the underground storage is full.

3.2 Water Quality Treatment

Currently the drainage networks discharges downstream of the Napier Park site into the Moonee Ponds Creek. Catchment generated contaminants from the impervious surfaces will therefore contribute to the degradation of the downstream recieving waters through both reduced water quality and the altered hydrology. By the implementation of this daylighting of the existing drainage course through Napier Park and the extraction of a proportion of stormwater for irrigation application, contaminants (nutrients and suspended solids) will be removed from the system resulting in benefits beyond the boundary of the site.

Based on preliminary modelling and a stormwater harvest of 6ML/yr the water quality performance has been estimated. The results are summarised in table 2

Table 2 Contaminant removal from system

Contaminant	Inflow	Outflow (Discharge)	Mass removed	% reduction
Total suspended solids (kg/yr)	7,370	1,558	5,812 kg/yr	79%
Total Nitrogen (kg/yr)	102	71	31 kg/yr	30%
Total Phosphorous (kg/yr)	15.1	5.8	9.3 kg/yr	61%

The volumes of removal are considered to be conservative based on only harvesting water for irrigation within the Napier Park site. Any additional harvest for purposes outside of the park (such as water truck refill) will improve the overall water quality performance of the system. Pollutant removal is increased significantly through the effective removal of over 20% (including infiltration/evaporation) of the mean annual runoff with their contaminant constuents. This stormwater treatment and harvesting scheme therefore provides the opportunity to significantly reduce the contaminant loadings into downstream recieving environments.

4.0 Design Components

Full landscape schematics are included in Appendix A. The following provides a brief summary of key functional aspects of the concept design. Figure 10 provides a schematic of the overall site.

Figure 10; Indicative schematic illustrating proposed works.

4.1 Drain Diversion

Storm water flows will be diverted from the existing junction in the north east of the site (feature 1 on figure 10). The invert level at the junction has been surveyed at 48.80m which is approximately 1.2 m below the existing ground level immediately above the pipe. Due to the relatively small catchment area it is proposed to divert the entire drain flow into the surface swale. Based on a 5 year runoff volume of up to $3m^3/s$, the diversion and downstream treatment have been designed to convey these flows.

The existing stormwater drain will be cut immediately downstream of the junction and discharge to the swale section which initially flows in a western direction to circumvent the adjacent Red Gums. An engineered headwall (can be faced with natural boulders) will be needed at the diversion point where the flows discharge to the swale. Due to the 1.2m elevation, a balustrade handrail will be required across the top of the diversion point. It is proposed that the existing pedestrian path will be re-routed to the north of the new alignment to avoid the cost implications of bridging the swale.

4.2 Vegetated Swale

The swale will effectively commence at the proposed drain diversion point and continue down to the underground storage cell in the south east of the site. The swale will be constructed with 4 identified sections which are briefly described below.

4.2.1 Section 1; Diversion Point to Daylight

Due to the depth of the existing drain invert and the design objective to avoid pumped diversion, the swale will initially be constructed at depth. Over a reach length of approximately 60m, the swale will gradually reduce in overall depth relative to the existing ground surface. Over this reach the swale will have a base slope of 2% (as opposed to the average existing ground slope of 3.5%). The base width will be 1m at the diversion point increasing to 3m for a section 30m downstream before constricting back to 2m at the point where the base of the swale is at 500mm below the existing ground surface.

The design of the side batters will be based on public safety and aesthetics. From the diversion point, the batters on the west of the swale will be 1V:5H and 1V:3H on the east side (to avoid excavation too close to the existing large red gum. This initial section will be subject to higher velocity flows (particularly immediately downstream of the pipe outlet) and require rock armouring to prevent scours and dissipate energy. The rock armour will extend across the floor of the swale extending up to 500mm up the batter slopes. A v notch low flow channel will be formed in the base of the swale with a width of 400mm and depth of 200mm. The low flow channel and the armour will comprise 200-250mm D^{50} rock hand placed (vegetation will over time likely establish between rocks). The extent of rock armour up the batter slopes and across the base can gradually reduce over the first 30m with the rock lined low flow channel continuing downstream. The upper portion of the batter slopes shall be planted with appropriate riparian vegetation to stabilise the upper slopes and enhance the aesthetics of the swale.

This section is excavated entirely within the existing mowed grass area and away from the base of existing trees. Figure 11 provides an indicative cross section through this reach of channel (full schematic included in Appendix A).

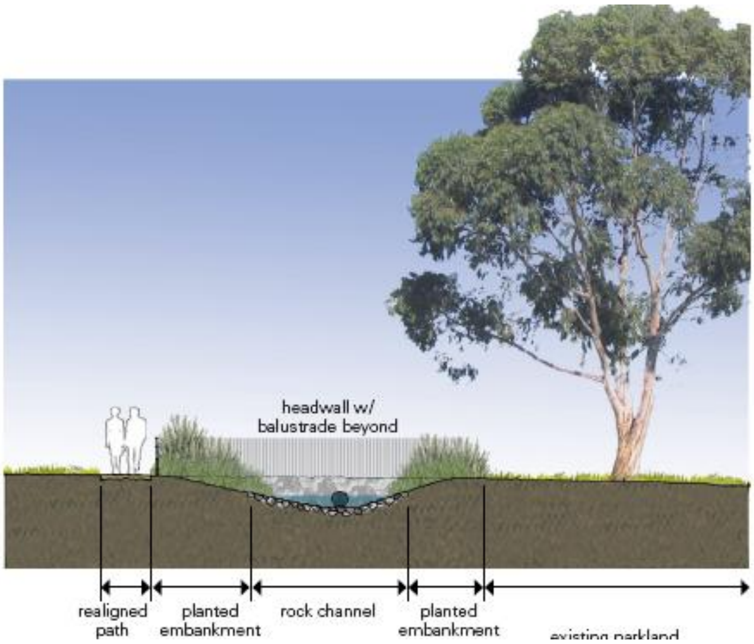


Figure 11; Cross section A, diversion point to daylight section

4.2.2 Section 2; Daylight to Flood basin

From the point where the swale is 500mm below the existing ground surface the swale will increase in slope to 4% and continue for a further 40m downstream. The base will typically be 2m wide (localised widening in places) with 500mm high 1V:5H side batters. The low flow channel (as described above) continues in the base of the swale. The swale base and side batters will be planted with grasses and riparian vegetation to filter the passing flows and provide landscape amenity. Intermittent large rocks and decaying logs can also be included to provide habitat and 'naturalise' the waterway.

This section will involve the removal of a number of small shrubs and juvenile red gums. Attention has been given to minimising the impact on any large established trees.

Figure 12 provides an indicative cross section through this typical form of the swale (full schematic included in Appendix A).

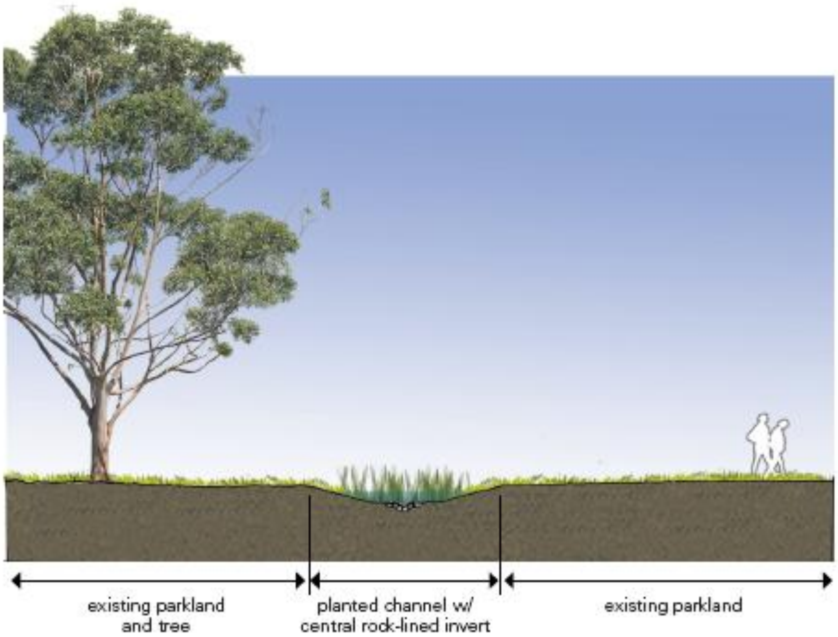


Figure 12; Cross section B, daylight to flood basin

4.2.3 Section 3; Flood basin

At the point approximately half way down the Napier Road boundary the swale will deviate to the west into the existing fenced off woodland area. The swale invert at this point will be at RL 46m. A flood basin will be constructed in the area between the existing large red gum and the footpath. The flood basin will be a shallow pan feature with a flat base at the 46m elevation. The western side of this (beneath the red gum will be in cut (up to 750mm at 1V:3H) and the east side (along the footpath boundary will be defined with a low bund (46.5m to 47m crest height). The existing trees in the area will be retained and will be inundated at the base during moderate flow events. The point where the swale turns into the flood pan shall be armoured with 500mm D^{50} rocks to prevent scour of the low embankment at this point. This section is designed to flood during rainfall events and partially retard a proportion of flows by the downstream outlet being set at 46.1m elevation. The base (and disturbed batters) will be planted with grasses and other vegetation suited to this hydrologic condition. The base of the flood basin can be locally deepened if desirable to provide an ephemeral wetted area which would dry relatively quickly following rainfall events.

Figure 13 provides an indicative cross section through the flood pan area (full schematic included in Appendix A).

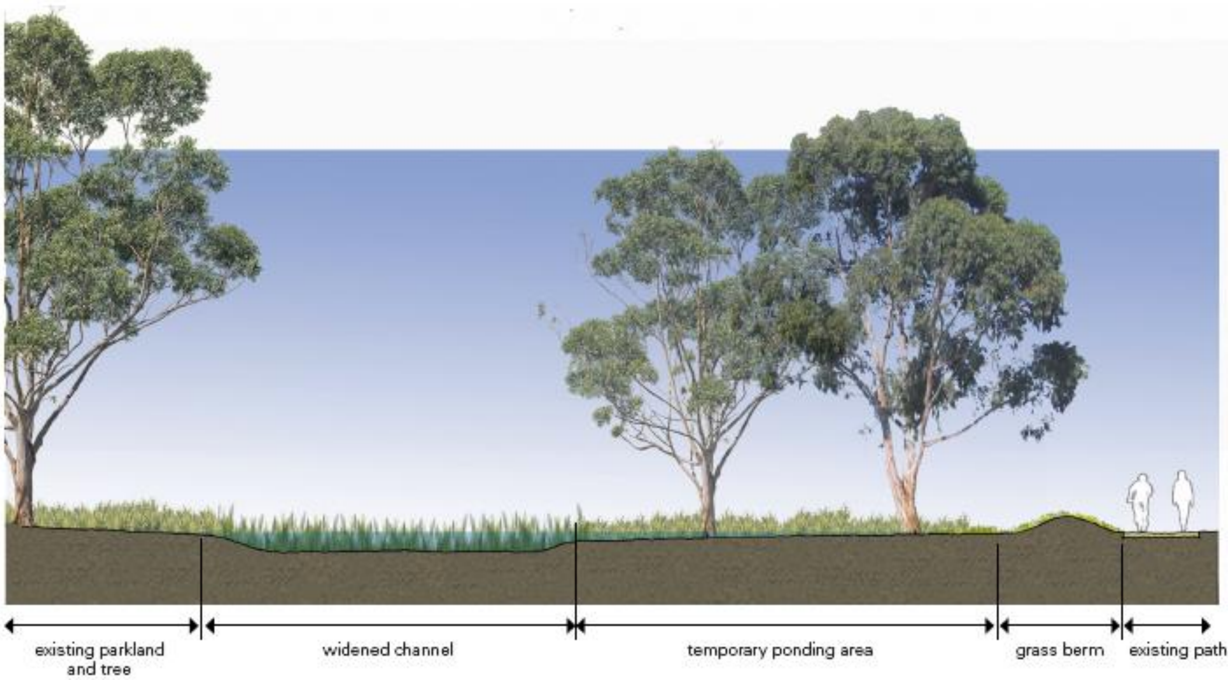


Figure 13; Cross section C, flood basin

4.2.4 Section 4; Downstream Reach

The flood basin will discharge at 46.1m from the downstream end between the two medium sized red gums. The swale will continue downstream with a base width of 2m and depth of 500mm at a slope of 3% to the outlet for the underground storage. The lower end of this section will form a depression (ponding during storm flows) with a ‘pill box’ outlet riser. The ‘pill box’ will be sized to convey the design flows into the storage with overflow diversion controls below ground level. Provision should be made to include a litter trap within this reach to remove leaf litter and other debris prior to discharge to the storage. Options for this can be further developed in the detailed design phase and should respond to the visual aspects of the waterway restoration.

The length of this section has indicatively been shown on Figure 10. This could be increased to provide a more visible feature from the road intersection if the location of the storage was moved to the south west corner of the site (beneath the existing pathways).

4.3 Underground Storage

Intermittent storage will be provided in a 200 kl underground storage. The design of these storages varies. It is proposed to use pre-cast concrete box sections which are installed onto a poured concrete slab. This system enables access for maintenance, rapid construction, high storage to bulk ratio and robust under load bearing applications. Figure 14 shows the construction of pre-cast underground storage.

Within the storage a pump sump will be positioned to extract the required irrigation water. Based on feedback of water level it is proposed that the tank will be drained (from full) in each application with the irrigation occurring overnight. This will be achieved with a pump rate of approximately 11l/s. The irrigation strategy and interaction with the storage will need to be further refined in the detailed design stage. It is likely that sufficient water will be available to extract additional water for filling water tankers to irrigate street trees throughout the municipality.

When the tank is full, the flows will overflow to the existing drainage infrastructure located beneath Napier Road. Discussions with council drainage Engineers indicate that the diameter of the existing stormwater pipe located in the south east corner of the site is suitable to convey flows equivalent to the upstream infrastructure. The construction of the underground storage could be integrated with overall landscape objectives for the site and be installed without cover (forming a hardstand surface for displays, seating or public art). This can be discussed further at the detailed design stage.

Figure 14 Construction of underground storage

4.4 Irrigation Reticulation

The design of the irrigation reticulation is intended to be undertaken at the functional design stage. For the purposes of concept design validation we have made assumption and developed a preliminary irrigation strategy as outlined in section 2.3. The irrigation strategy may be refined based on further investigation of the parks subsoil conditions and irrigation response to this to support the preferred flood cycle of the red gums.

At this stage, we have based our modelling on a 5 zone irrigation network with irrigation of the site occurring in 5 applications. This is likely to be achieved with low flow main lines feeding subsurface laterals to promote saturation of the soils. The specific design of this reticulation will need to provide a uniform distribution across the site and should be undertaken by an irrigation specialist.

4.5 Cost Estimates

Based on preliminary costing of the proposed system the following construction estimate is provided.

	Unit	Qty	$/unit	$
Upstream diversion works	LS	1	$10,000	$10,000
Upstream armouring	LS	1	$5,000	$5,000
Swale construction	m	160	$175	$28,000
Downstream storage diversion	LS	1	$10,000	$10,000
Underground Storage	kl	200	$750	$150,000
Connection with SW drains	LS	1	$10,000	$10,000
Pump sump and pump	LS	1	$20,000	$20,000
Irrigation reticulation	LS	1	$100,000	$100,000
Landscaping (include paths and barrier)	LS	1	$30,000	$30,000
TOTAL (ex GST)				**$363,000**

These cost estimates are indicative only and should be confirmed at the detailed design stage of the project. Irrigation design in particular will be dependent on the final design solution

5.0 Conclusions and Recommendations

Following preliminary catchment analysis and computational modelling (MUSIC) of the Napier park site and catchment, a concept design has been developed. The concept design is based on the stated objectives of day lighting the approximate original alignment of Five Mile Creek and harvest water for irrigation of the Napier Park site. Irrigation of the site will sustain the existing heritage listed Red Gums which are presently under significant stress due to modifications to the upstream catchment and prolonged drought conditions. The day lighting of the water course will also enhance the ecosystem of the park, provide passive irrigation to a corridor of Red Gums, improve the amenity value of the park and provide connectivity between the local community and the pre development hydrology of the landscape.

The concept design comprises a vegetated swale which daylights the existing underground drains and conveys the event based flows down the east side of the park. The water way will therefore be ephemeral in character which is consistent with the original stream on the site. Areas of the swale will facilitate localised shallow pooling to promote infiltration and provide diversity of ecology within the park. At the downstream end of the swale, the flow will be preferentially diverted into underground storage for holding prior to irrigation application. The proposed scheme has the potential to harvest 6ML/yr for irrigation with resultant water quality improvements through contaminant removal. Based on a mean annual flow of more than 30ML/yr it is likely that excess water will be available for additional demands depending on the temporal rainfall patterns and demands.

The irrigation strategy will be further defined following consultation with suitably qualified botanists and investigations into the localised geology of the site. In developing the scheme to the functional design stage the following works will be required;

- Consultation with the community including Friends of Napier Park and Indigenous representatives
- Refinement of irrigation demands based on consultation with botanists or other qualified experts
- Investigations to identify the site specific sub surface characteristics to determine relationship with original hydrology of the site
- Further clarification of the suitability of the downstream drainage infrastructure for overflow connection back into the existing stormwater network.

Appendix A

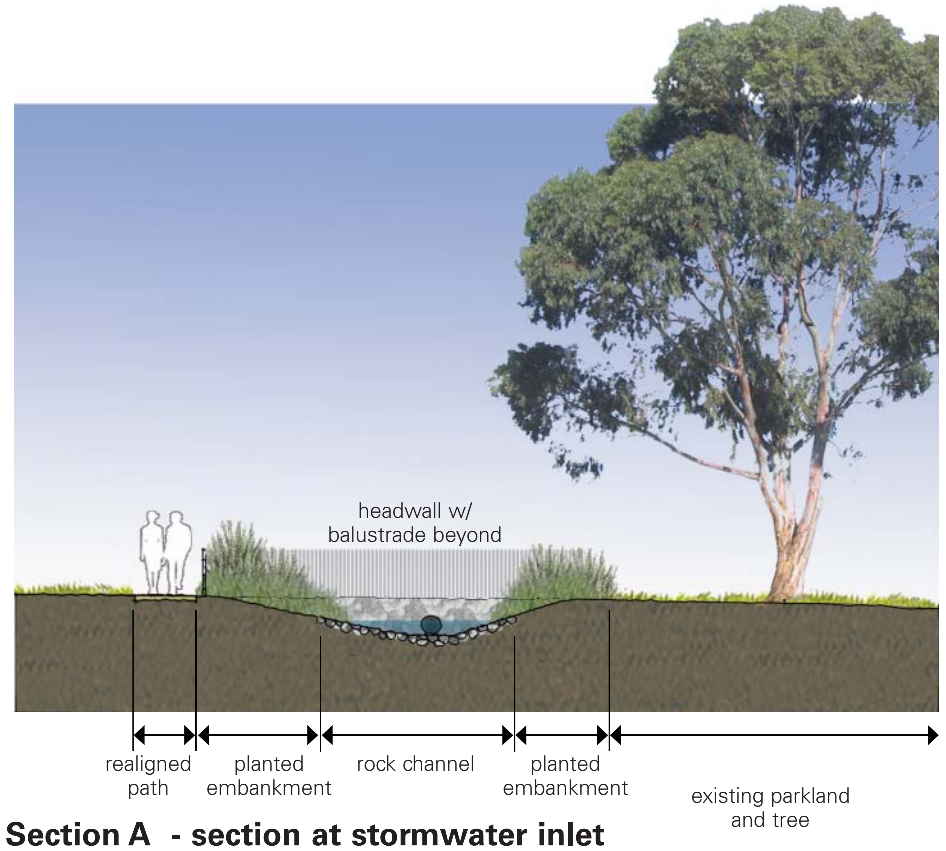
Landscape Drawings

AECOM

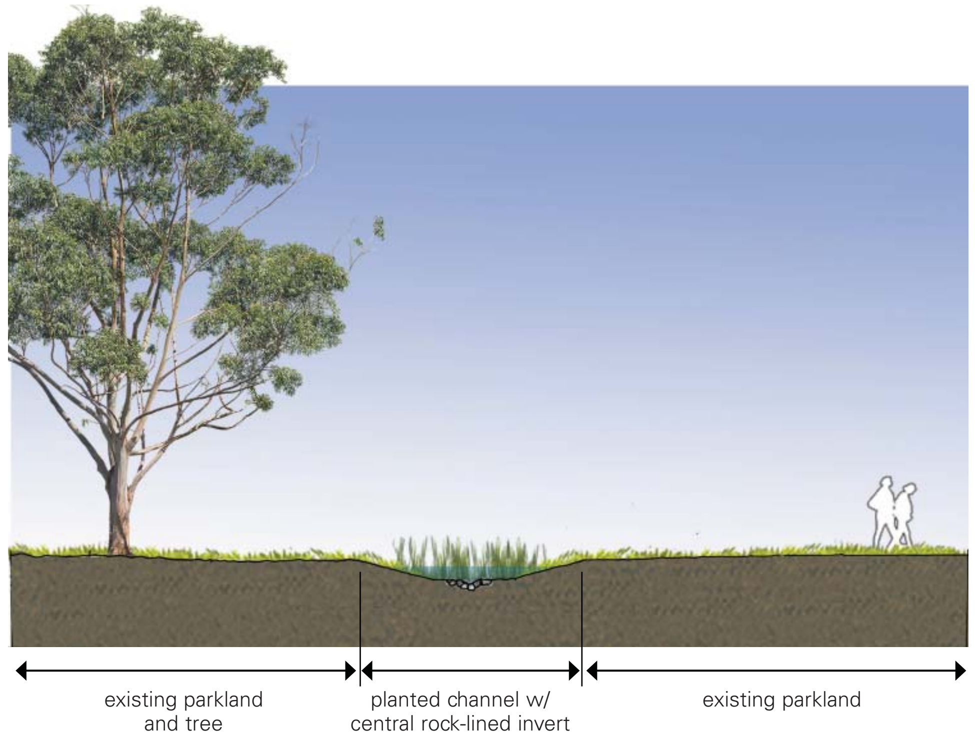
LANDSCAPE CONCEPT PLAN - REV A

ISSUE FOR CLIENT REVIEW 16.12.09

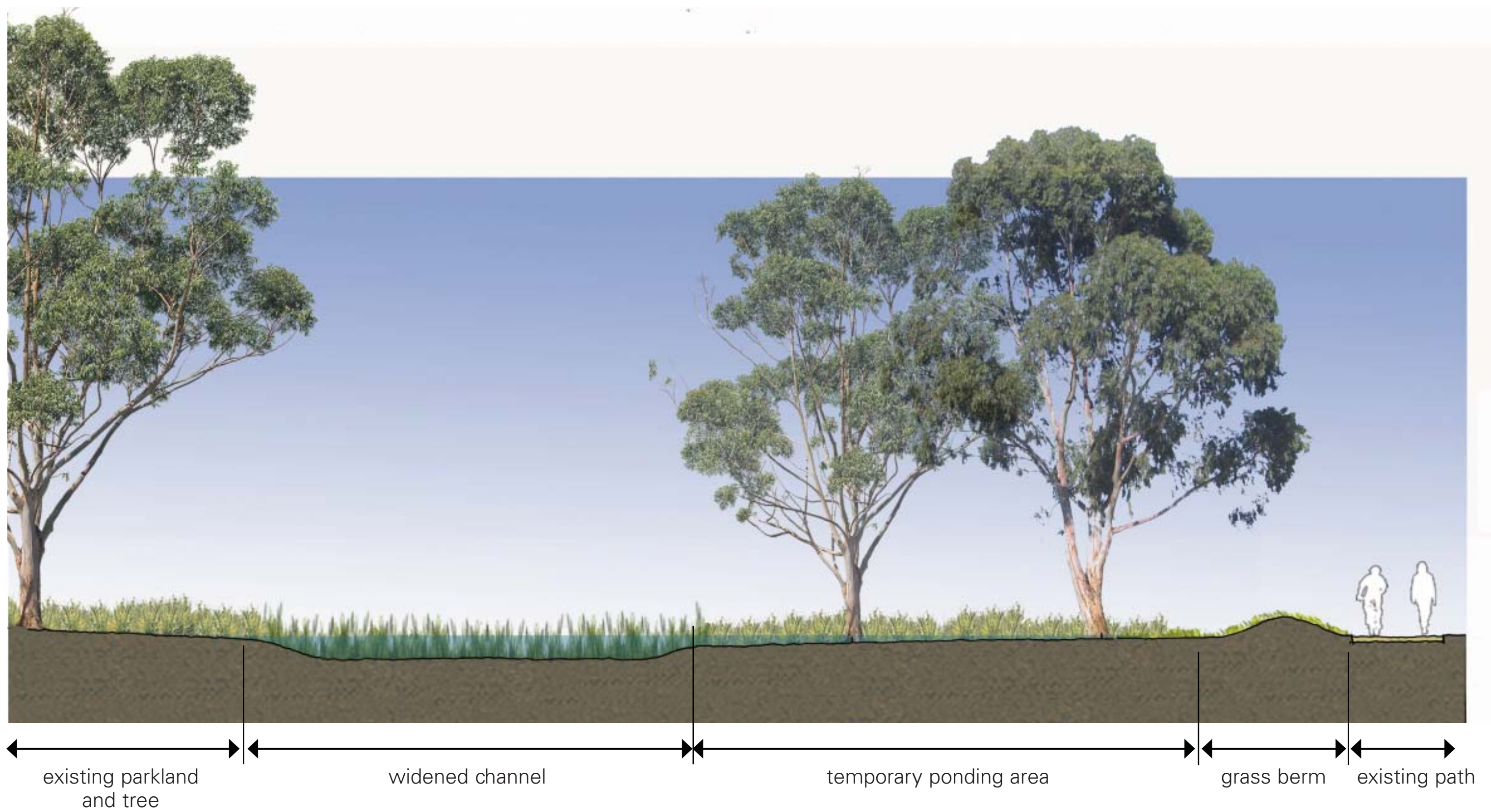
NAPIER PARK STORMWATER REUSE PROJECT



Section A - section at stormwater inlet



Section B - typical section across channel



Section C - section at temporary ponding area