Stevens Group Pty Ltd

VEGETATION MANAGEMENT PLAN

Lot 4 & 5 DP 838537
Pat O'Leary Drive, Kelso

Andrews Neil
URBAN DESIGN GROUP

ANDREWS NEIL PTY LTD

PO BOX 1476 GOSFORD NSW 2250 P. 02 4324 3633 F. 02 4324 3771
www.andrewsneil.com.au info@andrewsneil.com.au

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OUR REF: TH/09159/301009 VMP

Issue	Date	Description	By
A	30.10.09	Issue to Client – Draft for review	TH
B	28.01.10	Amendment to maintenance regime	TH

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1.0 INTRODUCTION

Andrews Neil Urban Design Group (UDG) has been engaged by Stevens Group Pty Ltd to prepare a Vegetation Management Plan (VMP) for Lot 4 & 5 DP 838537, Pat O'Leary Drive, Kelso, henceforth referred to as the subject site (Figure 1). The revegetation works are part of the proposed development of a Service Centre.

The VMP has been prepared to provide maintenance and monitoring guidelines for part of Raglan Creek.

The subject site is located in Bathurst Regional Council Local Government Area (LGA). The subject site lies approximately 3 kilometers to the east of Bathurst and 160 kilometers to the west of Sydney. It is bounded to the north by the Great Western Highway, to the east by light industry comprised of Clark's Plant Hire, a NSW Fire Brigade Station House and Blatch Quality Smash Repairs, also to the east is the Devro Small Goods Factory. To the south is the Great Western Railway Line and to the west is small commercial complex accessed from Littlebourne Street. The site is zoned 4(a) Industrial in the Bathurst Regional (Interim) Local Environmental Plan (2005).

Figure 1: The Subject Site

2.0 AIMS AND OBJECTIVES

The aim of the VMP is to provide guidelines for;

- the removal of exotic species along part of Raglan Creek;
- the establishment of additional native vegetation along the creek; and
- the maintenance and monitoring of the creek during and after the construction of the proposed development.

The objectives of this VMP are to;

- Revegetate the creek with native riparian vegetation;
- Enhance visual amenity throughout the subject site;
- Remove and control weeds within the subject site; and
- Ensure erosion and sedimentation are minimised and do not affect areas downstream of the proposed development.

3.0 METHODOLOGY

The following desktop studies were undertaken for the preparation of this VMP:

- Review of Bathurst Regional Council, Landscape Code, 20th July 2005;
- Review of Bathurst Regional Council Guide to Plant Selection;
- Review of Bathurst City Council Vegetation Management Plan, June, 2003;
- Assessment of aerial photos and topographic maps;
- Review of Department of Water and Energy 'Guidelines for Controlled Activities; Vegetation Management Plans' (2008); and
- A site visit was conducted on the 16th of October 2009.

4.0 SITE ANALYSIS

The subject site is a portion of Raglan Creek which is located in the town of Kelso which is east of the City of Bathurst. The surrounding area is light industry and cleared agricultural land with residential estates north of the Great Western Highway. There is no evidence of remnant vegetation and the vegetation in the creek line consists mainly of introduced species.

The Bathurst City Council Vegetation Management Plan informs us that early accounts of Bathurst describe the riparian vegetation as being mainly Casuarinas with some underlying shrubs. There is no evidence of this today with the portion of Raglan Creek that is the subject of this plan being vegetated with *Salix sp.* Willow, *Malus sp*. Apple Trees, *Rubus sp.* Blackberry, and *Lycium ferocissimum* African Box-thorn, amongst other exotic species noted in Table 1.

Raglan Creek meanders from Raglan in a westerly direction towards the Macquarie River. The creek generally has poor water quality that is the combined result of overgrazing upstream, invasive weeds, erodible granite creek banks, and storm water run-off from road systems.

The geology and soils of the site have been identified using the Soils Landscapes of Bathurst 1:250,000 Sheet. The dominant geology of the area is Bathurst Granite which has a tendency to form such soils as non-calcic brown soils and yellow soils.

The creek in the subject area is in a poor state with Willows, Apple Trees, Chinese Elm and other exotics forming the upper strata and the lower strata being comprised of Blackberry and African Box-thorn and introduced grasses. The creek banks are unstable with erosion evident where the root systems of the Willows are not stabilising the soil. Detritus stuck in the trees indicates that the in a heavy rainfall the creek can have heavy flows rates. Aquatic and macrophyte weeds are evident in the creek itself with Bullrush and *Alternanthera Spp.* being identified on site.

Photo 1: Looking west along Great Western Highway

Photo 2: *Salix Spp*. adjacent to creek.

Photo 3: Photograph taken from roadbridge showing creek line and weed infestation.

Photo 4: Heavy stands of *Rubus Spp*. are prevalent adjacent to the creek.

Photo 5: Stands of *Malus Spp.* and *Salix Spp.*

Photo 6: Looking north towards the roadbridge with stands of *Salix Spp.* heavily present to the site.

Photo 6: Looking into the creek bed from the top of bank.

Photo 7: Looking west across the proposed development area.

5.0 RESTORATION

McDonald (1999) suggests that developing restoration strategies for plant communities involves predicting whether the pre-existing species in a particular landscape unit could recover naturally or whether some higher degree of intervention, up to complete reconstruction, is needed.

The capacity of a species to regenerate after natural disturbance is referred to as its "resilience". This resilience is derived from the exposure of the individual species to natural disturbances during its evolution (Holling 1973 and Westman 1978). It can be assumed that this resilience to natural disturbance also functions after anthropogenic disturbance provided the latter disturbance resembles the natural disturbances to which the species has adapted (McDonald 1999).

McDonald (1999) suggests that areas with lower levels of disturbance have a higher resilience and a greater regeneration potential. Zones with high levels of disturbance have a lower resilience and thus there is an increasing need for a managed approach including revegetation and reconstruction.

The study area has high levels of disturbance and therefore a lower resilience. The implementation of measures to rehabilitate the creek and riparian zone must be undertaken with consideration of the removal of significant weed stands. Efforts are to be applied to these areas to ensure that no invasive exotic species return to impact on the revegetated area.

6.0 INTENT

The Vegetation Concept Plan (Andrews Neil UDG 2010, LD01 & LD02, Appendix 1), illustrates the plant species and locations within proposed revegetation works. The intent and function of the overall landscape design is to;

- Provide a vegetated link using native plants endemic to the area;
- Provide stabilisation to creek batters through planting;
- Provide a vegetated 'edge' to the development;
- Macrophyte planting along the creek edge; and
- Stabilisation to batters incorporated with native planting.

7.0 REVEGETATION AND REGENERATION WORKS

The suggested remediation works will be conducted in conjunction with the proposed construction work.

Revegetation works undertaken (as deemed necessary) during and after the construction works will include;

- Planting of native riparian species along creek banks;
- Planting of native species in a vegetated buffer;
- Removal of exotic species, including the retention of willow root systems (after poisoning) to increase bank stability.

Regeneration works undertaken during and after construction of the proposed development will involve the following;

- Primary and secondary weed removal and management.

It is assumed that;

- Stabilisation treatments to creek bank will be done by others;
- Regeneration and maintenance work will continue over a 2 year period; and
- All regeneration work would be carried out under the supervision of a suitably qualified and experienced bush regeneration contractor.

7.1 Weed Removal

Weed removal work should ideally be undertaken outside the seeding period of weeds that produce large quantities of seed. If any work is undertaken within these periods, seed is to be collected, bagged and disposed of off-site. Chemical removal is considered appropriate for larger weeds and areas of large infestation containing few natives.

Low impact weed management strategies are preferred where native vegetation is to be retained. It is recommended that bush regeneration methods discussed in Bradley (1997) and Buchanan (1989) are employed where possible. The Bradley method of bush regeneration employs four basic principles;

- Work from areas of intact native vegetation towards areas of weed infestation;
- Create minimal disturbance to the environment;
- Let native plant regeneration dictate the rate of weed removal; and
- Ensure primary weed control is followed up with consolidation and long term maintenance.

Manual removal of herbaceous weeds, regrowth and seedlings is preferred where possible with minimal disturbance to soil stability and existing native species. Areas where weeds are removed manually are to be stabilised or planted by the end of each working day.

Table 1 – Weed Treatment Schedule

Weed species	Primary control treatment	Secondary control treatment	Herbicide use	Disposal
Salix Spp. (Willow)	Cut and paint mature plants with herbicide, or scrape stem and paint.	Cut down and remove from site. Retain dead trunks in ground.	Paint cut or scraped stems.	Remove from site.
Silybum marianum (Variegated Thistle)	Herbicide spray large infestations Hand pull individuals	Herbicide spray or hand-pull seedlings	Spray.	Bag and remove from site.
Rubus sp. (Blackberry)	Cut and paint mature plants with herbicide, or scrape stem and paint.	Herbicide spray or hand-pull seedlings	Paint cut or scraped stems.	Remove from site.
Malus Spp. (Apple)	Cut and paint mature plants with herbicide, or scrape stem and paint.	Herbicide spray or hand-pull seedlings	Paint cut or scraped stems.	Remove from site.
Rumex Spp. (Dock Weed)	Herbicide spray large infestations Hand pull individuals	Herbicide spray or hand-pull seedlings	Spray.	Bag and remove seed heads from site.
Lycium ferocissimum (African Box Thorn)	Remove with machinery or Cut and paint mature plants with herbicide	Grub out roots or spray as new growth is observed	Paint cut stems.	Remove from site.
Acer negundo (Elm)	Cut and paint mature plants with herbicide, or scrape stem and paint.	Herbicide spray or hand-pull seedlings	Paint cut or scraped stems.	Remove from site.
Typha Spp. (Bullrush)	Cut plant below waterline after flowering.	Repeat previous action	None.	Bag and remove stems and seed heads from site.
Alternanthera Spp (Alligator Weed)	Spray plants. Continue with a follow up spray after plants have regrown.	Continue spraying and monitoring	Use non-residual glyphosate spray	Leave on site.

7.2 Herbicides

Any herbicides used will be of a non–residual glyphosate type and suitable for use in aquatic situations.

7.3 Stabilisation, Weed Suppression and Mulching

Stabilisation, weed suppression and mulching can be achieved simultaneously using a combination of mulched, weed-free native material cleared from the subject site and commercially available weed suppressant geotextile. If insufficient mulched material is available from the subject site, mulch suitable for native plants will be used, such as eucalyptus-based mulch.

Soil stabilisers are to be applied exclusively in areas where there is an erosion risk. This will be in the form of a geotextile material such as thick jute mesh. Areas of risk may occur along the banks of the creek. Refer to Engineer for advice.

7.4 Plant Stock

Local plants have evolved genetically to suit local environmental conditions. As such, plant stock will be sourced from locally occurring vegetation, preferably from within 10 kilometres of the subject site. This will ensure a maximum rate of plant survival and reduce the amount of replacement necessary.

Seed is to be sourced from an approved local supplier. It is important to ensure that recognised guidelines, such as Florabank (www.florabank.org.au), are adhered to by the contractors appointed to this project.

7.5 Plant Specifications

Quantities should allow for 5% contingency to cover plant failures or damage during the establishment period. Plants to be supplied are to:

- Be vigorous and free from pests and disease;
- Have well developed root systems that have reached the bottom of the tubes/virocells, but are not pot-bound;
- Have had a hardening-off period before delivery to the site, of at least two weeks; and
- Be stored in trays of like species and labelled for ease of identification.

7.6 Plant Rates & Location

Planting rates and patterns are specified in the Vegetation Concept Plan (Andrews Neil UDG 2010, LD01 & LD02, Appendix 1). The areas to be planted are the creek banks and adjacent flats extending to the development. Plant densities and arrangement have been designed to enhance visual amenity, reduce erosion and sedimentation. Retain and protect existing native species.

7.7 Planting Techniques

Plants are to be delivered to the subject site and planted within one or two days. In the event that plants cannot be planted on the day of delivery, they are to be planted as soon as possible and kept moist at all times.

Soil is to be de-compacted before planting to allow for plant root penetration.

Spacing of plants will depend on the form of the species and rates specified by the Vegetation Concept Plan (Appendix 1).

Tree guards should be installed around all shrubs and trees to exclude herbivores such as European Rabbit.

To minimise water loss, soil temperature fluctuations and weed invasion, mulch is to be applied adjacent to creek bank. Care will be taken to make sure mulch does not pile up around the base of the plants, as this can lead to rotting and plant death. The mulch layer is to be no thicker than 100mm at any point.

Weed control is essential around plants as many weeds can compete with seedlings for nutrients and water. Weed control is to be carried out around planted areas for at least one (1) year. All weeds within 200mm of plants will be removed.

7.8 Establishment

For healthy plant establishment ensure the following:

- Plants are actively growing at the time of planting;
- Plants are not pot-bound and roots are generally healthy;
- Soil is moist at the time of planting;
- Sufficient rain occurs and/or irrigation is provided in the following months; and
- The plants are kept free of weed competition.

7.9 Fertilisers

Given that local native species are to be planted, the use of fertiliser is likely to be unnecessary and even undesirable, given that fertilisers may lead to increased risk of predation. Additionally, propagated plants to be delivered to the site in tubes will be pre-fertilised at the nursery. If any fertilisers are determined to be necessary on the site these will be in pellet form and incorporated into the planting hole at the time of planting to avoid run-off. Fertilisers are to be approved by the Superintendent prior to use. A soil test should be undertaken prior to implementing planting.

7.10 Tree Guards

Rabbits, native animals, frost and wind may pose a threat to newly planted seedlings. If necessary, each tree and shrub is to be protected by a clear plastic sleeve and stakes. Tree guards are to be checked and maintained or removed as required.

7.11 Irrigation

Watering frequency will depend on the species, weather conditions, soil type and plant size. If the soil is dry at the time of planting each plant should be given up to 20 litres each with follow-up maintenance watering. Plants are to be watered well two to three times a year. This will encourage development of deep root systems that are able to access sufficient moisture for survival. Frequent light watering will be avoided, as this encourages development of a shallow root system that is unable to endure subsequent dry periods (Buchanan 1989).

Prior to planting, a temporary irrigation system such as a water tanker should be available so plants can be watered immediately after planting. Watering is to take place within two hours of planting. Water tanker will be used for the maintenance period.

8.0 MAINTENANCE WORKS

The maintenance period is a minimum of two years from the attainment of Practical Completion for the construction and revegetation works. Regular maintenance will assist to improve the vegetation community structure, habitat potential and water quality within the site. During this period maintenance works will be carried out by an appropriately qualified and experienced bush regenerator with inspections by a qualified Landscape Architect.

8.1 Description of Tasks

The annual maintenance program is summarised in Table 2 below.

Table 2 – Annual Maintenance

Management Activity	Frequency	Responsibility
Litter removal	Opportunistically	BR,
Weed control/inspection	Every 3 months (considering lifecycle of species)	BR, LA
Plant replacement	Every 3 months	BR,
Irrigation	Initial deep watering of at least 20 litres per plant then as required until plant establishment	BR,
Pests & diseases	Monitored every 3 days for first four weeks and then every 3 months	BR,
Maintenance inspection	Initial and 3 monthly	BRC, BR, LA

KEY TO ABBREVIATIONS
BR – Bush Regenerator
LA – Landscape Architect
BRC – Bathurst Regional Council

8.2 Litter Removal

Litter is to be removed by hand opportunistically when bush regenerators are on the site. All litter collected is to be removed from the site and disposed of appropriately.

Natural debris such as brush, logs and rocks is to be left in-situ or set aside and reused for wildlife habitat within the creek-line and riparian zone.

Any non-biodegradable materials used in the regeneration process such as pots and tree guards is to be removed and disposed of daily or when no longer necessary or within the two year maintenance period.

8.3 Secondary weed removal

A program of secondary weed removal is to be undertaken to remove weed seedlings and regrowth.

The creek is susceptible to future weed invasion from upstream areas. As such, secondary weed control on the subject site is to be co-ordinated with any other weed control activities in the local area. Bathurst Regional Council is to be consulted to determine if any local programs are being undertaken. If possible, weed control activities on the subject site should be conducted at the same time as any local programs to avoid reinfestation from adjacent areas.

8.4 Plant Replacement

For areas where plants have failed, been damaged or are suffering from pests and/or disease, replanting should occur twice a year in spring and late summer/early autumn when temperatures are milder and the risk of frost is reduced.

Plants are to be replaced at the size originally specified and in accordance with the Vegetation Concept Plan (Appendix 1).

If areas of erosion or subsidence occur, engineering advice should be sought and the area revegetated and mulched as soon as possible. If a particular species is performing poorly it is to be replaced with a substitute plant in consultation with Andrews Neil UDG and Bathurst Regional Council.

8.5 Irrigation

Watering of seedlings is to be continued as required until all plants are established. Weather and site conditions will determine the frequency of watering for plants over the maintenance period. Moisture levels and plant health are to be monitored weekly during drier periods.

Any Bathurst Regional Council water use restrictions are to be adhered to. Watering is to be undertaken early morning or late afternoon to avoid excessive evaporation during the hottest part of the day.

It is proposed to utilise a water tanker for the maintenance period.

8.6 Pests & Diseases

Plants are to be monitored for pests and disease every three days for the first four weeks and then every three months. Plants affected badly by pests and disease are to be removed, disposed of off-site and replaced.

To enable effective pest and disease management, actions undertaken on the subject site should be co-ordinated with any other pests and disease controls that may be taking place in local area.

Bathurst Regional Council is to be consulted to determine if any local programs are planned. If possible,

treatment of pests and diseases is to be conducted simultaneously to avoid re-infestation from adjacent areas.

8.7 Maintenance Inspections

The following aspects are to be investigated at 3 monthly maintenance inspections. Appendix 2 provides appropriate pro-forma for the collection of maintenance information.

a) Weeds: evaluate each weed species by noting number present, any observations and treatment recommendations;
b) Pest and disease: notes are to be made on the species affected by pest and disease, including % of species affected, signs observed and treatment recommendations;
c) Planting: notes on the planting success should be taken including initial planting size, performance, height and spread and whether natural regeneration is occurring;
d) Ground Stability: ground stability should be monitored where areas susceptible to instability have been observed. Photographs should be taken of these areas;
e) Irrigation: General notes are required regarding the moisture content of soil in different Management Zones as well as identification of species which may require more or less irrigation;
f) Mulch: the depth of each mulch type should be monitored at 3 monthly intervals; and
g) Litter removal: The removal of significant volumes of litter should be noted.

The following benchmarks should be achieved at each 3 month maintenance period:

a) Targets of 25% native plant cover should be achieved during each 3 monthly increment. (i.e. 3 months, 25%; 6 months, 50%; 9 months, 75%; and 12 months 100%);
b) Targets of 25% weed removal should be achieved during each 3 monthly increment. (i.e. 3 months, 25%; 6 months, 50%; 9 months, 75%; and 12 months 100%).

9.0 MONITORING AND REVIEW PROCESS

Having adopted and implemented the management plan, it will be necessary to undertake monitoring (bush regenerator) to ensure that management activities are achieving the objectives of this VMP. This may lead to the amendment of the VMP. Amendments are to be made in consultation with the Superintendent, Landscape Architect, or Bathurst Regional Council.

During the two year establishment period a 6 monthly report is to be prepared outlining any issues in implementing the VMP and recommendations for resolving these. Monitoring will be conducted using checklists filled out during maintenance tasks (Section 7.7 & Appendix 2). The following performance criteria should be addressed in the monitoring process:

a) Survival rates of plantings; if particular species of plants are experiencing a failed or poor success rate (as outlined in Appendix 2) the species is to be replaced;
b) Plant response to weed control; at 6 months if the % cover of weed infestation is observed to be high (3 monthly benchmark targets have not been met) the current weed removal technique for problem species is to be re-assessed. The source of weed infestation should be identified and weeding may require an increased scope;
c) Native plant cover; at 6 months if the % cover of native plants has failed to reach the 3 monthly benchmark targets the factors that may be attributing to the inability of the of the native plants to regenerate should be evaluated and actions devised to assist in the remediation of the issue; and
d) Information from other management operations not connected with maintenance should also be collected, for example the monitoring of water flow events. This information can then be used to amend the management plan if required.

At 12 months the overall success of the VMP should be evaluated. The most significant factor to determine the success of the regeneration works is whether there is an establishment of a native plant cover (HNCMT, 2000). It can be assumed that where the overall vegetation cover intended has been achieved and where the vegetation composition comprises approximately 95–100 % of native plants (i.e. allowing a 0 – 5% composition of weeds) then the project has been a success.

10.0 CONTACTS

Andrews Neil Pty Ltd
Att: Troy Harvey
Level 3 19-21 Watt Street, Gosford
Mail: PO Box 1476, Gosford NSW 2250
Ph: (02) 4324 3633
Fax: (02) 4324 3771
Email: troy.harvey@andrewsneil.com.au

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Bathurst City Council (2003) Vegetation Management Plan, Terra Consulting.

Bradley, J (1997) Bringing back the Bush: the Bradley Method of Bush Regeneration. Landsdowne Publishing. Sydney.

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APPENDIX 1 VEGETATION CONCEPT PLAN

VEGETATION CONCEPT PLAN 1:200

LEGEND

Core Riparian Zone.
Remove weeds and revegetate with mix of proposed plant species. Refer to LD02. Approximate area to be revegetated: 3000m^2.

Vegetated Buffer.
Revegetate with mix of proposed plant species. Refer to LD02. Approximate area to be revegetated: 550m^2.

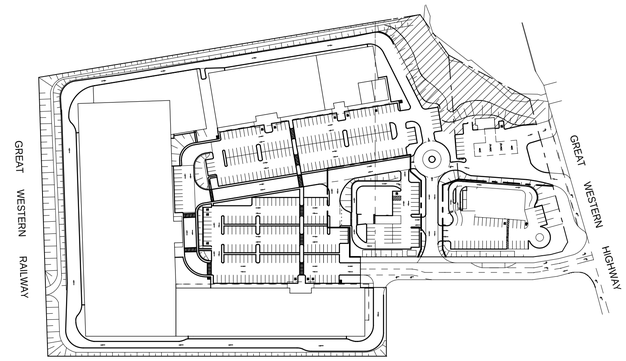
GENERAL LEGEND

Boundary.

Top of creek bank.

Extent of works.

Batter



LOCATION PLAN 1:2000

NOTE:
- The aim of this plan is to provide guidelines for establishment, maintenance and monitoring of revegetation within the propsed area.

- This drawing should be read in conjunction with the Vegetation Management Plan prepared by Andrews Neil UDG Pty Ltd dated January 2010.

- All works within the proposed area are to be implemented by a suitably qualified person and must undertake removal of weeds in consultation with Bathurst Regional Council Weed Control Officer.

- To maintain local floral genetics it is preferable that revegetation is undertaken using seeds or vegetative material sourced from within the region. Supplementary seed or nursery grown plant stock will be sourced from an approved supplier as seed from the site is not available.

- Existing native vegetation is to be retained and protected. If areas of native vegetation are disturbed, they are to be made good with the proposed species list.

- Plant numbers to be assessed onsite following removal of weed species.

- Allow to leave poisoned tree stumps in creek batter to protect soil from erosion.

1. MAINTENANCE
RECURRENT WORKS: Throughout the Planting Establishment Period, continue to carry out recurrent works of a maintenance nature including, but not limited to, watering, weeding, rubbish removal, fertilising, pest and disease control, staking and tying, replanting and keeping the site neat and tidy.

REPLACEMENTS: Continue to replace failed, damaged or stolen plants throughout the 24 month maintenance period. Contact Superintendent immediately if vandalism or theft has occurred. If a particular species is performing poorly, contact Superintendent for possible substitute.

MULCHED SURFACES: Use a Native Mulch. Maintain the surface in a clean and tidy condition and reinstate the mulch as necessary, mulch should be clear of plant stems.

STAKES AND TIES: Provide ties that are fixed securely to the stakes. Ties should be tied loosely to allow movement, stakes and ties are temporary and should be removed upon establishment.

2. TOPSOIL
Allow to rip planting areas to 200mm depth. Engineer to provide details for stabilisation of creek batters.

3. PLANTS
Supply plants which have large healthy root systems, with no evidence of root curl, restriction or damage; are vigorous, well established, free from disease and pests, of good form consistent with the species or variety; and are hardened off, not soft or forced, and suitable for planting in the natural climatic conditions prevailing at the site. Supply trees that are grown in accordance with Natspec 2.

- Any Bathurst Regional Council Water Usage Restrictions should be adhered to during the establishment and maintenance periods.
Irrigation should be undertaken early morning or late afternoon to avoid the hottest part of the day and unnecessary water loss. Water carts should be utilised for maintenance works.

- Young seedlings are desirable to pests such as rabbits and hares and if they are considered a problem, plastic tree guards should be used around each plant or reinstated where removed.

- All erosion and sediment control devices to be installed prior to start of construction. All stockpile areas are to be fenced with erosion and sediment control fencing.

- Monitoring will be conducted using checklists filled out during maintenance tasks.

SCALE 1:200
0 10 20m

DA EDITION

STEVENSGROUP

Architecture
Andrews Neil UDG Pty Ltd
19-21 WATT ST
PO BOX 1476 GOSFORD NSW 2250
TELEPHONE: 02 43 24 3633
FACSIMILE: 02 43 24 3771
EMAIL: info@andrewsneil.com.au
Nominated Architect: Andrew Dickson (NSW Reg. No. 7657)

REV	DATE	NOTATION/AMENDMENT
B	28/01/10	Amendment to riparian corridor
A	28/10/09	Issued for DA

DO NOT SCALE DRAWINGS. CHECK ALL DIMENSIONS ON SITE.
FIGURED DIMENSIONS TAKE PRECEDENCE.

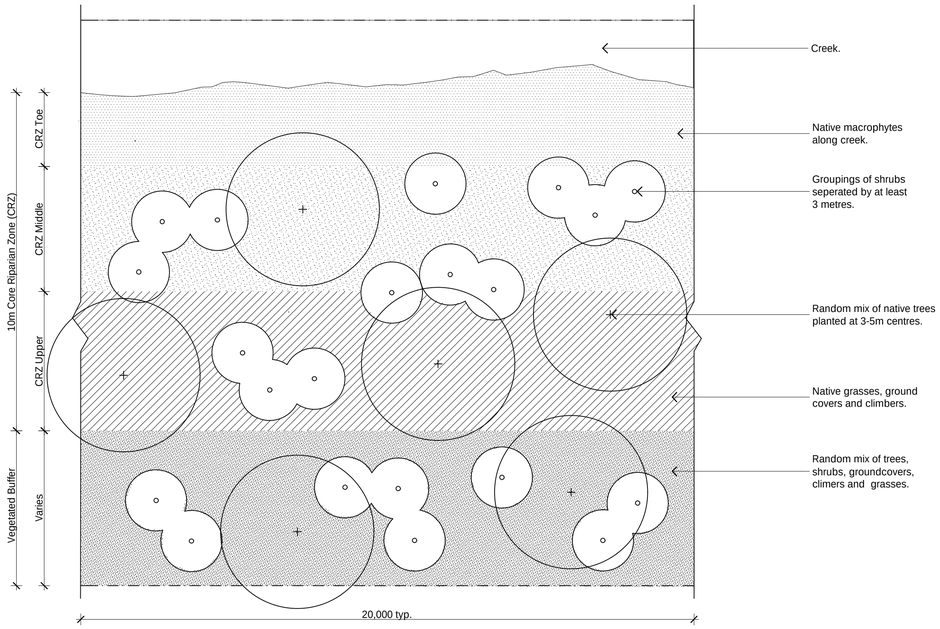
PROJECT
STEVENS HOLDINGS
PROPOSED SERVICE CENTRE

LOCATION
LOTS 4 & 5
DP 838537
PAT O'LEARY DRIVE, KELSO

CLIENT
STEVENSGROUP
SUITE 2, 257-259 CENTRAL COAST HWY
P.O.BOX 3171 ERINA NSW 2250
TELEPHONE: 02 43 65 3351
FACSIMILE: 02 43 65 3750

TITLE:
VEGETATION CONCEPT PLAN

DATE	DRAWN BY	PROJECT No	STAGE
JANUARY 2010	ZC	09159	DA
SCALE 1:200@A1			
PLOT DATE	CHECK BY	DRAWING No	REVISION
28/01/10	TH	LD01	B



DETAIL 1 - TYPICAL RIPARIAN CORRIDOR PLAN 1:100

DETAIL 2 - TYPICAL RIPARIAN CORRIDOR SECTION 1:100

INDICATIVE PLANT SCHEDULE
Randomly select from the following species ensuring that an equal mix is used;

CORE RIPARIAN ZONE - TOE

KEY	SPECIES	SIZE	SPACING
TREES			
MACROPHYTES			
	Juncus usitatus	Tubestock	4/m^2
	Eleocharis sphacelata	Tubestock	4/m^2

CORE RIPARIAN ZONE - MIDDLE

KEY	SPECIES	SIZE	SPACING
TREES			
	Acacia dealbata	Tubestock	3 - 5m c/s
	Casuarina cunninghamiana	Tubestock	3m c/s
SHRUBS			
	Acacia implexa	Tubestock	As shown
	Callistemon sieberi	Tubestock	As shown
	Grevillea rosmarinifolia	Tubestock	As shown
GRASSES, GROUNDCOVERS AND CLIMBERS			
	Dianella Spp.	Tubestock	4/m^2
	Hardenbergia violacea	Tubestock	4/m^2
	Lomandra longifolia	Tubestock	4/m^2

CORE RIPARIAN ZONE - UPPER

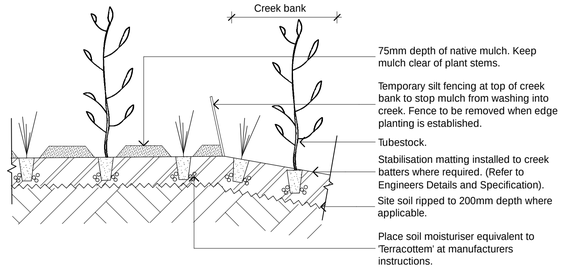
KEY	SPECIES	SIZE	SPACING
TREES			
	Acacia dealbata	Tubestock	3 - 5m c/s
	Eucalyptus blakelyii	Tubestock	3 - 5m c/s
	Eucalyptus bridgesiana	Tubestock	3 - 5m c/s
SHRUBS			
	Acacia implexa	Tubestock	As shown
	Callistemon sieberi	Tubestock	As shown
	Grevillea rosmarinifolia	Tubestock	As shown
	Hakea salicifolia	Tubestock	As shown
GRASSES, GROUNDCOVERS AND CLIMBERS			
	Dianella Spp.	Tubestock	4/m^2
	Lomandra longifolia	Tubestock	4/m^2
	Themeda australis	Tubestock	4/m^2

VEGETATED BUFFER

KEY	SPECIES	SIZE	SPACING
TREES			
	Acacia dealbata	Tubestock	3 - 5m c/s
	Eucalyptus blakelyii	Tubestock	3 - 5m c/s
	Eucalyptus bridgesiana	Tubestock	3 - 5m c/s
SHRUBS			
	Acacia implexa	Tubestock	As shown
	Callistemon sieberi	Tubestock	As shown
	Grevillea rosmarinifolia	Tubestock	As shown
	Hakea salicifolia	Tubestock	As shown
GRASSES, GROUNDCOVERS AND CLIMBERS			
	Dianella Spp.	Tubestock	4/m^2
	Hardenbergia violacea	Tubestock	4/m^2
	Lomandra longifolia	Tubestock	4/m^2
	Themeda australis	Tubestock	4/m^2

STILLING BASIN

KEY	SPECIES	SIZE	SPACING
MACROPHYTES			
	Juncus usitatus	Tubestock	4/m^2
	Eleocharis sphacelata	Tubestock	4/m^2



DETAIL 3 - TYPICAL PLANTING DETAIL 1:20

DA EDITION

STEVENSGROUP

URBAN DESIGN GROUP
Architecture
Andrews Neil UDG Pty Ltd
19-21 WATT ST
PO BOX 1476 GOSFORD NSW 2250
TELEPHONE: 02 43 24 3633
FACSIMILE: 02 43 24 3771
EMAIL: info@andrewsneil.com.au
Nominated Architect: Andrew Dickson (NSW Reg. No. 7657)

REV	DATE	NOTATION/AMENDMENT
B	28/01/10	Amendment to riparian corridor
A	28/10/09	Issued for DA

DO NOT SCALE DRAWINGS. CHECK ALL DIMENSIONS ON SITE.
FIGURED DIMENSIONS TAKE PRECEDENCE.

PROJECT
STEVENS HOLDINGS
PROPOSED SERVICE CENTRE

LOCATION
LOTS 4 & 5
DP 838537
PAT O'LEARY DRIVE, KELSO

CLIENT
STEVENSGROUP
SUITE 2, 257-259 CENTRAL COAST HWY
P.O.BOX 3171 ERINA NSW 2250
TELEPHONE: 02 43 65 3351
FACSIMILE: 02 43 65 3750

TITLE:
LANDSCAPE DETAILS

DATE JANUARY 2010	DRAWN BY	PROJECT No	STAGE
SCALE As shown	ZC	09159	DA
PLOT DATE 28/01/10	CHECK BY TH	DRAWING No LD02	REVISION B

APPENDIX 2 GUIDELINES TO MONITORING

GUIDELINES TO MONITORING

Please ensure all sections of this form are completed,

Date of survey		Time of survey	
Name of contractor undertaking monitoring and Company		Contact number	

SECTION 1 - WEEDS

Species	Zone	% of site coverage or No. of individuals	Recommended Treatment
e.g. *Lantana camara*	riparian	5%	

SECTION 2 - PEST & DISEASE

Pest/Disease	Species affected	Zone	% of species affected	Signs	Recommended Treatment
e.g. Phytophtora Root Rot	*Eucalyptus robusta*	riparian	25%	Dieback of branches	Remove affected plants. Drench areas with Fongarid & replant with alternative species eg A....@

SECTION 3 - PLANTING

Species	Zone	Initial planting size/ number	Performance - failed/poor/good/ excellent	Average height/spread at date of inspection	Natural regeneration occurring - yes/no
e.g. *Casuarina glauca*	batter	50mm tube	good	750mm/300mm	no

Key:
Failed - Species has had less then 25% success
Poor - Species has had 25% to 60% success
Good - Species has had 60% to 90% success
Excellent - Species has had 90% or greater success

Note: Percentage of success is determined by estimating the number of plants showing evidence of growth against the number originally planted.

SECTION 4. GROUND STABILITY

Identify on the landscape plan areas where soil stability is questionable and describe the condition. A photographic record is recommended to enable immediate input from either DNR or a specialist consultant.

SECTION 5 - IRRIGATION

$ General notes required regarding the moisture content of soil in different Management Zones

$ Identify species which may require more or less irrigation.

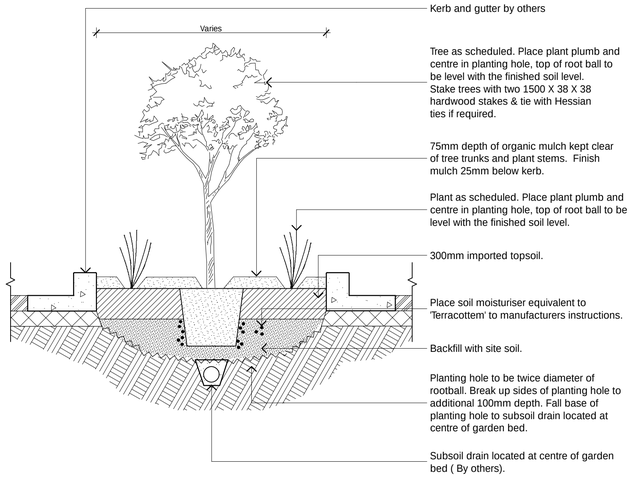
Notes:

SECTION 6 - MULCH

Mulch Type	Zone	Depth at time of inspection (mm)	Required Depth (mm)
e.g. leaf litter	Riparian	100mm	

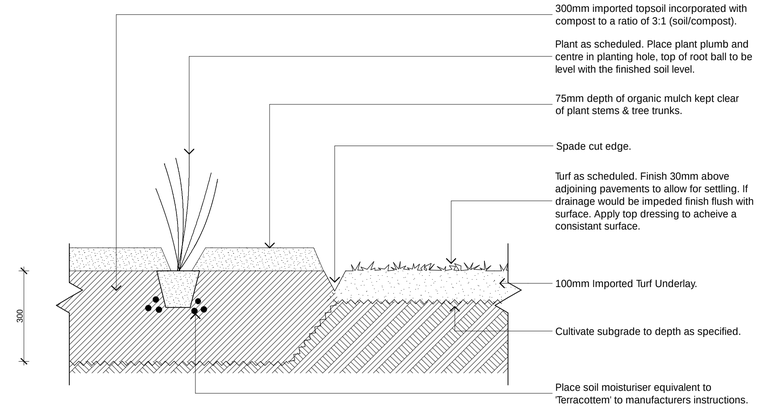
SECTION 7 - LITTER REMOVAL

Litter Type	Zone	Size of rubbish pile or % of site coverage	Action
e.g. Garden refuse	Riparian	1 cubic metre	Remove from site and dispose of correctly

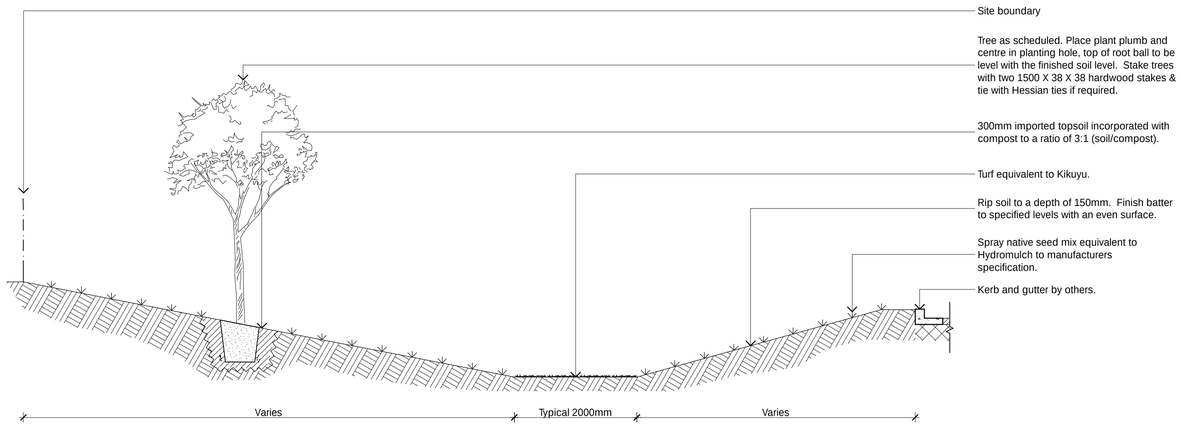


NOTE - Underground services to be located prior to excavation.

1 TYPICAL MEDIAN PLANTING
SECTION SCALE 1:20



3 TYPICAL MASS PLANTING
SECTION SCALE 1:10



2 TYPICAL BATTER PLANTING
SECTION SCALE 1:50

DA EDITION

STEVENSGROUP

URBAN DESIGN GROUP
Architecture
Andrews Neil UDG Pty Ltd
19-21 WATT ST
PO BOX 1476 GOSFORD NSW 2250
TELEPHONE: 02 43 24 3633
FACSIMILE: 02 43 24 3771
EMAIL: info@andrewsneil.com.au
Nominated Architect: Andrew Dickson
(NSW Reg. No. 7657)

REV	DATE	NOTATION/AMENDMENT
B	28/01/10	REVISED ISSUE FOR DA
A	27/10/09	ISSUE FOR DA

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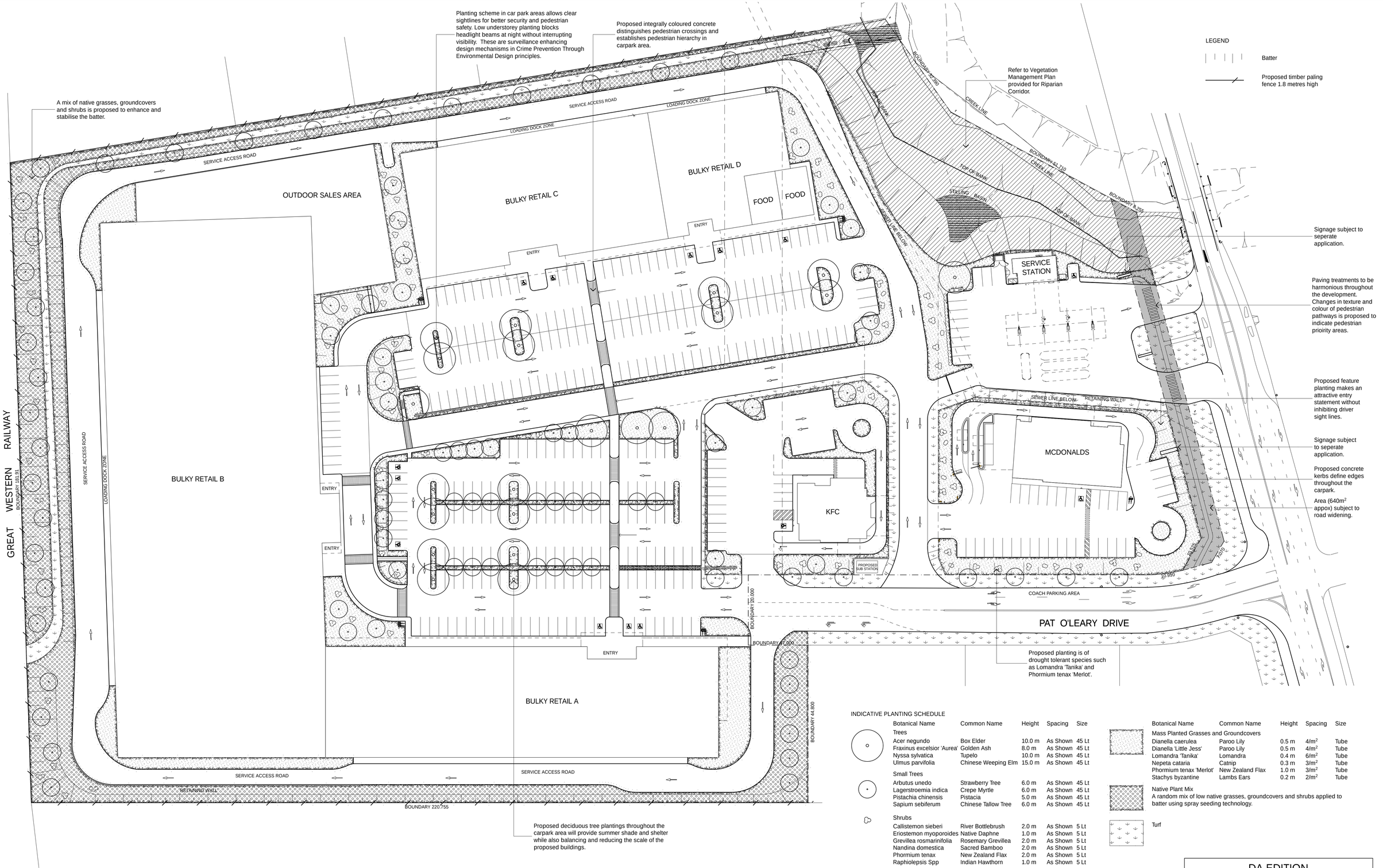
PROJECT
STEVENS HOLDINGS
PROPOSED SERVICE CENTRE

LOCATION
LOTS 4 & 5
DP 838537
PAT O'LEARY DRIVE, KELSO

CLIENT
STEVENSGROUP
SUITE 2, 257-259 CENTRAL COAST HWY
PO.BOX 3171 ERINA NSW 2250
TELEPHONE: 02 43 65 3351
FACSIMILE: 02 43 65 3750

TITLE:
LANDSCAPE DETAILS

DATE	JANUARY 2010	DRAWN BY	PROJECT No	STAGE
SCALE	As shown	ZC	09159	DA
PLOT DATE	28/01/10	CHECK BY	DRAWING No	REVISION
		TH	LD01	B



INDICATIVE PLANTING SCHEDULE

Botanical Name	Common Name	Height	Spacing	Size
Trees				
Acer negundo	Box Elder	10.0 m	As Shown	45 Lt
Fraxinus excelsior 'Aurea'	Golden Ash	8.0 m	As Shown	45 Lt
Nyssa sylvatica	Tupelo	10.0 m	As Shown	45 Lt
Ulmus parvifolia	Chinese Weeping Elm	15.0 m	As Shown	45 Lt
Small Trees				
Arbutus unedo	Strawberry Tree	6.0 m	As Shown	45 Lt
Lagerstroemia indica	Crepe Myrtle	6.0 m	As Shown	45 Lt
Pistachia chinensis	Pistacia	5.0 m	As Shown	45 Lt
Sapium sebiferum	Chinese Tallow Tree	6.0 m	As Shown	45 Lt
Shrubs				
Callistemon sieberi	River Bottlebrush	2.0 m	As Shown	5 Lt
Eriostemon myoporoides	Native Daphne	1.0 m	As Shown	5 Lt
Grevillea rosmarinifolia	Rosemary Grevillea	2.0 m	As Shown	5 Lt
Nandina domestica	Sacred Bamboo	2.0 m	As Shown	5 Lt
Phormium tenax	New Zealand Flax	2.0 m	As Shown	5 Lt
Raphiolepsis Spp	Indian Hawthorn	1.0 m	As Shown	5 Lt

Botanical Name	Common Name	Height	Spacing	Size
Mass Planted Grasses and Groundcovers				
Dianella caerulea	Paroo Lily	0.5 m	4/m²	Tube
Dianella 'Little Jess'	Paroo Lily	0.5 m	4/m²	Tube
Lomandra 'Tanika'	Lomandra	0.4 m	6/m²	Tube
Nepeta cataria	Catnip	0.3 m	3/m²	Tube
Phormium tenax 'Merlot'	New Zealand Flax	1.0 m	3/m²	Tube
Stachys byzantine	Lambs Ears	0.2 m	2/m²	Tube

Native Plant Mix
A random mix of low native grasses, groundcovers and shrubs applied to batter using spray seeding technology.

Turf

DA EDITION

SCALE 1:500
0 25 50m

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URBAN DESIGN GROUP

Architecture
Andrews Neil UDG Pty Ltd
19-21 WATT ST
PO BOX 1476 GOSFORD NSW 2250
TELEPHONE: 02 43 24 3633
FACSIMILE: 02 43 24 3771
EMAIL: info@andrewsneil.com.au
Nominated Architect: Andrew Dickson
(NSW Reg. No. 7657)

REV	DATE	NOTATION/AMENDMENT
C	18/02/10	REVISED ISSUE FOR DA
B	28/01/10	REVISED ISSUE FOR DA
A	27/10/09	ISSUE FOR DA

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PROJECT
STEVENS HOLDINGS
PROPOSED SERVICE CENTRE

LOCATION
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PAT O'LEARY DRIVE, KELSO

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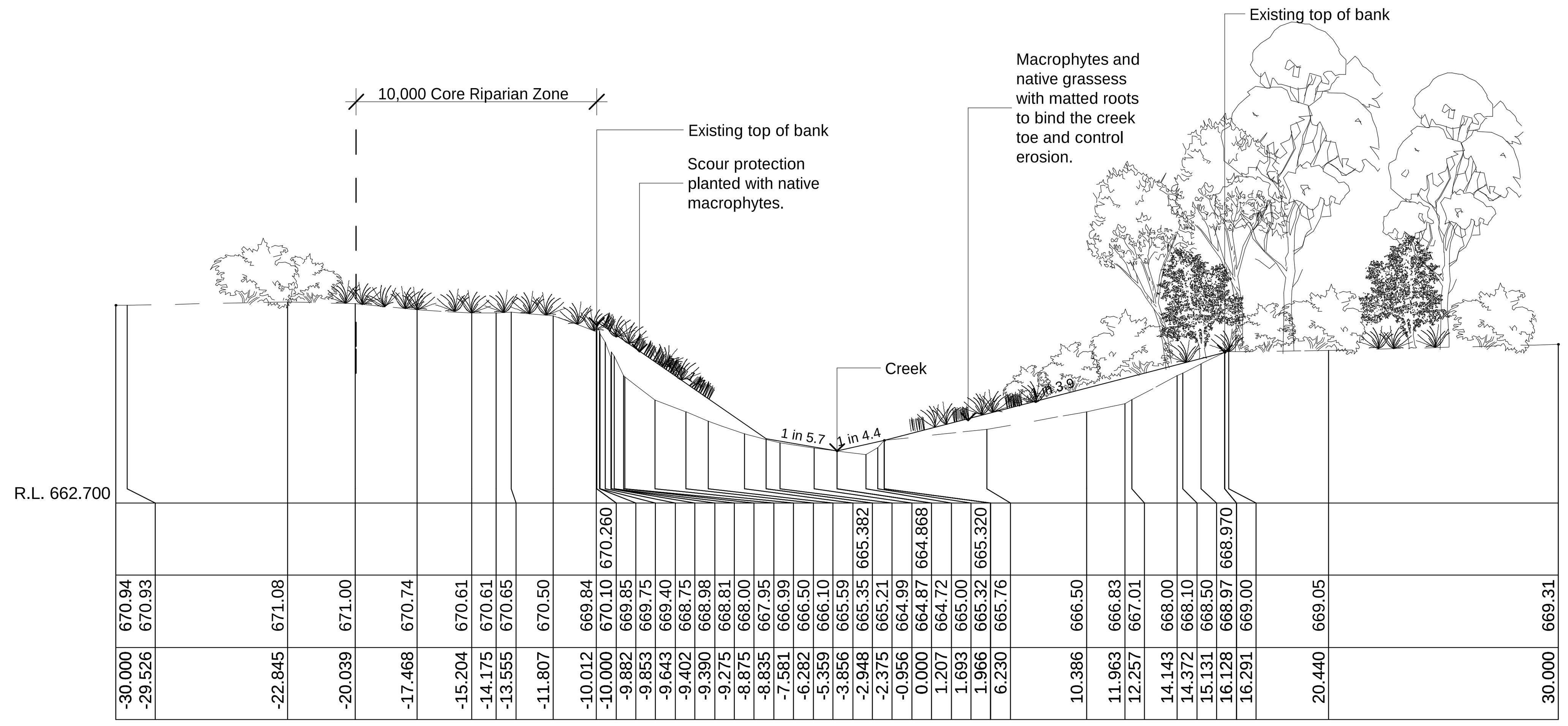
STEVENSGROUP
SUITE 2, 257-259 CENTRAL COAST HWY
PO BOX 3171 ERINA NSW 2250
TELEPHONE: 02 43 65 3351
FACSIMILE: 02 43 65 3750

TITLE:
LANDSCAPE CONCEPT PLAN

DATE	FEBRUARY 2010	DRAWN BY	PROJECT No	STAGE
SCALE	1:500 @ A1	ZC	09159	DA
PLOT DATE	18/02/10	CHECK BY	DRAWING No	REVISION
		TH	LD01	C



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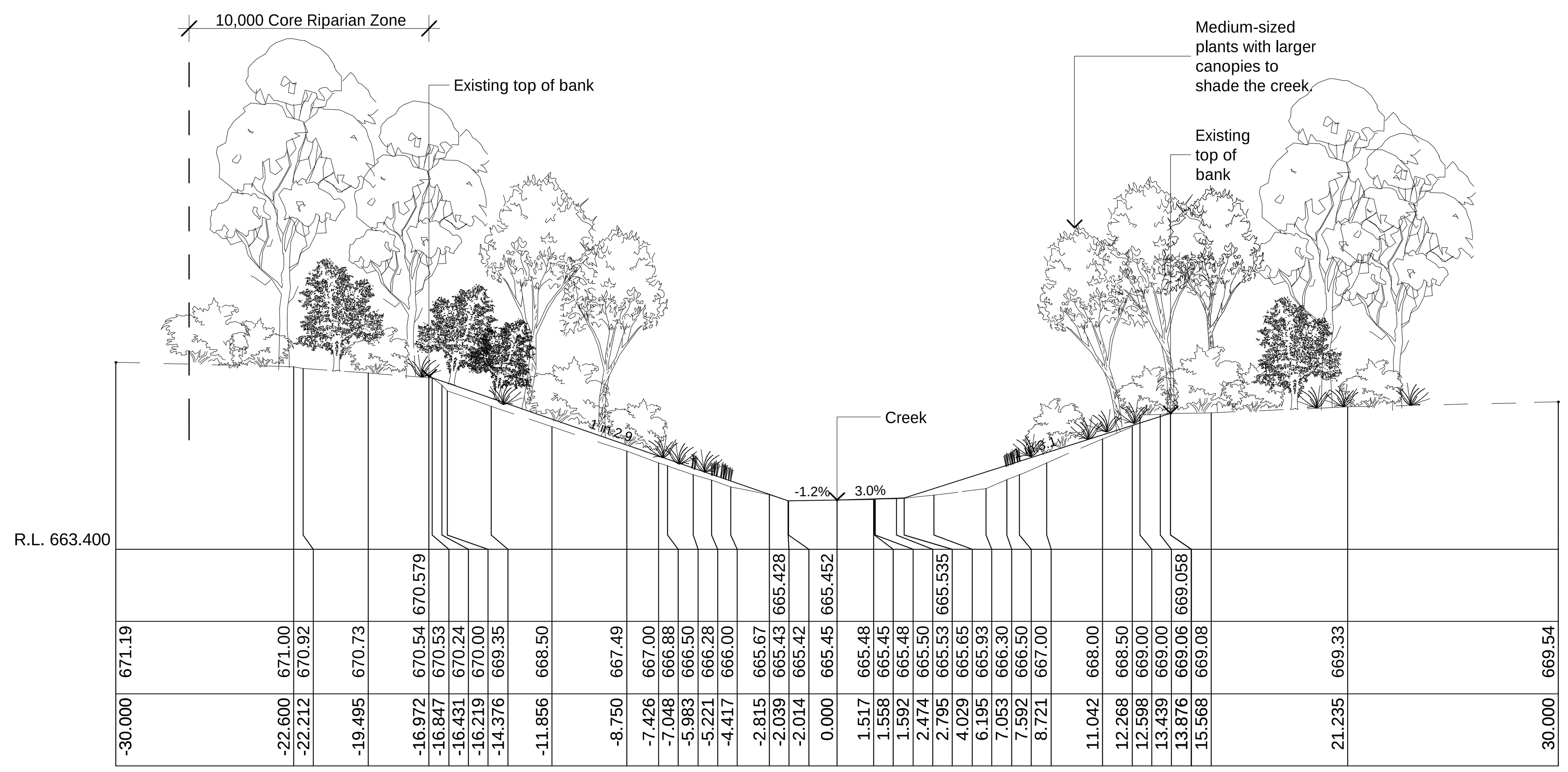
SECTION SCALE 1:200



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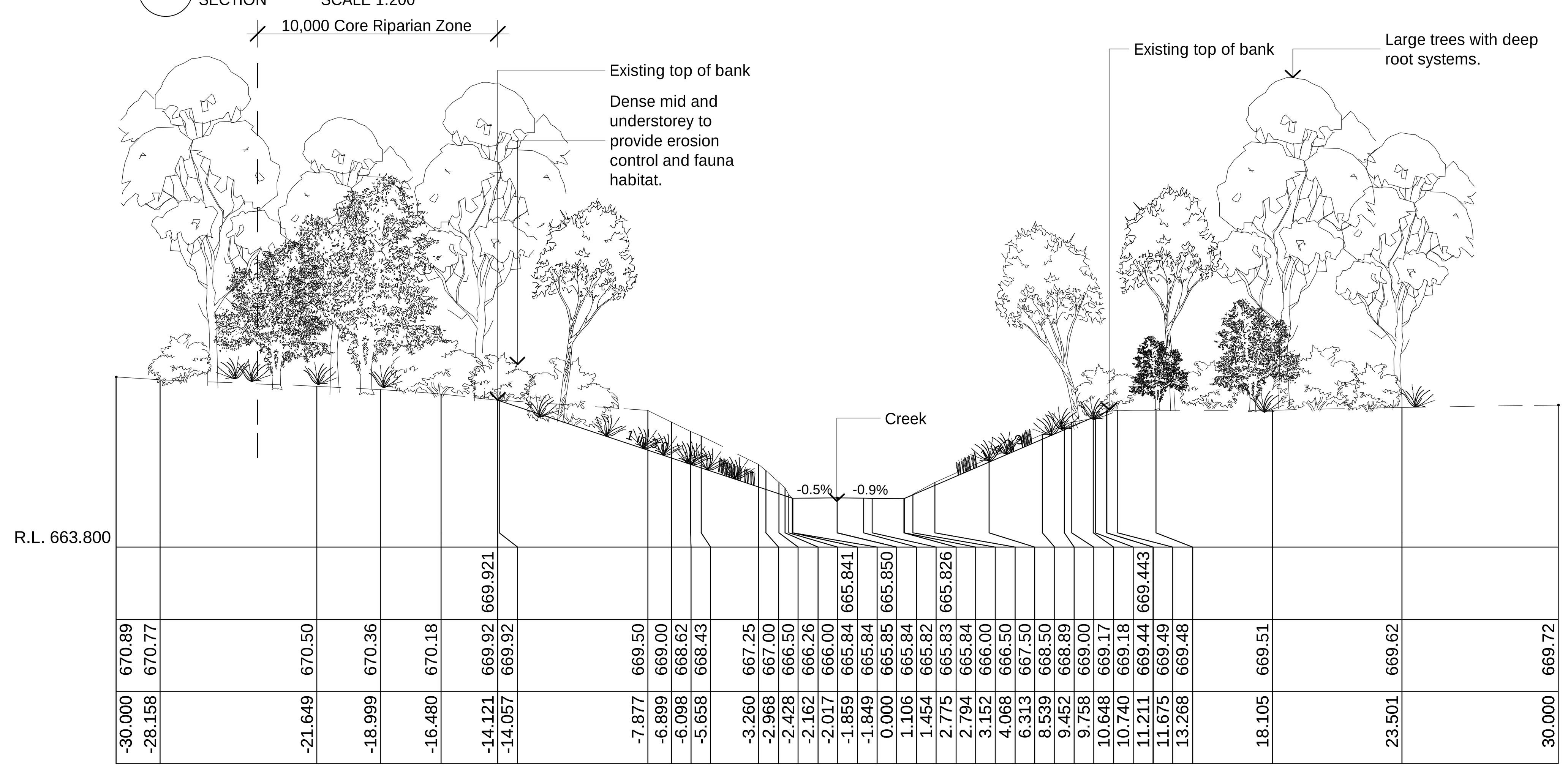
SECTION SCALE 1:200



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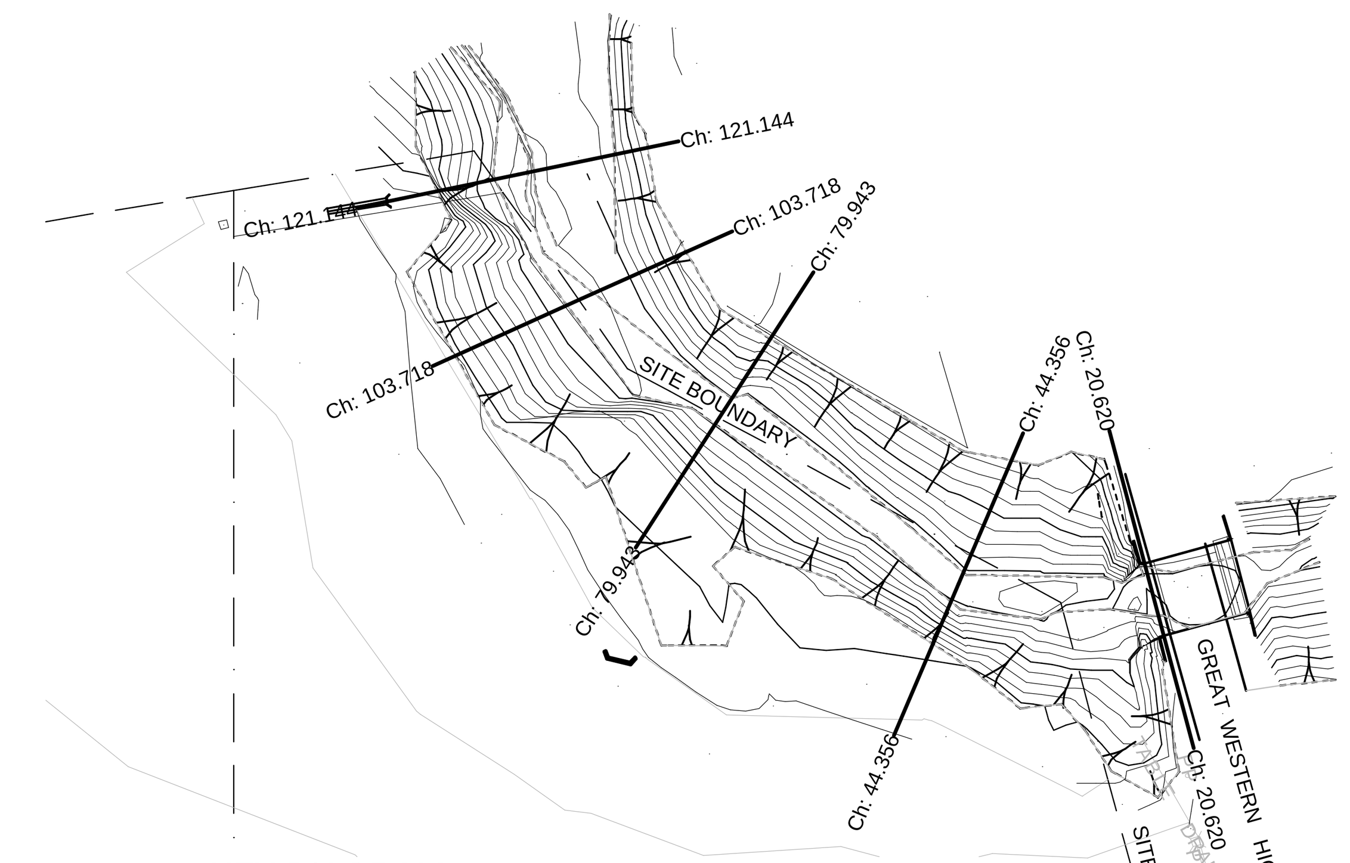
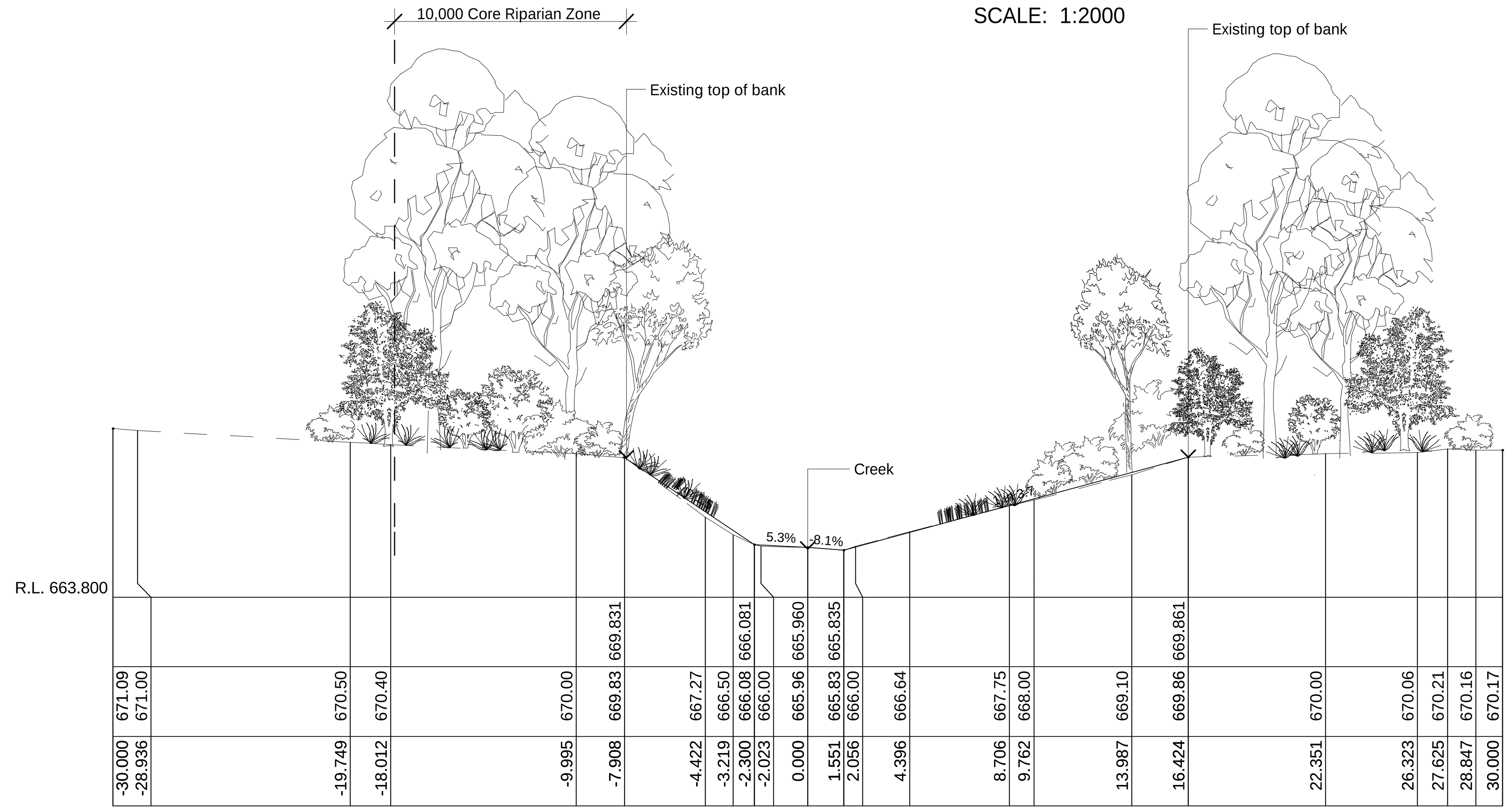
SECTION SCALE 1:200



KEY DIAGRAM
SCALE: 1:2000



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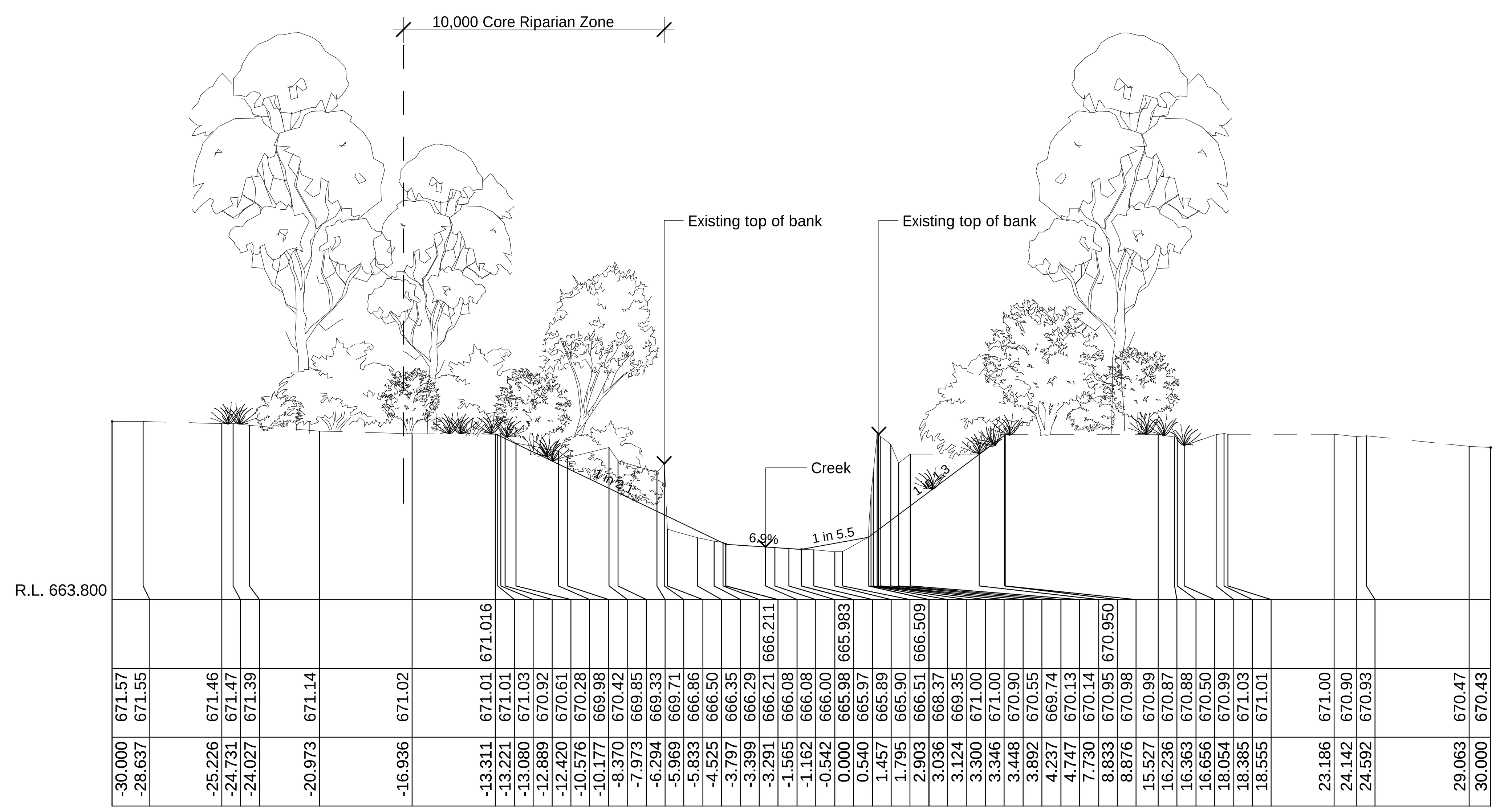
SECTION SCALE 1:200



5 CREEK SECTION - 20.620
SECTION SCALE 1:200

NOTE: Section bases provided by Northrop Consulting Engineers Pty Ltd.

DA EDITION

STEVENSGROUP

Architecture
Andrews Neil UDG Pty Ltd
19-21 WATT ST
PO BOX 1476 GOSFORD NSW 2250
TELEPHONE: 02 43 24 3633
FACSIMILE: 02 43 24 3771
EMAIL: info@andrewsneil.com.au
Nominated Architect: Andrew Dickson
(NSW Reg. No. 7657)
URBAN DESIGN GROUP

REV	DATE	NOTATION/AMENDMENT
D	23/02/10	AMENDED CREEKLINE SECTIONS
C	05/02/10	ADDED CREEKLINE SECTIONS
B	28/01/10	REVISED ISSUE FOR DA
A	27/10/09	ISSUE FOR DA

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PROJECT
STEVENS HOLDINGS
PROPOSED SERVICE CENTRE

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PAT O'LEARY DRIVE, KELSO

CLIENT
STEVENSGROUP
SUITE 2, 257-259 CENTRAL COAST HWY
P.O.BOX 3171 ERINA NSW 2250
TELEPHONE: 02 43 65 3351
FACSIMILE: 02 43 65 3750

TITLE:
CREEKLINE SECTIONS

DATE	FEBRUARY 2010	DRAWN BY	ZC	PROJECT No	09159	STAGE	DA
SCALE	As shown						
PLOT DATE	23/02/10	CHECK BY	TH	DRAWING No	LD03	REVISION	D

Narelle Heness/BathurstCC
26/02/2010 02:54 PM

To Darren Sturgiss/BathurstCC,
cc
bcc
Subject Fw: Attn: Darren Sturgiss - Proposed Development at Pat O'Leary Dr - Flood Study for Raglan Creek (MAIL)
FILE NUMBER 2010/0286-03

----- Forwarded by Narelle Heness/BathurstCC on 26/02/2010 02:54 PM -----

"Andrew Brown" <abrown@northrop.com.au>
26/02/2010 02:26 PM

To <darren.sturgiss@bathurst.nsw.gov.au>, <Council@bathurst.nsw.gov.au>
cc
Subject Attn: Darren Sturgiss - Proposed Development at Pat O'Leary Dr - Flood Study for Raglan Creek

Darren

Further to our conversations a few weeks ago, we have amended the report to include the following:

1. Slightly modified fraction impervious for upstream catchments (they have been determined by orthophotos).

2. A comment in relation to modelling the higher flow (48m3/s assuming full catchment development). Our assessment indicated little change in pre and post development flooding levels).

If you have any questions, then please do not hesitate to give me a call.

cheers

NORTHROP
Andrew Brown

ESDS1

Principal
Northrop Consulting Engineers Pty Ltd
T: 02 4943 1777
F: 02 4943 1577

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P
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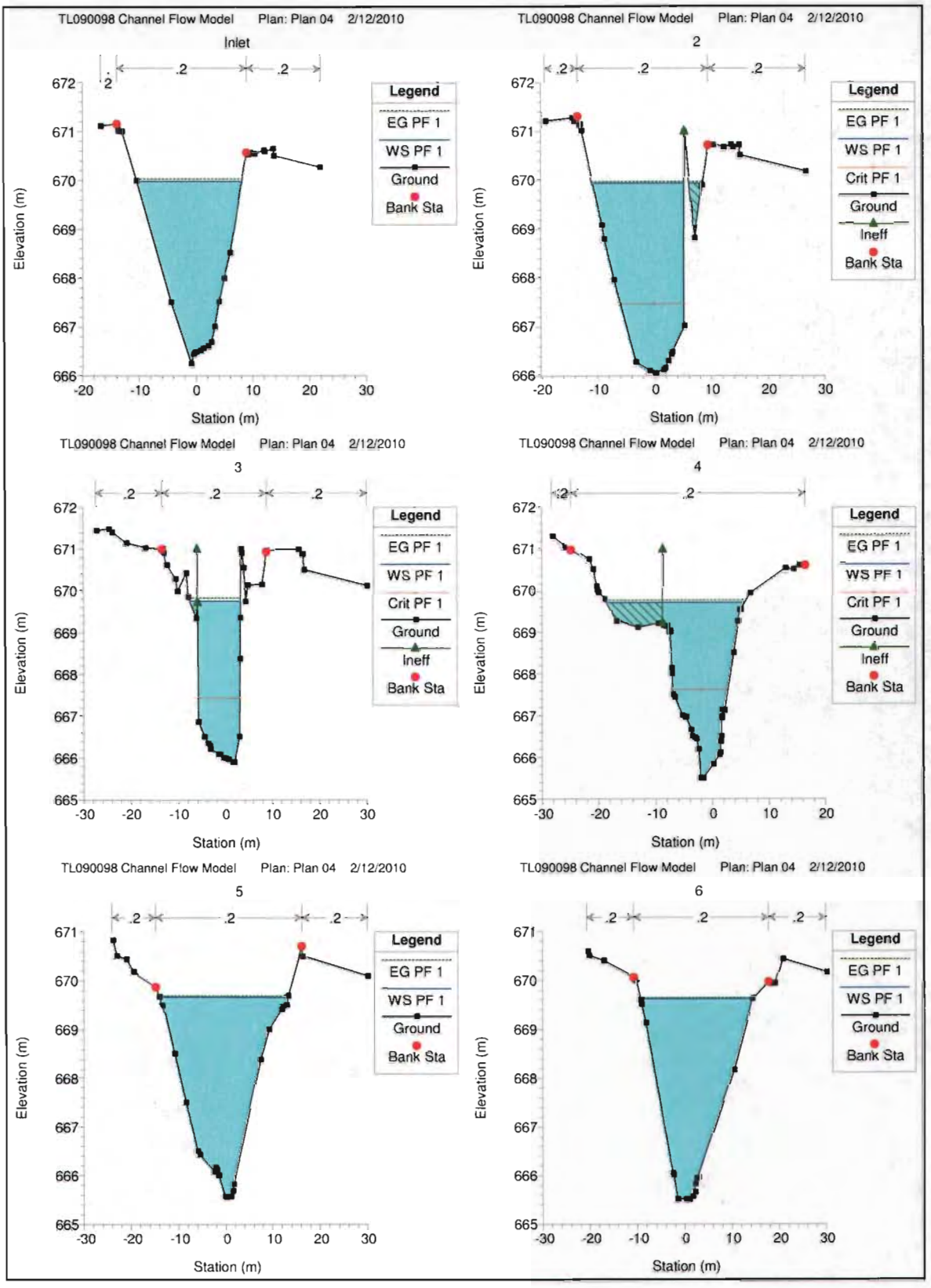
- Appendix A_RAS cross sections 38.2 m3 1.pdf - TL090098E01(B)_flood report.pdf - Appendix A_RAS cross sections 38.2 m3 2.pdf - Appendix A_RAS cross sections 38.2 m3 3.pdf - Appendix A_RAS cross sections 38.2 m3 4.pdf - TL090098_CO4(B)DA.pdf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TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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Station (m)
TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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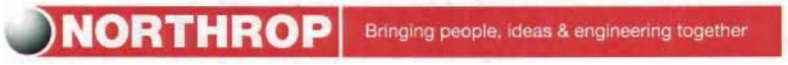
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

FLOOD STUDY
Pat O'Leary Drive proposed development
Kelso, N.S.W.

Prepared By:



ACN 064 775 088
323 Charlestown Road
CHARLESTOWN NSW 2290
FINAL

Phone: 02 4943 1777
Fax: 02 4943 1577
Job No: TL090098
Revision: B
Date: Jan , 2010

	BY	DATE
Prepared	DW	20.01.10
Checked	AB	20.01.10

Executive Summary

A hydrological and hydraulic assessment was undertaken for a stretch of Raglan Creek traversing the proposed development site located on Pat O'Leary Drive, Kelso. The runoff routing software suite DRAINS was used to estimate the peak 1% AEP flow, whilst the hydraulic software package HEC-RAS was used to predict the corresponding 1% AEP water profile.

The results of the modelling predicted a maximum change in water surface level within Raglan Creek was 8mm. The modelling also indicated the full 1% AEP peak flow is whole contained within the channel and does not break the creek banks. The change in flood profile due to the proposed development is deemed to be insignificant, and within tolerance for the modelling software.

Table of Contents

Contents

1.0 Introduction

1.1 Investigation Objectives

This study was undertaken by Northrop Engineers Pty Ltd on behalf of Paterson and Associates Pty Ltd. The Objective of this report is to summarise a hydrological and hydraulic analysis undertaken to provide flood level information for the proposed development located on Pat O'Leary Drive, Kelso. Of importance was the 100 year ARI floodplain and water surface profile change arising from the proposed development within Raglan Creek, a water course running through the proposed development site. This was to be done using a 100 year Average Recurrence Interval (ARI) storm event under the catchment conditions of a pre developed and post developed site.

1.2 Site Description

The proposed development site is bounded by Pat O'Leary Drive, the Great Western Highway and the railway line in Kelso, NSW and incorporates a total area of approximately 5.78 Ha. From site observations, the majority of the site has been cleared of natural vegetation, with grass now covering much of the site. The site has very little vegetation growth with the exception of the north-western boundary where Raglan Creek traverses the site. This channel has very dense vegetation growth and the channel itself is quite deep, approximately 4m, with steep banks. The deep geometry allows it to contain relatively high flows compared to the runoff derived from the contributing catchment. Figure 1 below depicts the proposed development site and Raglan Creek.

Figure 1 Pat O'Leary Drive Proposed Development Site. The Red Line Represents The Stretch Of Raglan Creek Being Modelled

The size of the contributing catchment upstream of the Raglan Creek bridge under the Great Western Highway is approximately 1257 Ha. There is a slight constriction in cross-section in the vicinity of the bridge. The catchment area consists primarily of agricultural land used for cropping. There are also areas of development / urbanisation which have been considered as part of our investigation. The maximum change in elevation within the catchment is 109m, corresponding to the longest flow path of approximately 4.6km, giving an average slope in the order of 2.4%. Within the catchment there are five main tributaries.

1.3 Catchment Analysis

The Raglan Creek catchment area investigated in this study has been analysed using 1:4000 topographic maps. The total catchment area for the streams under investigation was deemed to be approximately 1257 Ha. This was however divided into six sub-catchment areas, one for each of the five contributing tributaries

streams. The other catchment, which is to be altered by the proposed development, contributes to Raglan Creek at station 79.43 as opposed to the entrance of the site for modelling purposes. These subcatchments are illustrated in Figure 2 below.

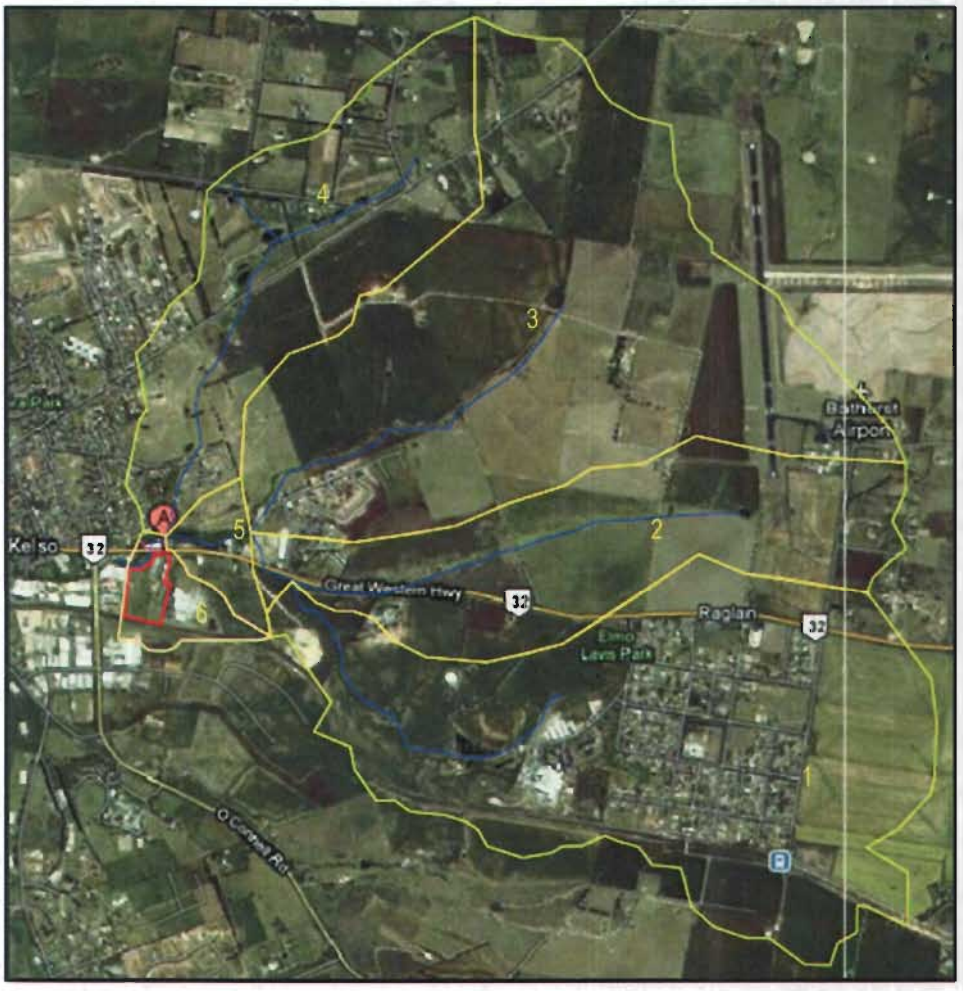


Figure 2 Sub Catchments Entering Raglan Creek, The Red Polygon Represents Pat O'Leary Drive Proposed Development Site.

From Figure 2 above it can be seen that subcatchment 1 routes into subcatchment 2. Subcatchments 2 and 3 route into 5 and subcatchments 4 and 5 then flow along Raglan Creek traversing the development site. Subcatchment 6 then enters Raglan Creek partway within the site.

For simplicity the catchment areas are illustrated in Table 1 below.

Subcatchment Number (Refer to Figure 2)	Area (Ha) (approx)
1	396.84
2	197.58
3	422.34
4	20.4
5	195.99
6	23.95
Total Area	1257.1

2.0 Hydrological Analysis

2.1 Description

The hydrological analysis for this study used the routing model 'DRAINS'. As previously mentioned, the proposed development site and its upstream catchment were divided into a series of subcatchments. 'DRAINS' modelling requires that each subcatchment is given a parameter of area. Furthermore each subcatchment can be divided into three land types of paved area, supplementary area and grassed area, to represent the catchment in its natural state, with a time of concentration applied to each land cover. These parameters, combined with hydrographs generated from input rainfall patterns based on Australian Rainfall and Runoff (AUS-IFD) data are used in loss modelling and time-area routing to model the system's behaviour and estimate peak discharge. 'DRAINS' then produces a figure from which the peak flows from each catchment can be identified and the way in which the peak flows move down the catchment are observed. Refer to Table 2 for subcatchment parameters, which were determined by orthophotos.

Subcatchment	Subcatchment Area	Paved Area (%)	Supplementary Area (%)	Pervious Area (%)
1	396.84	2	0	98
2	197.58	2	0	98
3	422.34	4	0	96
4	20.4	7	0	93
5	195.99	13	0	87
6 Pre Development	23.95	12	0	88
6 Post Development	23.95	32	0	68

Table 2 –Subcatchment Parameters

2.2 Rainfall Data

Design Rainfall intensity-frequency-duration (IFD) for the site, were obtained using methods set-out in the Australian Rainfall and Runoff (ARR) 1987.

2.3 'DRAINS' Modelling Parameters

2.3.1 Losses

'DRAINS' modelling was undertaken using an initial and continuing loss model. A parameter of depression storage is entered for each surface type which is considered as initial loss. A parameter of soil type was also entered which is used to calculate continuing loss from all grassed areas. The depression storage and soil type parameters adopted are as follows.

- Depression storage
  - Paved area 1mm
  - Supplementary area 1mm
  - Grassed area 5mm
- Soil Type 2

2.3.2 Time of Concentration

The time of concentration for each subcatchment was calculated using the detailed data tool in 'DRAINS'. This is simply a more accurate method of calculating a time of concentration for each catchment then numerical formulas based purely on catchment size. This method determines the time of concentration using parameters such as roughness, lengths of flow paths and slopes within each catchment in conjunction with the kinematic wave equation.

2.3.3 Channel Routing/Travel Time

Channel routing effects in 'DRAINS' are modelled by entering a travel or lag time. The adopted lag times as well as channel lengths can be seen in Table 3.

Linked Subcatchments	Channel Length (m)	Lag Time Adopted (min)
1-2	360	6
2-4	458	7.68
3-4	458	7.68
4-Raglan Creek Entrance	291	4.85
5-Raglan Creek Entrance	291	4.85
6-Mid Raglan Creek	6	0.1

Table 3 – Estimated Lag Times

2.4 Discharge Estimates

Using a 100 year ARI storm event, peak discharge was estimated for each of the subcatchments using 'DRAINS'. 'DRAINS' also routed the hydrograph discharges through the catchment incorporating losses and the different lag times estimating flow within the modelled section of Raglan Creek. This was done for storm durations ranging from 5 minutes to 6 hours to determine the critical storm duration which produced the highest peak flow within the modelled section of Raglan Creek. It was found that the critical storm duration of 45 minutes produced the largest flow of 37.5m^3/s. The flow running off the development site (Catchment 6, refer Figure 2) and into Raglan Creek at station 79.94 was also simulated in these models for both pre and post development of the catchment. It has been found that the contributing flows into Raglan Creek were:

Stage Of Development	Pre Development (m^3/s)	Post Development (m^3/s)
Flow Entering Raglan Creek At Section 79.94	0.5	0.7

2.5 State Rational Method

For verification of the flows obtained from 'DRAINS' the Statistical Rational Method was used to calculate the flows out of the catchment in a 100 year ARI by hand. This method simply uses a precipitation intensity, runoff coefficient and area.

$$Q = C \times I \times A \quad \text{(Equation 1)}$$

The precipitation intensity was found using Australian Rainfall and Runoff (AUS-IFD) tables for a 100 year ARI. This was generated based on location and the time of concentration of the total catchment, found using Pilgrims method. A runoff coefficient was obtained using the Institute of Engineers, Australia (1987) Australian Rainfall and Runoff volume 2 textbook. This value was for a ten year ARI however was converted to the 100 year ARI using the frequency factor $FF_{100} = 1.2$. The peak flow rate calculated using the Statistical Rational Method was $32.72 m^3/s$.

2.6 Discussion

Both the Statistical Rational Method and routing software DRAINS provided similar estimates for the peak 100 year ARI event. As a further precaution of conservatism, the larger flow predicted by the more comprehensive 'DRAINS' routing software was used in the hydraulic modelling. The final flow will be $37.5 m^3/s$ into the top of the modelled reach of Pat O'Leary Drive Proposed Development Site. With an additional $0.5 m^3/s$ representing inflow at station 79.94 of the modelled reach in the Pre development phase and $0.7 m^3/s$ representing the post development phase.

3.0 Hydraulic Analysis

3.1 Description

The hydraulic analysis for this investigation was undertaken using the one-dimensional river hydraulics model HEC-RAS. Cross-sections were taken perpendicular to the direction of flow, at intervals along the length of the drainage channel to be modelled. The extent creek modelled started approximately 30m upstream of the Great Western Highway bridge and finished just downstream of the proposed development site (refer to drawing C03 for cross-section locations). HEC-RAS calculates the predicted water surface profile at each cross-section dependent upon the channels shape, peak flood discharge and energy losses.

3.2 Channel Modelling Parameters

3.2.1 Manning's 'n' Estimation

HEC-RAS requires an estimation of the channel roughness or manning's 'n'. The manning's 'n' values adopted for the model were estimated compared to the hydraulic reference text 'Open Channel Hydrauilcs', published by V T Chow. The manning's 'n' values adopted were generally very high as the channel and its banks were heavily vegetated by trees and thick underbrush. The typical munnings value used within the channel was 0.2.

3.2.2 Boundary Conditions

HEC-RAS requires the input of boundary conditions to calculate the water level at both the upstream and downstream sections of the watercourse being modelled. The boundary conditions entered for the modelled channel were:

- Upstream Boundary Condition — Normal Depth S=0.1085
- Downstream Boundary Condition — Normal Depth S=0.00723

When using the 'normal depth' boundary condition in HEC-RAS an energy slope is required at the channel boundary. This is then used to calculate normal depth using Manning's equation in conjunction with the

flow. Given that the energy slope was unknown, it was approximated by using the slope of the channel bottom at that boundary, this was determined from the detailed survey data.

3.2.3 Cross Sections

Cross sections for the modelled section of Raglan Creek were obtained using a detailed survey of the channel. Cross sections were entered in no more than 15 meter centres and whenever there was a significant change in channel shape.

3.3 Results

Simulations of the surface levels both before and after the proposed development were run in order to find the effects of the development on the water levels both up and downstream. Table 3 below depicts the predicted pre-development and post-development 1%AEP flood level water surfaces.

Station	Station Distance Downstream (m)	Water Surface Elevation Pre-Development (AHD)	Water Surface Elevation Post-Development (AHD)	Change in Water Surface Elevation (m)
1 (Upstream)	5.399	669.978	669.982	0.003
2	9.58	669.938	669.941	0.004
Bridge	Bridge	Bridge	Bridge	Bridge
3	20.62	669.745	669.749	0.004
4	23.62	669.698	669.702	0.004
5	29.191	669.668	669.673	0.005
6	37.964	669.613	669.618	0.005
7	44.356	669.559	669.564	0.005
8	55.791	669.441	669.447	0.006
9	65.061	669.351	669.358	0.007
10	79.943	669.126	669.134	0.008
11	85.119	668.991	668.999	0.008
12	90.128	668.912	668.920	0.008
13	94.086	668.888	668.896	0.008

14	103.718	668.820	668.829	0.008
15	112.342	668.752	668.760	0.008
16	114.951	668.732	668.740	0.008
17	117.539	668.719	668.727	0.008
18	121.144	668.702	668.710	0.008
19 (Downstream)	132.717	668.637	668.644	0.008

Table 3 Surface Elevations Occurring In Raglan Creek Arising From 100 Year AEP In Pre And Post Development Scenarios

From this table it can be seen that there are only slight backwater effects caused by the extra runoff of the site being developed. The magnitude of the change in the water level is quite minimal (with a maximum of 8mm predicted) towards the lower and central reach of the creek. The upstream reach exhibited a mere 3mm increase (insofar as the level of accuracy of such modelling software).

It should also be noted that the 1%AEP flood is completely contained within the creek banks with no overbank flow occurring along the modelled length. The water levels within each cross section of the channel can be found in Appendix A and is further illustrated in plan view on drawing C03. The majority of the earthworks proposed as part of the development do not encroach onto the 1%AEP with the exception of eight meters of battering which encroach a maximum of one meter around station 29.191 (See drawing C03). It has been found that this does not significantly affect creek hydraulics.

3.4 Discussion

The increased flow derived from developing the site has little effect on the flood profile, with an estimate maximum effect of 8mm. This increase is not considered to be significant and is within tolerance for the modelling software. We have also held discussions with Darren Sturgess (Manager of Technical Services) of the local Council who has advised that Council has previously analysed the catchment assuming full urban development (i.e., decades in to the future) as opposed to its current state. That study has indicated the peak 100yr flow within Raglan creek would be in the order of 48m^3/s. As a matter for conservatism, we have also modelled this higher flow within HEC-RAS to determine the impact and have observed a similar result that those expressed above; that being very minor changes in flood levels between pre and post development scenarios.

4.0 References

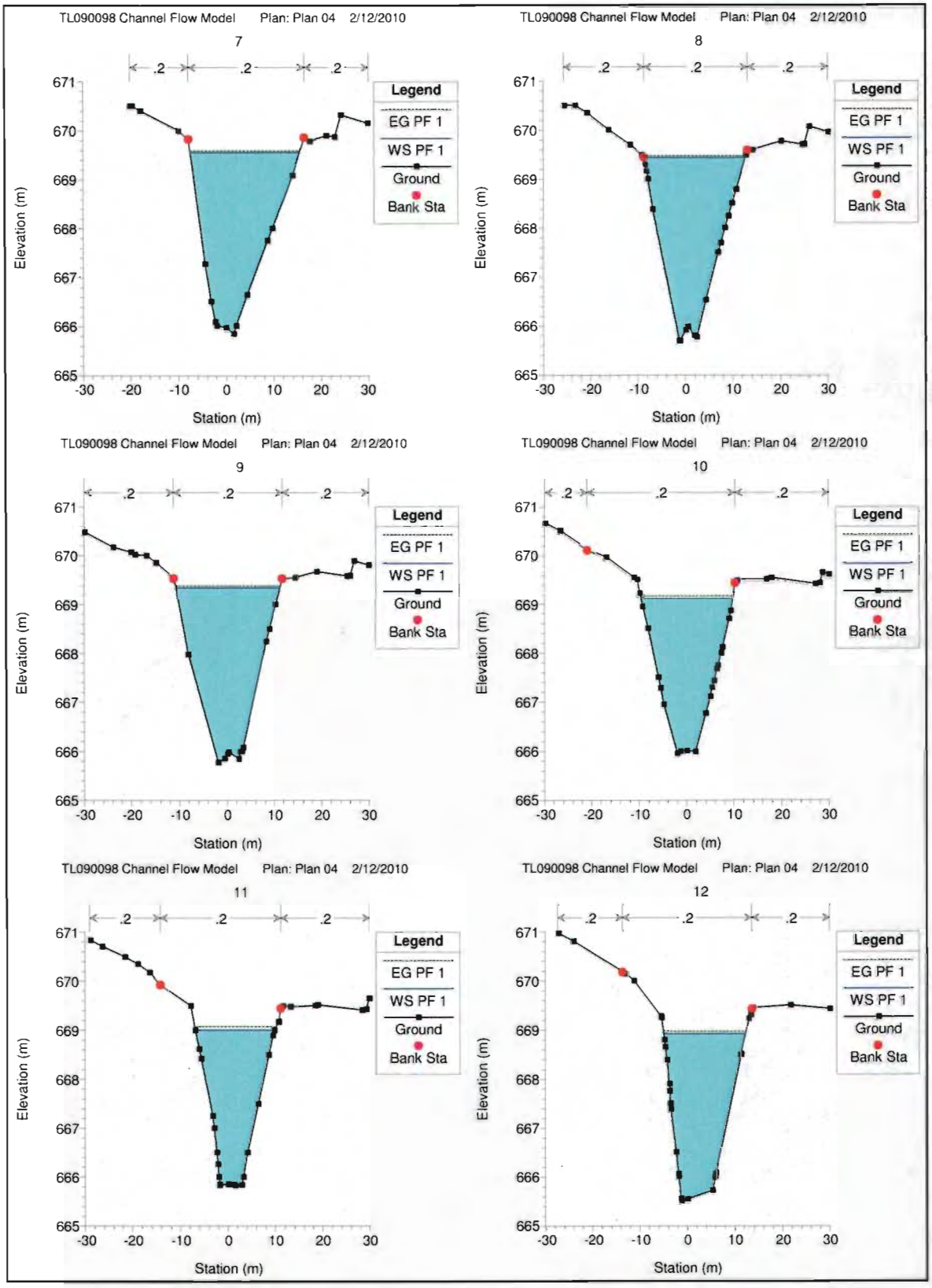
Urban Water Cycle Solutions (2004) Stormwater Management at the Proposed Bridgman Ridge Development in Singleton

US Army Corps of Engineers (2006) HEC-RAS River Analysis System User Manual

The Institute of Engineers, Australia (1987) Australian Rainfall and Runoff

Watercom Pty Ltd, Sydney (2005) DRAINS User Manual

Appendix A – HEC-RAS Cross-Sections


TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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Station (m)
TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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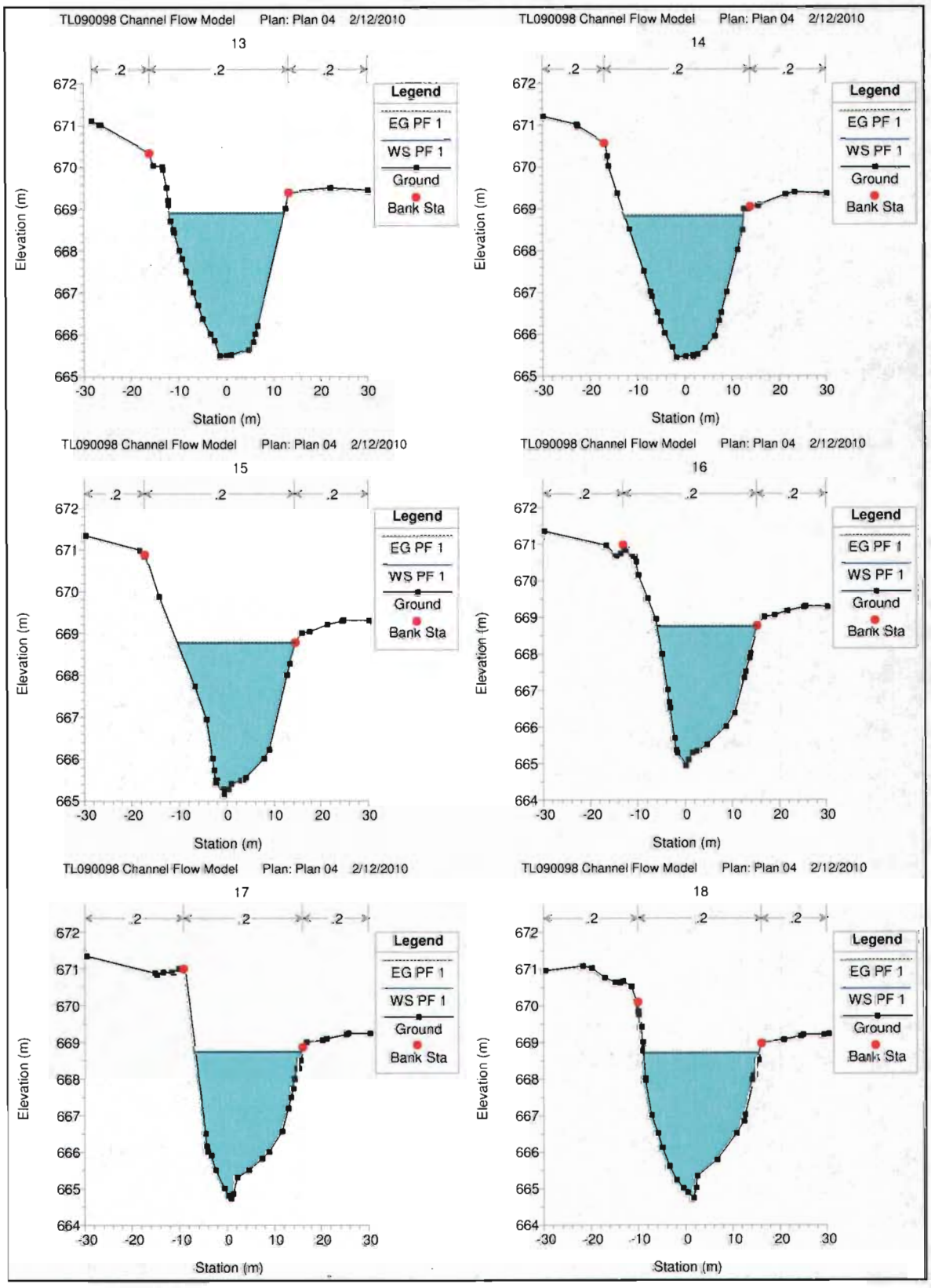
TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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Legend
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WS PF 1
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Elevation (m)
Station (m)
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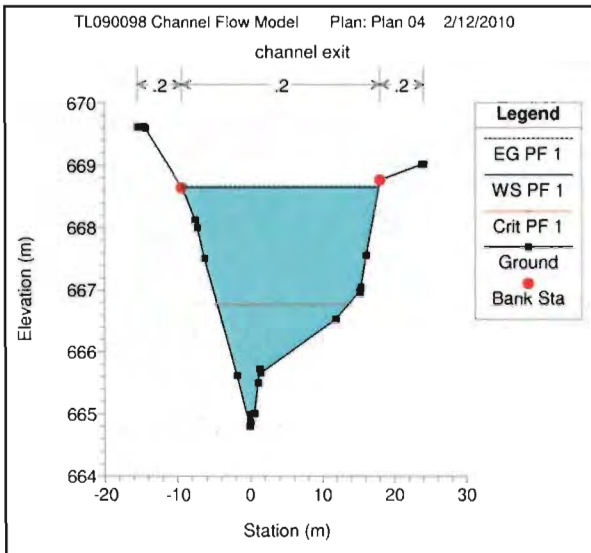
TL090098 Channel Flow Model Plan: Plan 04 2/12/2010
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Elevation (m)
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Station (m)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

ISSUE	AMENDMENT	DRAWN	APPROVED	DATE
A	ISSUED FOR APPROVAL	AB	AB	22.01.18
B	FLOOD PLAIN REVISED	AB	AB	12.02.18

CLIENT: STEVENS GROUP

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JOB NUMBER: TL090098
DRAWING NUMBER: C04 DA
ISSUE: B