Travers

bushfire & ecology

watercourse assessment

Lot 1 DP 218016, Lot B DP 370979
& Lot 22 DP 564065
166 - 176 St Andrews Road,
Varroville, NSW

October 2015
REF: A15141W

Watercourse Assessment

Lot 1 DP 218016, Lot B DP 370979
& Lot 22 DP 564065
166-176 St. Andrews Road, Varroville

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The mapping is indicative of available space and location of features which may prove critical in assessing the viability of the proposed works. Mapping has been produced on a map base with an inherent level of inaccuracy, the location of all mapped features are to be confirmed by a registered surveyor.

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Executive Summary

This watercourse assessment report has been prepared by *Travers bushfire & ecology* to verify the existing watercourses on site and to identify the riparian buffer vegetated riparian zone (VRZ) constraints in accordance with the NSW Office of Water *Controlled Activities On Waterfront Land - Guidelines for Riparian Corridors on Waterfront Land (*July 2012).

Based on ground truthing, this report identifies that watercourses do affect the site within Lot 1 DP 218016, Lot B DP 370979 & Lot 22 DP 564065, 166-176 St. Andrews Road, Varroville. The watercourses are grouped three catchments including:

- Western watercourses – Catchment A consisting of second and third order streams divided into 3 sub-catchments.
- South Eastern watercourses – Catchment B consisting of first and second order watercourse and associated drainage line.
- North Eastern watercourses – Catchment C affecting only drainage lines.

All works within the riparian protection zone and ongoing management will be in accordance with NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land (*July 2012) and the issued General Terms of Approval for future development applications.

Alternative solutions are appropriate for highly degraded watercourses and approvable under a Controlled Activity Approval from the NSW Office of Water in accordance with the requirements of the *Water Management Act 2000 (WM Act).*

This will require the preparation of a vegetation management plan (VMP) for all retained watercourses to accurately define the planning layout, inclusive of densities, spacing and plant species to be used.

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Introduction 1

Travers bushfire & ecology has been requested by *Catholic Metropolitan Cemeteries Trust* to undertake a watercourse assessment for the planning proposal located at 166 - 176 St Andrews Road, Varroville.

The identification of watercourses and vegetated riparian zones (VRZs) are required pursuant to the *WM Act* which controls activities within 40m of a designated watercourse. Any controlled activities being undertaken within 40m of a designated watercourse require a permit from the administering authority, the NSW Office of Water, Department of Environment and Climate Change (DECCW).

This advice identifies whether the site is affected by a watercourse as defined under the *WM Act*, assesses the existence and condition of the mapped watercourses, presence of any sensitive riparian habitat, confirms the extent of watercourses, their classification and assesses the level of riparian corridor protection required in accordance with the Controlled Activity Guidelines for watercourses as issued by the NSW Office of Water.

Where warranted, recommendations are also made for poor condition watercourses that can be diverted or replaced with designed embankments and vegetated banks and offline stormwater quality and quantity control devices that will protect the catchment and riparian functions and habitat.

1.1 Proposed Varroville cemetery masterplan

The site is currently zoned under the Campbelltown Local Environmental Plan (LEP) – District 8 (Central Hills Lands) 2008 as 7(d1) Environmental Protection (Scenic) and part 6(c) Open Space (regional).

The initial planning proposal seeks to amend local planning controls under the LEP to allow a cemetery as an additional permissible land use on the site.

A concept master plan has been developed (Figure 1) which has been designed subject to the site constraints including the identified ecological, riparian and bushfire issues. The master plan provides for the following built facilities:

- one chapel with the capability to be divided into three separate chapels seating 150 in each
- one condolence room
- one café

Figure 1 – Proposed Varroville Cemetery Masterplan

In addition to these built assets, the vision for the cemetery is to provide for the following:

- a distinctive landscaped cemetery providing concealed, private and low lying burial spaces to minimise visual impact;
- a sculpture park, offering opportunities for local and Australian artists; and
- an arboretum for future preservation and education of generations to come.

The design of the proposed cemetery has avoided impacting on significant ecological constraints of the site. Minor impacts on existing vegetation areas are identified with red hatching.

1.2 Staging

The *Catholic Cemeteries Metropolitan Trust*, which manages several government cemeteries in the Sydney's metropolitan area, has purchased this site with the view to providing a landscaped cemetery for the whole community in Sydney's west.

Typically, each stage would represent 5-10 years of burial demand, slowly extending the footprint of the cemetery, one manageable "bite" at a time. The northern half of the site is expected to reach capacity in approximately 105 years and full capacity in approximately 170 years. Should the current trend of double interment continue, these numbers would double (i.e. half capacity in 210 years and full capacity in 340 years).

1.3 Site description

The site is approximately 113 ha in size. It lies between Camden Valley Way and the Hume Highway, south of St James Rd and encompasses several parcels of land known as Lot B, 22 and 1, on St Andrews Rd, Varroville

The site is characterised by undulating grassed hills and pockets of forested areas. It enjoys panoramic views to the Blue Mountains, Sydney CBD and the Campbelltown valley. It sits within the Scenic Hills area and surrounds the historic Varroville House.

The site encompasses the Bunbury Curran hilltop. From this local high point, the land drops steeply to a valley along the western boundary whilst the eastern boundary offers a lower ridge protecting it from the eastern views. This lower ridge continues towards Varroville House (which is not part of the property), effectively separating the site into two distinct precincts with different exposure and outlook.

The land presents several constraints for development, including steep topography, the presence of Moist Shale Woodland and Cumberland Plain Woodland, heritage curtilage extending beyond the boundary of Varroville House, riparian zones, waterways and historical dams.

The first European land owner was Dr Robert Townson who obtained the large landholding (which contained this property) as part of the 1809 colonial land grants. He established the property as pasturage and vineyards. His grapes were said to have been recognised as amongst the best in the colony. Captain Charles Sturt was also amongst the owners (c 1830s) and is thought to have established the western lakes. Varroville House, a substantial single storey house (not part of the proposed cemetery) was established in 1858-59 and is historically significant.

The subject site mostly drains in a south easterly direction into Bunbury Curran Creek, then into the greater Georges River Catchment. The watercourses of the site and its associated catchment are split by St Andrews Road and in part flow through Mount Carmel Catholic High School.

Table 1– Site features

Location	166 - 176 St Andrews Road, Varroville
Local government area	City of Campbelltown
Lot & DP	Lot 1 DP 218016, Lot B DP 370979 & Lot 22 DP 564065
Grid reference	299000E 6235700N
Elevation	50-100m AMSL
Topography	Situated on a steady SE sloping landscape parallel to St Andrews Road with a steeper incline towards the vegetated northern boundary.
Geology and soils	Geology; Shale carbonaceous claystone, laminate, coal in parts. Unnamed sandstone member – fine to medium grained quartz-lithic sandstone.
Catchment and drainage	Catchment – Bunbury Curran Creek Small creeks and tributaries across the site drain SE joining until they reach Bunbury Curran Creek.
Vegetation	Where present, native vegetation has a riparian structure due to small creeks and tributaries running through the site. In most areas, trees are around 15-25m tall, there is a limited mid-storey mostly made up of weeds such as African Olive and a ground layer of grasses and herbs. The vegetation is highly modified throughout the study area due to previous clearing.
Existing land use	Rural, grazing and unmanaged
Clearing	The majority of the study area has been previously cleared for indicated land uses.

Aerial photography and mapping obtained from the NSW Land and Property Management Authority's (LPMA) *Spatial Information Exchange* (*SIX Viewer*), *Google Earth Pro* and topographic mapping indicates that there are a number of farm dams and streams located within, and in the vicinity of, the site (refer Figure 2). Where required, measures need to be taken to provide appropriate riparian protection for any future development to maintain water quality and to conserve riparian vegetation and associated faunal habitat.

Accordingly, *Travers bushfire & ecology* has been engaged to determine the riparian constraints for the property associated with the existing watercourses within land surrounding the site.

This report was based on a detailed site investigation to verify the presence and environmental value of any streams and to provide recommendations on riparian setbacks that will apply to any future development.

Mapped Watercourses 2

Electronic aerial photography from *Google Earth Pro* and *Spatial Information Exchange* were viewed. Topographic mapping for the site (Figure 2) was also viewed as the key trigger of a nominated watercourse for assessment purposes.

This mapping shows that the site is affected by several unnamed watercourses (Figure 2) including:

- Western watercourses – Catchment A consisting of second and third order streams divided into 3 sub-catchments.
- South eastern watercourses – Catchment B consisting of first and second order watercourses and associated drainage line.
- North eastern watercourses – Catchment C affecting two drainage lines.

Watercourses from Catchment A feed into Bunbury Curran Creek and cover a catchment area of 202ha. Consequently, the main watercourse appears to be a permanent flowing stream carrying significant quantities of potential stormwater drainage. Watercourses to the south east of St Andrews Road were not inspected. Approximately 50% of Catchment A is contained within the planning proposal area and forms the major portion of the site.

Catchment B containing the south eastern watercourses drains 35ha of the site. The watercourse below the existing dam is not well defined due to the artificial dam and is now directed overland through a spillway and grass pasture which was most likely to be Swamp Sclerophyll Forest prior to clearance of the land for agricultural use. The dam and incised gullies above are most likely to have been artificially created as part of past land use and we expect this part of the landscape may have been intensively used for orchids or vines, given its close proximity to Varroville House, south easterly aspect and close proximity to dams.

Catchment (C) is not affected given that a very minor portion of the catchment is contained within the site (Figure 2). The mapped watercourses are in fact grassed swales with no channel formation and hence are not classed as watercourses but drainage lines.

This watercourse assessment has only addressed watercourses within the site.

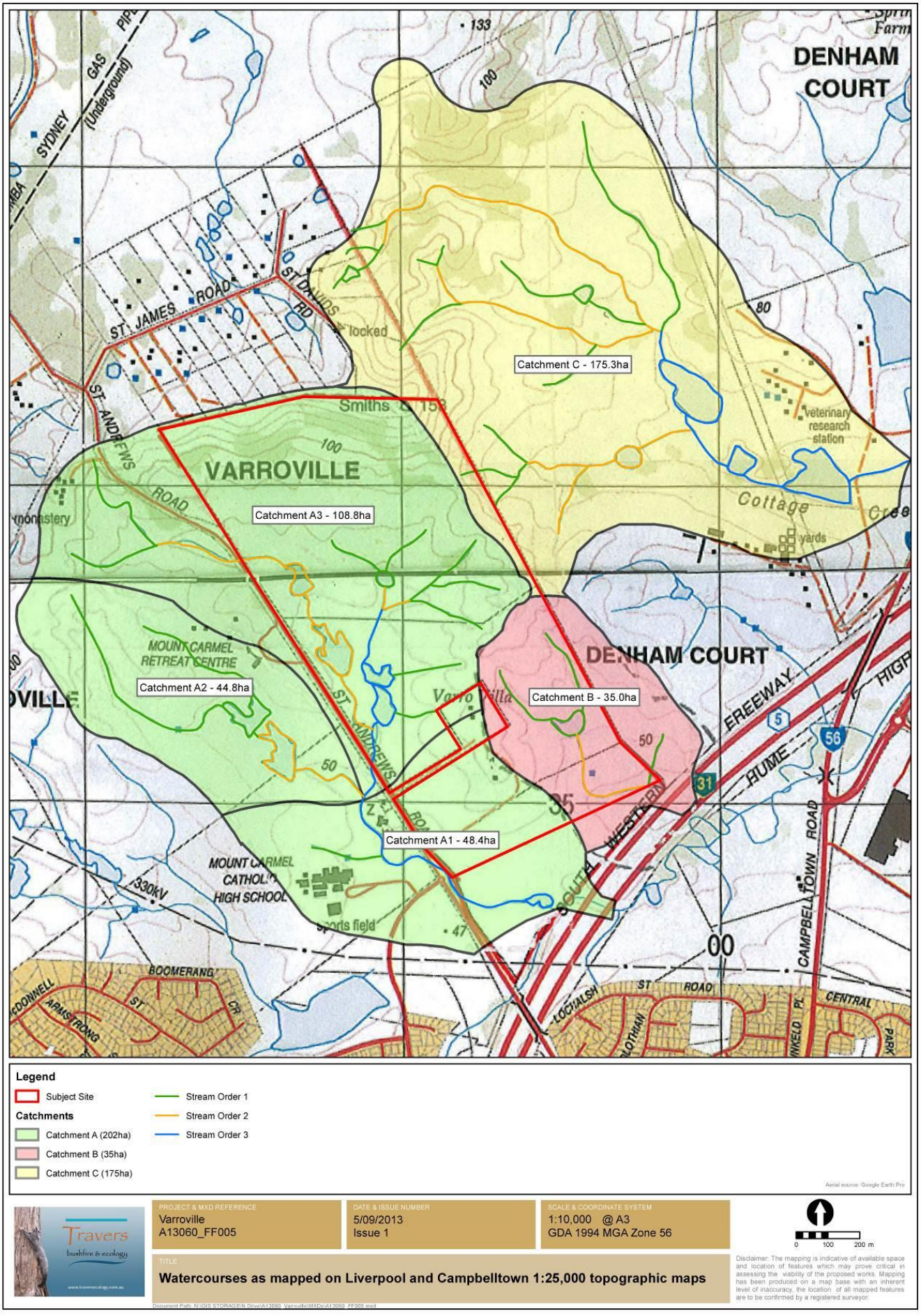

Figure 2 – Watercourse and stream order as mapped on Liverpool and Campbelltown 1:25000 topographic maps

Validation of Watercourses 3

An inspection of the site and its watercourses was undertaken on 27 June 2013 to identify the presence or absence of watercourse features.

For each watercourse present, the following features were assessed:

- the presence of a defined channel (either intermittent or continuous) along the alignment of the watercourse;
- the extent of riparian vegetation;
- the presence of vegetation with environmental value
- the presence of noxious weeds and degree of weed infestation
- the presence of any ponded water;
- the presence of flow along the stream and the associated flow velocity;
- the potential connectivity between any riparian vegetation and upstream or downstream riparian vegetation.

As identified on Figure 2, the site drains into four (4) sub-catchments as follows:

- Catchment A - 202ha consisting of three (3)sub-catchments (A1 - 48.4ha, A2- 44.8ha, A3 – 108.8ha)
- Catchment B - 35ha
- Catchment C - 175ha (small portion within site which drains into adjoining lands on the north eastern boundary)

The extent of each validated watercourse is shown on Figure 3 which also identifies drainage lines that are not watercourses. Watercourses in sub-catchment A2 are not considered as they are wholly contained within adjoining lands.

3.1 Catchment A1 – Watercourse 1

This is the lowest portion of the site with approximately 25% within the site, 50% on adjoining lands to the south west of St Andrews Road and the remaining 25% within the adjoining Crown Land. Watercourse 1 is located within the adjoining road corridor and is highly degraded. It will potentially require bank stabilisation and channel reconstruction to cater for storm flows. Buffers for watercourse 1 impact on the site and may need to be considered in the concept master plan.

The inspection identified the following characteristics:

- Permanent flow and defined channels;
- Sparse riparian vegetation mostly exotic, waterlogged pasture on the flats;
- Ponding of water in channels and dams;
- No direct vegetative connectivity downstream; and

Physical evidence supports the presence of a modified third order watercourse that is capable of providing a long term vegetative link but requires reconstruction and stabilisation.

3.1.1 Recommended management

Watercourse 1 is third order streams which require a 30m VRZ from top of bank. Management options include:

- Protect with a 30m VRZ from top of bank and revegetate corridor with Cumberland Plain Woodland (upper reaches) and Swamp Sclerophyll Forest (lower reach on flats).
- Integrate drainage works with downstream management on Crown Lands.

3.1.2 Watercourse photos

Photo 1 – *Watercourse 1 (upper portion within road reserve of St Andrews Road) facing downstream constructed channel, highly weed infested portion, however, stable*

3.1.3 Drainage lines

There were no further drainage lines observed.

3.2 Catchment A3 – Watercourses 2, 3, 4, 5, 6, 7 & 8 and Dams 2, 3, 4, 5, 6, 7, 8 & 9

Figure 2 identifies Watercourse 2 as a third order stream. Watercourses 3, 4, 5, 6, 7 and 8 are identified as second order streams based on the existing topographic mapping (Figure 2). Based on the catchment size and presence of channelisation, this classification is appropriate.

The inspection identified the following watercourse features:

- Two (1) large online dams built with functional spillways;
- Three offline dams, Dams 7 & 8 are stable and usable in current condition, Dam 9 is very small and does not hold significant water;
- Dams 2, 3 & 6 are online but stable with low weed infestation;
- Presence of a defined channel in the lower and upper reaches which appeared to have intermittent flows;
- Scattered remnant native trees hugging creek particularly on the lower reaches adjoining St Andrews Road;
- Mostly stable stream bed, often stabilised with weeds and kikuyu;
- Mostly pasture species in Watercourse 4 but increasing native vegetation upstream in Watercourses 7 & 8, with low levels of weed infestation. The adjoining vegetated landscape upstream of Watercourse 8 is dominated by African Olive in the understorey;
- Low weed levels within the dams but moderate levels of weed infestation in the riparian vegetation; and
- Dams show high turbidity levels due to stock access and erosion from upper slopes.

Physical evidence supports the presence of a moderately watercourses which are mostly stable, however, lacking good native riparian vegetation. Sufficient canopy and ground covers are present in the lower reaches to regenerate Cumberland Plain Woodland with assisted revegetation works. Resilient remnant Cumberland Plain Woodland in upper reaches of Watercourses 7 & 8.

3.2.1 Recommended management

Watercourses 4, 7 & 8 contain three online dams. Dams 2 & 3 are interconnected by the spillway and Dam 6 is located at the upstream end of Watercourse 7. This results in a highly controlled flow regime below Dam 2 which will generally only flow after a significant rainfall event which overtops the dams. Dam 7 is located high in the catchment which is linked by a grassed swale.

Watercourses 3, 5 & 6 are also similarly controlled by dams 4 & 5 which result in intermittent flows.

Management options include:

- Retain Dams 2,3, 4, 5 & 6 as an online storage protected with a 10m VRZ from top of bank
- Stabilise spillway of Dam 2;
- Retain Dam 8 as an offline storage – target weed control required on banks to remove Blackberry
- Remove Dam 9 or convert to a landscape feature
- Retain Dam 7 as an offline storage which can be enhanced as a landscape feature;

- Protect Watercourse 2 with a 30m VRZ from top of bank and progressively revegetate corridor with Cumberland Plain Woodland.
- Protect Watercourses 3, 5 & 6 with a 20m VRZ from top of bank and progressively revegetate corridor with Cumberland Plain Woodland.
- Target weed control required to promote regeneration of native species
- Watercourse channel to be stabilised with native sedge species; and
- All nominated drainage lines are to be incorporated into the general landscape and are to be kept stable at all times with 100% grass cover.

Alternative management options are potentially feasible to reconstructed channel with a 20m VRZ. This is given the very wide drainage channel (20m) which could be reconstructed to provide a more concentrated drainage path. During heavy storm events, the whole channel may be inundated. A proposal to modify the watercourse would also need to be accompanied by stormwater modelling to ensure sufficient capacity and flood drainage.

3.2.2 Watercourse and dam photos

Photo 2 – *Watercourse 2 (extension of Watercourse 1) St Andrews Road culvert showing dense lantana and African Olive understorey*

Photo 3 *– Watercourse 3 with defined channel (intermittent flows)*

Photo 4 – *Watercourse 4, intermittent channel with a wide grassed channel*

***Photo 5** – Watercourse 5, a wide grass swale in excess of 20m in width (intermittent flows)*

***Photo 6** – Watercourse 6 within site, upstream of Dam 5*

Photo 7 *– Watercourse 6, upstream of site and beyond western boundary*

Photo 8 – *Watercourse 7, intermittent channel with a wide grassed channel*

Photo 9 – *Watercourse 8 with shallow pools*

Photo 10 – *Dam 2 (approx. 5000m^2)*

Photo 11 *– Spillway for Dam 2 - requires stabilisation*

Photo 12 – *Dam 3 (approx. 4100m^2) (Source Google Earth Pro 2013)*

***Photo 13** – Dam 4 (approx. 9,950m^2)*

***Photo 14 –** Dam 6 (approx. 2,750m^2)*

Photo 15 – *Dam 7 (approx. 1,200m^2) (Source Google Earth Pro 2013)*

Photo 16 – *Dam 5 (approx. 5,100m^2)*

Photo 17 – *Dam 9 (approx. 1,300m^2) and Dam 10 (approx. 120m^2) (Source Google Earth Pro 2013)*

3.2.3 Drainage lines 4, 5, 6, 7, 8, 9, 10, 11, 12 & 13

Drainage lines 4, 5, 6, 7, 8, 9, 10, 11, 12 & 13 are confirmed by ground truthing as not being watercourses. This is demonstrated by lack of defined channels and lack of ponded or concentrated surface runoff after heavy rainfall

Photo 18 – *Drainage line 4, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 19 – *Drainage line 5, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 20– *Drainage line 6, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 21 – *Drainage lines 7 & 8 junction, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 22 – *Drainage line 9, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 23 – *Drainage line 10, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 24 – *Drainage line 11, grassed swale with small dam at head no evidence of drainage < 12 hours after heavy rains*

Photo 25 – *Drainage line 12, grassed swale with light surface drainage < 12 hours after heavy rains*

Photo 26 – *Drainage line 13, grassed swale with small dam at head no evidence of drainage < 12 hours after heavy rains*

3.3 Catchment B – Watercourses 9, 10 and 11 and Dams 10 & 11

Watercourse 9 is mapped as a second order stream and Watercourses 10 & 11 are mapped as first order streams in accordance with topographic mapping. The inspection identified the following watercourse features:

- Presence of a deep channels on Watercourses 10 & 11, immediately above Dam 9 which has evidence of past erosion;
- Stable grassed swales which extend upslope with intermittent flow;
- Watercourse 10 with significant bed erosion, canopy of Cumberland Plain Woodland and an understorey densely infested by African Olive and Box Thorn;
- Watercourse 9 is deeply incised but stable with a head cut at the top most point of the mapped watercourse being kept in check by a remnant tree but will require stabilisation;
- Dam 9 is stable with ornamental waterlilies;
- Dam 10 is small and has been breached in the main wall but still holds water with no freeboard; and
- Water flows via spillway on north eastern aspect of dam through a grassed swale, water course becomes more defined in lower reaches as indicated by the remnant Swamp Sclerophyll Forest canopy.

Physical evidence supports the presence of a highly degraded watercourse with a small catchment area. It has low ecological value and suits a first order stream, however, in accordance with *NSW Guidelines for Controlled Activities of Waterfront Lands,* it has been mapped as a second order stream below the existing dam. Alternative management solutions are appropriate for Watercourses 9, 10 & 11 due to presence of unstable banks and intermittently defined channels and small catchment size.

3.3.1 Recommended management

The following works are recommended:

- Retain Dam 9 as an ornamental feature and stormwater control;
- Dam 10 should be filled and reconstructed to a drainage channel;
- Dam 12 should be filled or reconstructed as a landscape feature;
- Reconstruct and stabilise Watercourses 10 and 11 and revegetate with Cumberland Plain Woodland; and
- All nominated drainage lines are to be incorporated into the general landscape and are to be kept stable at all times with 100% grass cover.

3.3.2 Watercourse photos

Photo 27 – *Watercourse 9 (lower reach)*

Photo 28 – *Watercourse 10, deep incised gully held in check by remnant native canopy and weeds*

Photo 29 – *Watercourse 11, looking upstream*

Photo 30 – *Dam 9 (approx. 5,200m^2) (Source Google Earth Pro 2013)*

Photo 31 – *Dam 10 (approx. 650m^2)*

3.3.3 Drainage lines 1, 2 & 3

Drainage lines 1, 2 and 3 are confirmed by ground truthing as not being watercourses:

Photo 32 – *Drainage line 1, site inspection revealed a grass swale below a small breached Dam 12 (approx. 500m^2 in size)*

Photo 33 – *Drainage line 2, no evidence of channelisation or drainage after heavy rains*

Photo 34 – *Drainage line 3 looking downstream to Watercourse 10, grassed swale with no evidence of any surface drainage <12 hours after heavy rain*

3.4 Catchment C – Drainage lines 14 & 15

Both drainage lines were mapped as a stream on 1:25000 topographic maps sheets, both were inspected for evidence of watercourses. Neither mapped stream showed evidence of channelisation and were the uppermost extent of the adjoining catchment.

3.4.1 Recommended management

All nominated drainage lines are to be incorporated into the general landscape and are to be kept stable at all times with 100% grass cover.

3.4.2 Drainage lines 14 & 15

Drainage lines 14 & 15 are confirmed by ground truthing as not being watercourses.

Photo 35 – *Drainage line 14, grassed swale with no evidence of drainage < 12 hours after heavy rain*

Photo 36 – *Drainage line 15, grassed swale with no evidence of drainage < 12 hours after heavy rain*

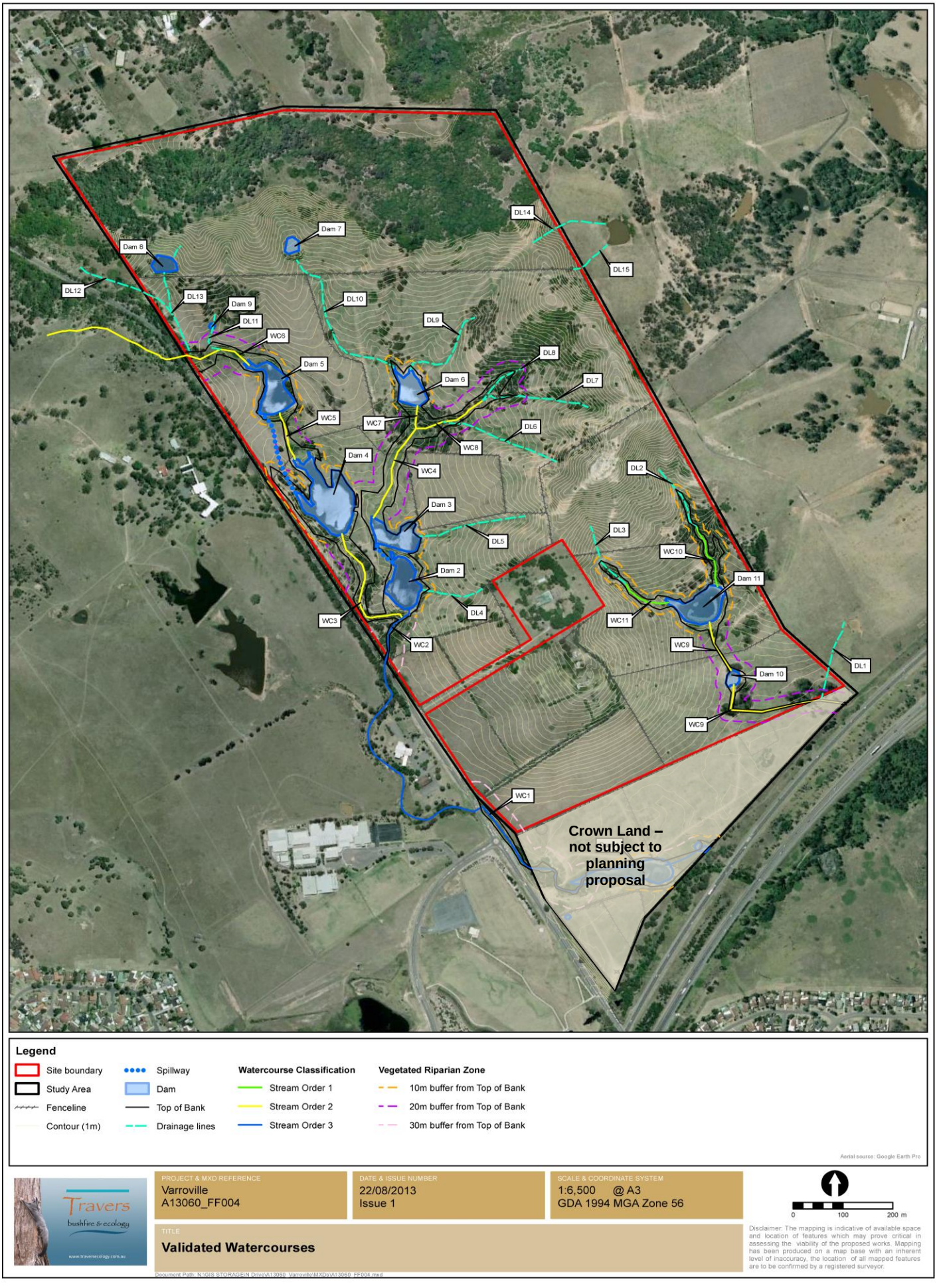

Figure 3 - Validated watercourses

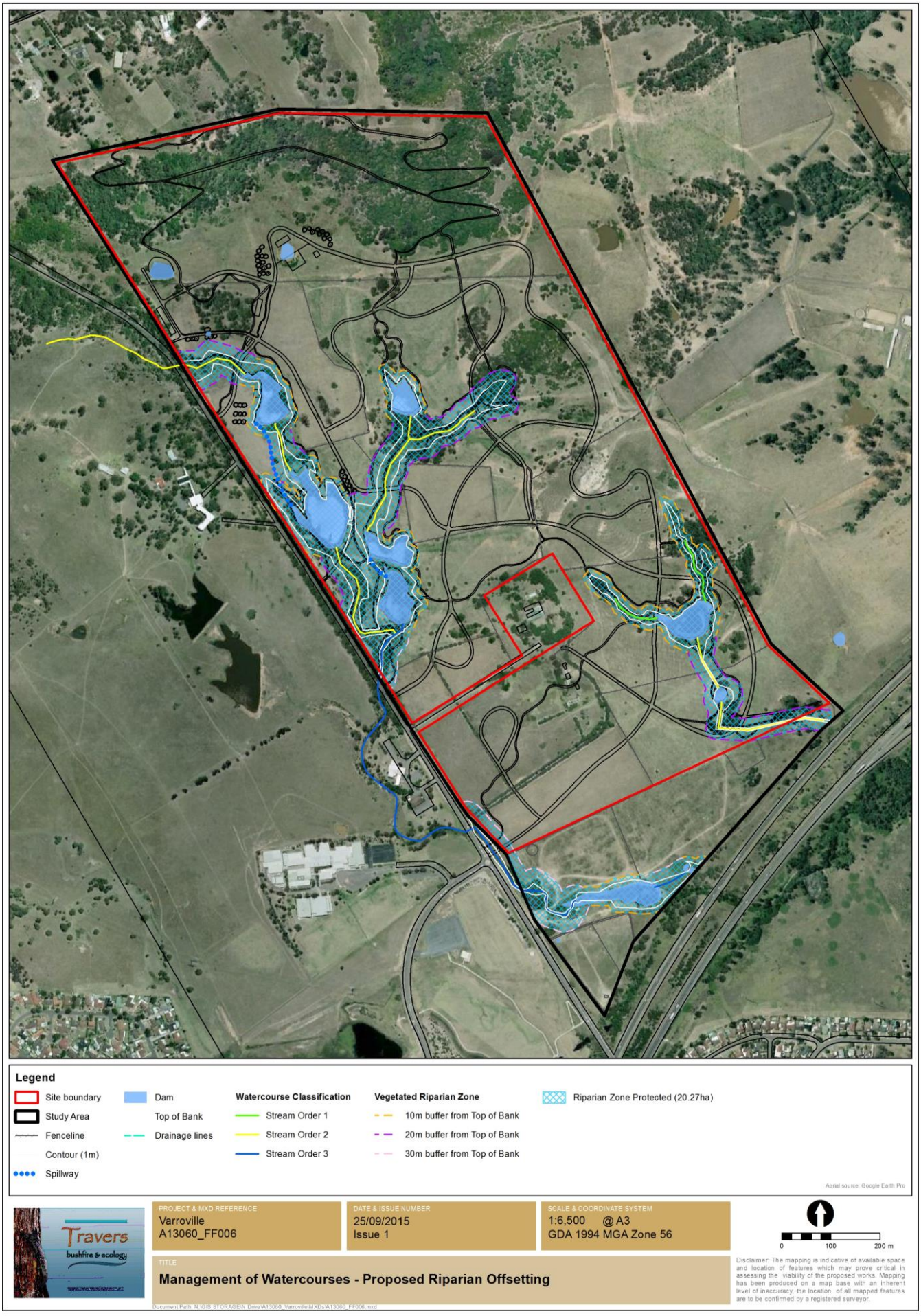

Figure 4 – Recommended riparian protection zones

Riparian Buffers & Controls

4

4.1 Objectives for riparian corridor management

The overarching objective of the controlled activities provisions of the *WM Act* is to establish and preserve the integrity of riparian corridors (NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* 2012). Ideally, the environmental functions of riparian corridors should be maintained or rehabilitated by applying the following principles:

- Identify whether or not there is a watercourse present and determine its order in accordance with the Strahler System.
- If a watercourse is present, define the riparian corridor / vegetated riparian zone on a map in accordance with Table 1.
- Seek to maintain or rehabilitate a riparian corridor / vegetated riparian zone with fully structured native vegetation in accordance with Table 1.
- Seek to minimise disturbance and harm to the recommended riparian corridor / VRZ.
- Minimise the number of creek crossings and provide a perimeter road separating development from the riparian corridor / VRZ.
- Locate services and infrastructure outside of the riparian corridor / VRZ. Within the riparian corridor / VRZ, provide multiple service easements and / or utilise road crossings where possible.
- Treat stormwater run-off before discharging into the riparian corridor / VRZ.

The NSW Office of Water however, does allow for a range of works and activities on waterfront land and in riparian corridors to better meet the needs of the community, providing that they cause minimal harm, as outlined in the riparian corridor matrix below.

4.2 Riparian corridors

Controlled activities carried out in, on or under waterfront land are regulated by the *WM Act.* The NSW Office of Water administers the *WM Act* and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity.

Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40m of the highest bank of the river, lake or estuary. This means that a controlled activity approval must be obtained from the NSW Office of Water before commencing the controlled activity.

The NSW Office of Water has developed *Controlled Activity Guidelines* (2012) to assist applicants who are considering carrying out a controlled activity on waterfront land (Appendix I). On 1 July 2012 new rules commenced regarding controlled activities within riparian corridors. The new rules amend the riparian corridor widths that apply to watercourses, providing more flexibility in how riparian corridors can be used. Key aspects of the changes include:

- Provision of greater flexibility in the allowable uses and works permitted within riparian corridors.
- The core riparian zone and vegetated buffer have been combined into a single VRZ.
- The width of the VRZ within the riparian corridor has been pre-determined and standardised for first, second, third and fourth order and greater watercourses.
- Where suitable, applicants may undertake non-riparian corridor works or development within the outer 50% of a VRZ, as long as they offset this activity by connecting an equivalent area to the riparian corridor within the development site, and
- The riparian corridors matrix enables applicants to determine what activities can be considered in riparian corridors.

As stated in the *Controlled Activity Guidelines* for the preparation of VMPs (NSW Office of Water 2012), a riparian corridor forms a transition zone between the land, also known as the terrestrial environment, and the river or watercourse or aquatic environment. Riparian corridors perform a range of important environmental functions such as:

- Providing bed and bank stability and reducing bank and channel erosion.
- Protecting water quality by trapping sediment, nutrients and other contaminants.
- Providing diversity of habitat for terrestrial, riparian and aquatic plants (flora) and animals (fauna).
- Providing connectivity between wildlife habitats.
- Conveying flood flows and controlling the direction of flood flows.
- Providing an interface or buffer between developments and waterways, and
- Providing passive recreational uses.

The protection, restoration or rehabilitation of vegetated riparian corridors is important for maintaining or improving the shape, stability (or geomorphic form) and ecological functions of a watercourse (NSW Office of Water 2012).

The proposed management of the riparian corridors can accommodate all these functions without compromising the bushfire safety of the proposed development areas.

4.3 Riparian corridor widths

The NSW Officer of Water recommends a VRZ width based on watercourse order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps (see Figure 2, 5 and Table 5). The width of the VRZ should be measured from the top of the highest bank on both sides of the watercourse (NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* 2012).

Figure 5 - The Strahler System

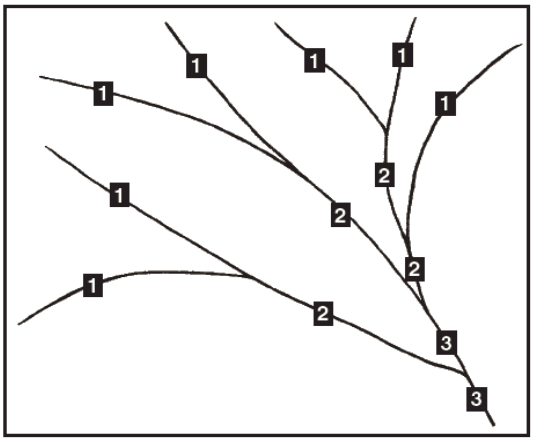

Table 2 - Recommended riparian corridor widths

Watercourse type	**VRZ width** (each side of watercourse) (metres)	**Total RC width (metres)**
First order	10	20 + channel width
second order	20	40 + channel width
third order	30	60 + channel width
fourth order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40	80 + channel width

Stream order: The watercourse order as classified under the Strahler System based on 1:25,000, 1:50,000 or 1:100,000 topographic maps, whichever is the smallest scale available. A full list is provided at Part 2, Schedule 2 of the *Water Management (General) Regulation 2011.*

Adherence to the NSW Office of Water Controlled Activity Guidelines is subject to the approval by the NSW Office of Water and the development consent authority. Consequently, alternative solutions are assessed by the NSW Office of Water based on their performance in terms of achieving riparian management objectives. Where a watercourse does not exhibit the features of a defined channel with bed and banks, the NSW Office of Water may determine that the watercourse is not waterfront land for the purposes of the *WM Act.*

The proposed riparian setbacks are consistent with the *NSW Office of Water Guidelines for Controlled Activities on Waterfront Lands (2012).* Riparian corridors will provide hydraulic and ecological functions and assist in maintaining ecological connectivity upstream and downstream of the site.

To promote ecological as well as hydraulic functions, the riparian corridors can be revegetated over the life of the project which allows for progressive revegetation and regeneration works.

Preparation of a VMP for the riparian corridors is recommended to accurately define the planting densities, spacings and species to be used within each riparian corridor and to integrate with any other vegetation management works or landscaping within the site.

4.4 Permissible works and activities within riparian corridors

The following riparian corridor matrix enables applicants to identify certain works and activities that can occur on waterfront land and in riparian corridors. Applicants should note that the matrix relates to controlled activity approvals under the *WM Act* only. They are still required to comply with other relevant government legislation, such as threatened species, flood planning levels and fisheries guidelines.

Table 3 - Riparian corridor matrix

Stream order	Vegetated Riparian Zone (VRZ)	RC off-setting for non RC uses	Cycleways and paths	Detention basins		Stormwater outlet structures and essential services	Stream realignment	Road crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1st	10m	•	•	•	•	•	•	•		
2nd	20m	•	•	•	•	•		•		
3rd	30m	•	•	•		•			•	•
4th +	40m	•	•	•		•			•	•

4.4.1 Riparian corridor off-setting for non-riparian corridor uses

In accordance with the NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* (2012), non-riparian uses, such as APZs are allowed within the outer 50% of the vegetated riparian zone, as long as offsets are provided in accordance with the averaging rule.

The riparian corridor offsetting provision can be used to offset the loss of any portions of the riparian corridor impacted by proposed works within the riparian corridor.

Other proposed activities such as cycleways, paths, detention basins, stormwater outlet structures and essential services and stream realignment are permissible in accordance with the NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* (2012).

In accordance with Figure 4, two buildings are proposed within the 10m riparian protection zone adjacent to dams, and one building is proposed adjoining a second order stream. Asset protection zones will also be required for these buildings which will potentially impact on the riparian protection zone.

Where buildings are adjacent to mapped first order stream, the building and associated APZ are not to encroach within 10m of the top of bank as a minimum standard. Where the proposed building and APZ impact on mapped riparian protection zone for a second order stream or higher, then the proposed building and associated APZ are not to encroach within 50% of the mapped riparian protection zone. Therefore in the case of a second order stream with a 20m riparian protection zone from top of bank, a minimum 10m riparian protection zone is to be provided with an equivalent area riparian protection offset.

Where a building is proposed adjoining an existing on-line dam, then a building is recommended to be set back to 10m from top of bank in accordance with the NSW Controlled Activity Guidelines. Other structures such as pathways maybe approved at the discretion of NSW Office of Water with equivalent area riparian protection offsets.

Conclusions and Recommendations 5

Based on ground truthing, this report identifies that watercourses do affect the site within Lot 1 DP 218016, Lot B DP 370979 & Lot 22 DP 564065, 166-176 St. Andrews Road, Varroville.

The watercourses are grouped into three (3) catchments including:

- Western watercourses – Catchment A consisting of second and third order streams divided into 3 sub-catchments.
- South eastern watercourses – Catchment B consisting of first and second order watercourse and associated drainage line.
- North eastern watercourses – Catchment C affecting only drainage lines.

The classification of field validated watercourses is illustrated on Figure 3. The watercourses are partially degraded i.e. lack riparian vegetation but are on the whole stable. Watercourses 10 & 11 are highly degraded and have evidence of bed cutting.

Alternative solutions for highly degraded watercourses are appropriate for this site and approvable under a Controlled Activity Approval from the NSW Office of Water, in accordance with the requirements of the *WM Act.*

Ongoing management of the site's riparian zones will generally be in accordance with the *Controlled Activity Guidelines for Riparian Corridors* as issued by the NSW Office of Water and the issued General Terms of Approval.

This will require the preparation of a VMP for all retained watercourses to accurately define planning densities, spacing and plant species to be used.

In accordance with the NSW Controlled Activity Guidelines, the following riparian protection zones apply:

- First order streams – 10 m from top of bank
- Second order streams – 20m from top of bank
- Third order streams – 20m from top of bank

As 'on-line' dams form part of the watercourse they are contained with waterfront land and approval from the NSW office of Water is required for any works within waterfront land. *Travers bushfire & ecology* recommends a riparian protection zone of 10m from top of bank be applied for any buildings. For 'off-line' dams – no protection zone is required.

In accordance with the NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* (2012), non-riparian uses are allowed within the outer 50% of the vegetated riparian zone, as long as offsets are provided in accordance with the averaging rule.

The riparian corridor offsetting provision can be used to offset the loss of any portions of the riparian corridor impacted by proposed works within the riparian corridor. An equivalent area riparian corridor offset can be provided for any losses of riparian protection zone.

The placement of buildings and any other non-riparian corridor uses are to be in accordance with the Table 3 - Riparian corridor matrix and the ‘Averaging Rule’ of the NSW Controlled Activity Guidelines (2012).