Appendix A

Agency and stakeholder consultation letters
Mount Victoria to Lithgow Alliance  
PO Box 164  
St Leonards NSW 1590

22 October 2012

RE: Mount Victoria to Lithgow upgrade of the Great Western Highway  
(Forty Bends Section)

The Office of Environment Heritage (OEH) has reviewed the exhibited Review of Environmental Factors for the Forty Bends section of the Mount Victoria to Lithgow upgrade of the Great Western Highway, and provides the following submission at Attachment A - Biodiversity for consideration by the NSW Roads and Maritime Services.

Our review has concluded that the requirements of the OEH have essentially been met although the issue of a suitable offset remains.

If you have any questions regarding this matter further please contact Robert Taylor on 02 6883 5354.

Yours sincerely,

[Signature]

ROBERT TAYLOR  
Manager, Environment & Conservation Programs  
North West Region
Attachment A

BIODIVERSITY IMPACTS

The Environmental Assessment requirements of the OEH and the DoPI require proponents to present justification of their preferred option based on four key thresholds – including whether or not the proposal, together with actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts will maintain or improve biodiversity values. The Department also evaluates offset proposals against the Department’s ‘Principles of the use of biodiversity offsets in NSW’.

Our review of the draft Review of Environmental Factors (REF) of the Forty Bends section of the Mount Victoria to Lithgow upgrade of the Great Western Highway has concluded that the requirements of the OEH have essentially been met although the issue of a suitable offset remains.

Issue:

The REF does not include a detailed offset proposal. Offset commitments should be demonstrated prior to the approval of the impact.

Background:

The REF states that the impact of the Forty Bends section of the Mount Victoria to Lithgow upgrade of the Great Western Highway will include 7.39 ha of native vegetation including 0.05 ha of Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland EEC. Two threatened species were recorded in the Forty Bends study area - Purple Copper Butterfly (Endangered under the TSC Act and Vulnerable under the EPBC Act) and Eastern False Pipistrelle (Vulnerable under the TSC Act).

The REF states that a biodiversity offset strategy will be developed with one potential offset location having been identified at South Bowenfels currently owned by RMS which supports a population of Purple Copper Butterfly.

Given the staged nature of the Mount Victoria to Lithgow upgrade of the Great Western Highway OEH has concerns regarding the manner in which offsetting for each stage may potentially be managed. It would be preferable to have a single, consolidated offset rather than a number of small offsets for each section of the highway upgrade. OEH appreciates that environmental assessments may not have necessarily been undertaken for all sections of the upgrade. However, a preliminary assessment of the vegetation types likely to be impacted by other parts of the Mt Victoria to Lithgow development could be used to inform selection of a suitable offset site.

Recommendation:

A detailed offset strategy should be provided to OEH so that its likely effectiveness in maintaining or improving biodiversity can be analysed. The offset strategy should:

- propose an offset which is supported by a suitable metric and which addresses the OEH ‘Principles for Biodiversity Offsets in the NSW’;
- selects an area that will allow further offsetting required for other parts of this multiphase development.
Christopher Barnett  
Project Manager  
Roads & Maritime Services  
PO Box 164  
ST LEONARDS NSW 1590

Dear Mr Barnett

I refer to your letter inviting the Heritage Council to provide comment on the Review of Environmental Factors (REF) undertaken for the proposed upgrade of the Great Western Highway at Forty Bends (South Bowenfels).

It is noted that the Heritage Council has previously provided comments on the proposed upgrade at Forty Bends in May 2012 and that a number of these comments were adopted as part of the REF process including undertaking a Statement of Heritage impact for the works program, consideration to minimising impacts to heritage and the identification of suitable mitigation measures.

Accordingly, the Heritage Branch, on behalf of the Heritage Council, has considered the information supplied in the REF and its associated appendices and provides the following comments:

1. Where impacts to heritage are unavoidable, the Heritage Council expects that the necessary Approvals are obtained prior to works commencing.

2. Mitigation measures must include a commitment to 'make good' any impacts to heritage items which may be outside the area of impact, but sustain peripheral impact due to the nature of the works.

3. The Heritage Branch requests that any Heritage Reports undertaken for these works are provided to the Heritage Branch, Office of Environment & Heritage for comment prior to works being approved and commencing.

If you have any questions regarding the above advice, please feel free to contact Katrina Stankowski at Katrina.Stankowski@heritage.nsw.gov.au.

Yours sincerely

23/10/2012

Vincent Sicardi  
Manager – Conservation Team  
Heritage Branch  
Office of Environment & Heritage  
As Delegate of the NSW Heritage Council

Helping the community conserve our heritage
Chris Barnett  
Project Manager  
Mount Victoria to Lithgow Alliance  
PO Box 164  
St Leonards NSW 1590

Dear Mr Barnett,

Review of Environmental Factors - Mount Victoria to Lithgow, Great Western Highway – Forty Bends Upgrade

Thank you for your letter dated 16 October 2012, and attached Review of Environmental Factors (REF) for the Forty Bends upgrade of the Great Western Highway between Lithgow and Mount Victoria. The Sydney Catchment Authority (SCA) appreciates the opportunity to comment on the REF documents.

This proposal is located in the Mid Cox’s River Catchment which is a part of the Sydney drinking water catchment. The SCA is responsible for managing and protecting the quality and quantity of water in the catchment.

The SCA has reviewed the REF: Volume 1 Main Report and the Technical Paper 6 Water Quality (October 2012) and notes the potential impacts on water quality are detailed and management measures are identified. The REF also includes a Neutral of Beneficial Effect (NorBE) assessment in accordance with Clause 11 of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011.

The REF states on page 15 (section 3.3.1) that existing water quality from Whites Creek would be reviewed when available from the SCA. At this point in time, water monitoring is not undertaken within the area of White’s Creek and the SCA is unable to provide any further information than the information already provided to the RMS.

The SCA supports the proposed use of bio-retention basins and bio-filtration swales as well as other measures detailed in the Appendices of the Technical Paper 6: Water Quality. In particular, the SCA supports the proposal to engage a soil conservationist for the duration of the project. These measures have been successfully incorporated into other RMS road upgrades along the Great Western Highway as per SCA Current Recommended Practices and the SCA agrees they can be usefully incorporated into the design of this proposal for the long term management of water quality.

A Soil and Water Management Plan (SWMP) and Erosion and Sediment Control Plan (ESCP) are proposed to be prepared for this proposal. The SCA requests the opportunity to comment on the SWMP.

If you have any queries regarding this matter, please contact me on 2724 2452.

Yours sincerely,

MALCOLM HUGHES
Manager Planning and Assessments

Ref: D2012/94205
Mount Victoria to Lithgow Alliance  
PO Box 164  
ST LEONARDS NSW 1590

Attention: Chris Barnett

Dear Mr Barnett

Review of Environmental Factors for the Mount Victoria to Lithgow Great Western Highway upgrade – Forty Bends upgrade

I refer to your letter of 16 October 2012 seeking comment from the NSW Office of Water (Office of Water) on the Review of Environmental Factors (REF) for the upgrade of Great Western Highway at Forty Bends.

The Office of Water has reviewed the REF and provides the following detailed comments in Attachment A.

Should you require further information please contact Janne Grose, Planning and Assessment Coordinator on (02) 4729 8262 at the Penrith office.

Yours sincerely

Mark Simons  
A/Manager Major Projects, Mines and Assessment  
2 November 2012
Review of Environmental Factors Mount Victoria to Lithgow Great Western Highway upgrade – Forty Bends upgrade

Watercourses and Riparian land

Under Section 38 of the Water Management (General) Regulation (2011), a Public Authority is exempt from the requirement for a Controlled Activities Approval. Despite this exemption, the project should be carried out in accordance with the Guidelines for Controlled Activities (see http://www.water.nsw.gov.au/Water-Licensing/Approvals/Controlled-activities/default.aspx)

Diversion of creeks

Section 6.5.4 of the REF notes that during construction there is potential for drainage lines to be temporarily blocked or diverted (page 209). The RMS need to ensure:

- any diversion of drainage lines will cause minimal harm to the watercourses and riparian vegetation
- the watercourses and riparian areas are adequately rehabilitated post construction to mimic naturalised systems, and
- the stability of the watercourses will remain in their current state or where possible bed and bank stability will be improved to emulate a naturalised system.

Tributary of Whites Creek

The REF indicates the proposed drainage system would discharge substantially more water in all events to the creek and there is potential for geomorphological change in the channel (page 218). It is noted a geomorphological site investigation survey would be undertaken for the 1250 m long tributary of Whites Creek (Table 6-44, page 226). If there is likely to be substantially more discharge to the tributary then stabilisation of the creek needs to be part of the design considerations and any solutions need to emulate a naturalised system of the area. The RMS need to ensure the tributary will remain in its current state of stability or have the bed and bank stability enhanced and improved to mimic a naturalised state.

Whites Creek crossing

It is noted the existing highway crossing of Whites Creek consists of a twin pipe culvert arrangement (page 200). Sections 2.4.3 and 2.4.4 of the REF outline that two options were considered for the upgrade crossing of the creek; namely, the option of twin bridges (one for each direction of traffic flow), or the option for a fill embankment to span the creek and this would include a box culvert. The REF identifies the twin bridge is the preferred option.

The Office of Water supports the twin bridge option as this would reduce potential environmental impacts on Whites Creek and riparian vegetation and it would improve riparian connectivity between Hassans Walls and the Cox River via Whites Creek.

It is noted in Table 6-15 that the bridge would be designed (height, carriageway separation) to allow sufficient light and moisture to penetrate beneath the structures to encourage plant growth (page 148). This safeguard measure is supported as this will assist to improve riparian connectivity and naturalised stabilisation of the banks.
The REF includes a safeguard measure to line waterways around any additional permanent structures such as bridge piers to avoid erosion (for example see Table 7-1, WQ-21, page 353). It is recommended any safeguard measures mimic a naturalised channel.

The Office of Water supports rehabilitating the existing alignment of Whites Creek to create a natural creek bed following the removal of the redundant section of the existing highway (see section 3.2.4, page 60).

**Water Quality basins**

Section 3.4.1 of the REF notes eight basins would be constructed during construction and five would be retained as permanent basins (page 78). It is recommended the water treatment basins are located offline and outside the riparian corridors to avoid disturbing the function and value of riparian land and/or the rehabilitation of riparian vegetation. It would appear one permanent basin is proposed to be located online (see Figure 4-1, page 87). If it is not possible to locate the basin offline and outside the riparian corridors, it is recommended the basins are located in areas that are currently cleared of native vegetation.

The proposed planting of the permanent basins with aquatic and mesic species should mimic the local endemic vegetation for wetland areas.

**Construction Compound sites**

Section 3.4.1 of the REF notes consideration will be given to locating the construction compound sites more than 40 m from a watercourse (page 77). The Office of Water supports this approach and recommends it is adopted as a safeguard measure to mitigate impacts on watercourses, water quality, riparian vegetation etc. If this is not possible, any riparian areas disturbed by the compound sites should be rehabilitated post-construction with local native plant species that are representative of the local vegetation community.

**Riparian land**

The RMS need to consider the riparian setbacks that need to be provided along affected watercourses to ensure the riparian areas are adequately protected and any riparian areas disturbed by the upgrade are rehabilitated after construction works are completed.

In order to mitigate the extent of disturbance of riparian areas, it is recommended the upgrade includes the following mitigation measures:

- riparian areas disturbed by the upgrade are rehabilitated once construction is completed. The rehabilitation should be located at, or near the area of disturbance, or if this is not possible, offset by establishing native riparian vegetation elsewhere along the relevant watercourse
- The rehabilitation is undertaken in a two step process. The primary stage should rapidly stabilise disturbed riparian areas and the second stage should establish a permanent cover of vegetation that emulates the local native vegetation community
- Bush regeneration/weed removal is undertaken in areas adjacent to the proposed construction areas until the areas that are being rehabilitated have become established
- areas of disturbance near watercourses should be inspected particularly after major rainfall events to ensure any stabilisation works have been effective
- Rehabilitated riparian areas are maintained for a minimum period of at least 2 years after final planting
To assist mitigate potential impacts on the downstream environment, weed management should be undertaken throughout the extent and duration of the project and on an ongoing basis at the work sites and down slope of the construction areas.

**Water licencing and water requirements**

Table 7-2 in the REF notes liaison with the Office of Water would be undertaken prior to construction to determine whether an aquifer access licence and/or aquifer interference approval would be required (page 372). The RMS is encouraged to maintain close contact with the Office of Water as the project progresses in relation to licensing issues.

Section 3.3.3 of the REF indicates the volume of water required for construction is expected to be about 30-50 ML and this would be sourced from farm dams or groundwater bores (page 72). Section 6.1.2.4 of the REF also notes groundwater may be used as a water supply but the sources of construction water would be identified during detailed design (page 307). While the RMS is exempt from the requirement to obtain Water Access Licences for the construction of the upgrade and road maintenance it is requested the project minimises the take of water from groundwater sources.

The REF indicates four farm dams would be removed by the proposal and there are potential changes to the yield of farms dams resulting from the operation of the proposal (see pages 216, 354 and Figure 6-14). The proposed measure to mitigate decreased flow volumes to farm dams by enlarging existing farm dams to increase available storage capacity may increase the dam capacity more than the harvestable right, as defined in the Harvestable Rights Dam Capacity Guidelines (http://www.water.nsw.gov.au/Water-licensing/Basic-water-rights/Harvesting-runoff/default.aspx). If this occurs, the landholder will need to obtain a licence from the Office of Water (see Table 7-1, HY-3, p 354). The Office of Water recommends the maximum Harvestable Right Dam Capacity is calculated for any affected dams. If the proposed capacity is greater than the Maximum Harvestable Right Dam Capacity, application for licences should be made to the Office of Water.

Section 6.12.4 of the REF notes the proposal would result in the removal of two existing NOW registered bores (GW070637 and GW105910) and the current use of these bores is unknown (page 306). GW105910 is a licensed domestic bore and it is recommended the RMS contact the owners of the bore as soon as possible in relation to this issue.

**Groundwater**

The Office of Water supports the environmental safeguard measures for groundwater that are included in Table 7-1 (pages 366 -367) but as noted above it is recommended the owners of the bores to be removed are consulted as soon as possible.

End Attachment A
24 October 2012

Mount Victoria to Lithgow Alliance
PO Box 164
St Leonards NSW 2065
Email: MV2Linformation@MV2L.com.au

Dear Sir/Madam,

SUBJECT Mt Victoria to Lithgow Concept Design

The Blue Mountains City Council (BMCC) wishes to acknowledge the detailed and thorough community consultation process that the Roads and Maritime Services (RMS) has undertaken in the development of this project. To date, BMCC staff have been actively engaged in the community information sessions, route option and concept design workshops. The BMCC has also provided the project team with the relevant Blue Mountains information and data as requested.

The information contained in this submission relates to the review of the following document:

- Mount Victoria to Lithgow - Great Western Highway Upgrade – Concept Design July 2012

A presentation will be made to Blue Mountains Councillors on 13 November 2012 by the Project Manager Chris Barnett, following this; the BMCC may provide further comment.

The BMCC submission on the Mount Victoria to Lithgow - Great Western Highway Upgrade – Concept Design is enclosed for your consideration.

If you require any further information on this matter then please contact Glenn Sherlock, Strategic Planning Specialist Transport on 4780-5692 or gahherlock@bmcc.nsw.gov.au

Yours faithfully

STEVE CORBETT
Director, City & Community Outcomes
Blue Mountains City Council Submission - Date: 24 October 2012

Mount Victoria to Lithgow - GWH Upgrade – Concept Design July 2012

The Blue Mountains City Council (BMCC) wishes to present the following points for consideration, as part of the continuing investigations into this project.

In November 2000, the Greater Blue Mountains World Heritage Area (GBMWHA) was incorporated to the World Heritage List. The Greater Blue Mountains Area covers a total area of about one million hectares of mostly forested landscape on a sandstone plateau, 60 to 180 kilometres inland from central Sydney (inland from Wollongong to Newcastle). The City of Blue Mountains has a population of 78,391 and is one of only two cities in the world that is wholly contained within a designated World Heritage Area.

The City’s location within a World Heritage Area places responsibilities on the community, the BMCC and other agencies to ensure that impacts of urban development are carefully managed and that the internationally recognised values of this natural environment are protected. The Blue Mountains attracts millions of visitors from throughout the world to its magnificent environment, making it one of the top five tourist destinations in Australia. It is the only World Heritage Area in Australia readily accessibility by public transport from a major capital and Sydney airport, the main point of entry for most international visitors to Australia.

The Blue Mountains serves as a bridge between Sydney and Central Western NSW with the main transport corridors for road and rail located on the central ridgeline across the City. The Great Western Highway is the primary vehicular connection between Sydney and the Central West and the Western Railway Line is heavily utilised for passenger and freight movement within and outside of the region. These transport corridors place pressures and impacts on the local Blue Mountains community and the natural environment and yet they also provide essential links for the Blue Mountains community, allowing access to local services along the length of the 100km corridor and to employment and specialist services outside the City.

Cost effective, efficient and equitable transport infrastructure is fundamental to meeting these expectations and managing our responsibility to the GBMWHA.

Review

The BMCC welcomes the RMS’s process which has involved extensive public consultation for the identification of an appropriate route to bypass Mt Victoria to Lithgow.

The BMCC is making this submission as part of this process and would welcome the opportunity to provide additional input that may be required to ensure a fair and equitable determination for residents within the City of Blue Mountains and for the long term sustainability of the GBMWHA.
In developing the BMCC's submission, consideration was given to those factors identified in the RMS's community newsletters, participation at community information sessions, route option and concept design workshops.

**General Comments**

**Highway operation and safety:** Characteristics that influence highway operations and safety include the multiple functions and traffic mix on the highway, road capacity and highway performance, roadside friction, vehicular and pedestrian movements.

**The upgrade project must:** Enhance the operation and safety of the highway as part of an integrated transport system, be consistent with land use planning initiatives and taking into account the needs of all transport modes. Types of highway users to be considered include pedestrian, cyclist, local motorist, commuters, tourist, freight operators and long distance travellers.

**Environmental Protection:** Environmental issues have been grouped into four main areas, namely;

1. natural and cultural heritage values;
2. visual and aesthetic environmental values;
3. acoustic impacts; and
4. water catchment protection.

**The upgrade project must:** Maintain or improve the visual amenity of the highway corridor, and to protect the natural and cultural environmental values of the Blue Mountains.

**Social and Commercial:** Issues of a social or commercial nature has been grouped into the following categories:

1. bisection of townships;
2. commercial centre operations;
3. tourism; and
4. local residential amenity

**The upgrade project must:** Maintain or improve the social cohesion and commercial viability of the Blue Mountains Township so as to fulfil the needs and expectations of the residents and visitors, as well as to provide opportunities for resident's involvement in planning the future of the highway corridor.

**BMCC Strategies**

The impact of the Great Western Highway upgrade is an ongoing concern for the BMCC and its residents. The BMCC has focused on providing alternative transport...
options and encouraging more sustainable travel behaviour with the objective of creating more sustainable places through the application of appropriate planning strategies. This thrust is evidenced through policy and strategy documents, including the 25 year City Vision and Map for Action: Towards A More Sustainable Blue Mountains, the Commuter Car Parking Policy, the Pedestrian Access and Mobility Plan, the Blue Mountains Bike Plan 2020, the Local Environmental Plan 2005. BMCC's four year Capital Works Program also has a strong focus on providing footpath connections to transport nodes.

Undergrounding of Electricity
- The BMCC has consistently sought the undergrounding of all electricity wires as part of the GWH upgrade program;
- The goal of building a contemporary, safer highway is at odds with placing power poles in or adjacent to the road reserve;
- The function of a highway is to provide a safe, efficient and visually aesthetic road corridor for local, regional and state traffic. The current ad hoc approach to electricity infrastructure along the corridor is undermining the achievement of undergrounding opportunities;
- The benefits to the environment, road users and the general community are very well documented;
- The highway is within a World Heritage environment and not undergrounding power where appropriate is complete unacceptable; and
- The Blue Mountains is a known bush fire prone area and the unreliability of above ground power supply in such environments is not considered appropriate or sustainable.

Drainage & Stormwater
- The BMCC will assess all the detention basin sites once identified. The Council will consider the impacts on BMCC's stormwater systems downstream, the natural water courses, the aesthetics and potential future use required by the land that is used in their design;
- To enable the BMCC to more fully assess the proposal, BMCC requires the DRAINS graphs that will be produced. This is to confirm the results for stormwater modelling and its impacts on the surrounding area. The results of this analysis may affect the support or otherwise of this proposal;
- That the RMS constructs a 1 in 100 year basins;
- RMS should consider the aesthetic impacts to the area in their design; and
- Block work retaining structures similar to Katoomba/Leura Stage 2 project are not considered acceptable.

Additional Environmental Issues
- The BMCC should be consulted on the location of all new and temporary stockpile sites. For all new sites and in the case where existing sites will be implemented an environmental assessment report should be completed and provided to the BMCC;
The BMCC requests that they be consulted on the sizing, position, and type on either retention or detention basins to be used to capture and treat RMS drainage basin sizing and locations to take into account the overland flow path if rainfall exceeds capacity. The design should allow for a failsafe to road if the basin goes to full bypass;

- In locations where the proposed access roads are to be constructed along the current constructed highway path, the pavement structure needs to be removed and the base re-compacted. This will allow for the maximum asset life for BMCC (pending acceptance at time of handover); and
- The BMCC requests that copies of the Project Environmental Management Plan (PEMP) and Construction Environment Management Plan (CEMP) be forwarded to the BMCC once completed.

**Landscaping & Urban Design**

- Landscaping is to be with native indigenous plants in the open spaces within the road corridor;
- The landscape and urban design study requires careful consideration in order to secure sustainable high quality outcomes that mitigate the impact of works. It is essential that future development of the concept plan to draft design be in full consultation with the BMCC;
- Reference should be made to the Great Western Highway Urban Design Framework 2006 and RTA Landscaping Guidelines 2008;
- The BMCC request the earliest opportunity to comment on the draft landscape plans and species selections;
- The BMCC is concerned that inappropriate maintenance can undermine even well established and extensive planting. Long term viability of planting is dependent on appropriate maintenance and regimes need to be targeted at plant health and longevity as well as road safety. All plantings should be duly maintained by the respective authorities as per the terms of the RMS/BMCC Maintenance Agreement and not allowed to deteriorate as has occurred at other locations along the highway;
- The BMCC should be consulted in regards to proposed maintenance regimes and programs for new planting;
- The BMCC is also interested in working with the RMS during the landscaping works to ensure that plantings are completed in accordance with landscape details. It is important to ensure that Landscape Contractors are supervised during their maintenance contracts;
- It is critical that suitable bedding material is provided in plant landscaping areas. Previous experiences has shown that inappropriate treatment during post construction of the sub surface material almost guarantees the failure of landscaping establishment;
- In addition, the BMCC is seeking the support of the RMS in the maintenance of all the landscape works along the highway. Landscaping/urban design works on all upgrades require significant investment. In the past, BMCC has been
expected to take over the maintenance of works without any assistance. BMCC is not in a position to increase maintenance budgets for works that are ‘inherited’ and consequently the appearance of the highway corridor is poor in some areas; and

- The BMCC would be interested in developing a partnership with the RMS in establishing contract arrangements for the on-going maintenance of the upgraded sections.

In response to the details provided in the Concept Report - July 2012, BMCC provides the following comments:

**Positive Comments**

- Provides significant improved traffic and transport environment:
  - Separated carriageways;
  - Local residential access via local service roads;
  - Separation between state and local traffic;
  - Graded separated intersections;
  - Consistent speed zones and additional overtaking opportunities;
  - Improved freight efficiency;
  - Reduced right turn movements to and from the upgraded highway;
  - Improved access to private properties;
- Significant improvements to road alignment, gradients and crash locations at:
  - Forty Bends & South Bowenfels (black ice);
  - Jenolan Caves Road & Cox’s River Road; and
  - Mt Victoria Pass
- Sensitive to Aboriginal and Non Aboriginal heritage items;
- Sensitive to identified heritage precincts of Little Hartley and Hartley;
- Sensitive to the diverse range of fauna and flora habitats;
- Consideration of the impacts from re alignments on the long term viability of Mt Victoria, Hartley and Little Hartley;
- Consideration of the impacts on locally based tourism;
- Consideration of the impacts on other social infrastructure and economic industries;
- Sensitive to the cultural and scenic values of the village of Mt Victoria and Hartley Valley;
- Safer environment for cyclist, pedestrians and local bus services; and
- Location of heavy vehicle rest area on each side of highway between Carroll Drive and Mid Hartley Road.

**Negative Comments**

- No connection with Darling Causeway to allow heavy vehicles to bypass Mt Victoria Village;
- Significant impacts on native vegetations;
- Significant visual impacts from bridges, viaducts and road infrastructure i.e. cuttings;
- Negative impact on value of property values;
• Negative impact on access to private properties;
• Ownership and maintenance responsibility of access roads and old sections of state roads; and
• Does not address heavy vehicle issues at Caltex Service, Mt Victoria;

**Summary**

The BMCC has provided the above comments based on the *Concept Report - July 2012*. The BMCC will be able to provide a more comprehensive assessment once the detail design documents are produced.

The six key areas of concern at this point in time are:

1. Failure of the concept to adequately address the heavy vehicle parking issues currently being experienced at the Caltex Service Station in Mt Victoria;
2. The ongoing viability of business within the Mt Victoria Village;
3. Ownership and maintenance responsibilities of access roads and old sections of the highway;
4. Lack of connection from the bypass with Darling Causeway;
5. Adverse impact on the environment; and
6. Adverse impact on cultural and heritage items.
Appendix B

Geomorphological assessment
GREAT WESTERN HIGHWAY UPGRADE,
MOUNT VICTORIA TO LITHGOW ALLIANCE

FORTY BENDS UPGRADE
GEOMORPHOLOGICAL ASSESSMENT OF
BASIN #3205 CREEK

October 2012
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Executive Summary

This report documents a geomorphological assessment of an unnamed tributary of Whites Creek which is predicted to experience an increase in peak flows due to the proposed Forty Bends upgrade. The predicted increase in peak flows would result from a transfer of subcatchments from the proposed drainage design and additional runoff due to the increase in road pavement area.

The unnamed tributary is hereafter referred to as Basin #3205 Creek. The creek is located immediately to the west of the main Whites Creek channel. It is 1205 metres long with a 170 metre drop in elevation over this length. The creek passes through largely cleared agricultural and rural residential land with an area of woodland before its confluence with Whites Creek.

The assessment involved a field inspection of the creek line to identify the current geomorphological condition and describe the current physical processes driving the channel form. The increases in peak flow volumes for a range of rainfall events were evaluated. Soil conditions were inferred from soil testing undertaken in 2011 for the Forty Bends concept design development.

Four representative sites along the creek line were examined and changes in peak flow velocity calculated at these locations. The site inspection indicated that the creek line is already experiencing geomorphological change. Flow velocity increases are predicted to range from up to 33% (1 year ARI) to 4% (100 year ARI). It is therefore likely that the increases in flow velocities would increase the risk of erosion and sediment transport.

In light of the above findings it is proposed to modify the drainage design by transferring the flows directly to Whites Creek. The water quality basin would no longer be required reducing the overall number of permanent water quality basins to be installed as part of the Forty Bends project, to four. This transfer would increase flows to Whites Creek however due to the relatively larger size of the Whites Creek catchment, the impact of the additional flow would not be substantial.
1. Introduction

The proposed drainage design for the Forty Bends upgrade would replace the existing drainage system for the Great Western Highway. The existing drainage system is a distributed system which comprises table drains, longitudinal pipes and culverts at 23 locations along the 2.8 kilometre length of the proposed upgrade. The new drainage system would have about 14 culverts with flows from the roadway directed to water quality basins for treatment prior to discharge into the surrounding Whites Creek catchment.

It is proposed to transfer a number of sub catchments to the west of the main channel of Whites Creek to an unnamed tributary hereafter referred to as Basin #3205 Creek. The effect of this transfer would be to significantly increase peak flow volumes to this creek.

This report documents an investigation to assess potential geomorphological impacts associated with the proposed catchment transfer to Basin #3205 Creek. As a result of the investigation, changes are proposed to the drainage design and these changes are described in Section 5 of this report.
2. Study objectives and methodology

The objectives of the study are to:

- Characterise the current geomorphological condition in Basin #3205 Creek
- Describe current physical processes driving channel form
- Summarise pressures on channel integrity as a result of the road upgrade
- Identify the most sensitive stretches to geomorphological change
- Outline generic measures to mitigate these potential changes.

The baseline conditions of Basin #3205 Creek have been assessed using a combination of a desktop review of physical environmental features, a rapid walkover assessment and subsequent data analyses.

The desktop review utilised soil data collected near Basin #3205 to infer erosivity potential of the sub-catchment, the longitudinal profile of Basin #3205 Creek to identify channel stretches where erosion is already occurring and hydrological modelling (supplied by the MV2L Alliance hydrological team) to summarise the forecast flow condition changes.

A rapid walkover survey have been used to ground truth the desktop assessment by selecting four representative reaches, characterising current geomorphological condition in these reaches using the RiverStyles™ procedure (Thompson et al., 2001) and measuring channel morphology (bankfull width and depths). Peak flow velocities in the channels have been derived from the walkover and subsequent data analyses. These velocity estimates have been compared to standard literature values for sediment entrainment. This information has been collated in order to identify sensitive reaches that exhibit the greatest potential for geomorphological change in the post-works flow regime. Finally, best practice measures to minimise impacts from the flow changes in these sensitive reaches are proposed.
3. **Site setting**

A desktop review of the location, land use, geology, soils (geotechnical information) and hydrology pertinent to the site are contained in the following four sub-sections. This information has been used to inform the baseline condition survey (Section 3.3.2).

### 3.1. Location

Forty Bends Road is located approximately eight kilometres north west of Mount Victoria and four kilometres north west of the Great Western Highway and Jenolan Caves Road intersection, at Hartley.

The site contains Basin #3205 Creek, an unnamed tributary that flows into Whites Creek. The headwaters of Basin #3205 Creek begin in a highly vegetated area, before crossing the Great Western Highway (GWH) and then flowing through cleared land. The cleared land is used for agricultural and rural residential use and contains a number of farm dams. The creek then flows through woodland before the confluence with White Creek.

The majority of the land around Forty Bends Road has been classified as rural residential (SKM, 2009). Further down gradient, grazing land for cattle and sheep is present.

### 3.2. Soils and Geology

Soil data was obtained from the Geotechnical Investigation Report which details geotechnical field investigations undertaken by the MV2L Alliance in June and July 2011 (MV2L Alliance 2012b).

Soil testing at pit TP151 has shown erodibility of the soil in the study area is moderate (k factor of 0.034). However, this number must be interpreted with caution because TP151 is located within a vegetated area approximately 600 metres from Basin #3205 Creek. The cleared land around the site may have very different soil properties.

Geotechnical data was recorded at borehole pit TP153, which is approximately 200 metres north-north-east of the headwater of Basin #3205 Creek and is located in cleared land. The soil profile is 1.8 metre deep comprising the following structure:

- **Top soil 0-0.2 metre depth.** Material is sandy silt: brown in colour with fine and coarse grained sand, traces of rootlets were found.

- **Residual soil 0.2-0.8 metre depth.** Material is silty clay: orange brown in colour with low plasticity (HP in-situ 380-420 kilopascals) with some fine to coarse sub-rounded gravel (with rounded up to 300 millimetre boulders).

- **Bedrock 0.8-1.8 metre depth.** Material is sandstone and siltstone: orange, pale grey, dark grey in colour with fine to coarse grains, fine to coarse rounded to sub-angular gravels and cobbles of siltstone ironstone and igneous rocks. Indistinct bedding, iron stained, highly weathered and very low strength.
3.3. Hydrology

The Basin #3205 Creek longitudinal profile and sinuosity are discussed below. This will be followed by discussion on the drainage and discharge pre and post-highway upgrade.

3.3.1. Basin #3205 Creek

Basin #3205 Creek flows south into Whites Creek, and Whites Creek continues to flow south into Cox’s River. The creek is in the Upper Cox’s catchment, which is in part of the Hawkesbury-Nepean Basin. The catchment of Basin #3205 Creek has been divided into four parts; the existing catchment to the GWH culverts, and downstream of the GWH; catchment A, catchment B and catchment C (Figure A-1; Appendix A).

Figure A-1 (Appendix A) indicates that Basin #3205 Creek ends to the north of farm dam 10 in catchment C. The contours however show that the natural drainage line continues to the north until the northern boundary of the existing catchment.

Two desktop methods can help to understand channel stability within Basin #3205 Creek: a longitudinal profile of the creek will assess vertical channel stability and sinuosity will assess lateral stability.

The longitudinal profile indicates a 170 metre drop in elevation over the course of the 1250 metre long creek, which is a 1:7 gradient (Figure 1). The headwaters in catchment A and the bottom reach in catchment C have a steeper gradient than the middle reaches. However, the frequency of sharp increases in channel gradient, ‘knickpoints’ in catchment C decreases with chainage length. It has been reported previously that slopes in this geographical area facing slightly east or north tend to be less steep than facing west or south (Holland et al., 1992). The tributary is facing south. There is some evidence that soils are shallower and more compact on these south facing slopes (Holland et al., 1992), which would lead to faster runoff rates and higher erosion potential during a large storm event.
The sinuosity of Basin #3205 Creek was calculated for each sub-catchment. Sinuosity is a measure of how active the channel is and the potential for lateral migration due to bank erosion. Typically lower sinuosities are noted at the headwaters of a channel due to the higher energy regime transporting fine sediments through the reach, compared to the valley where sediments are deposited. Basin #3205 Creek was found to have slightly higher sinuosity at the head of the channel compared to the downstream end, where values tended towards 1.00, i.e. a straight channel (Table 1).

**Table 1  Sinuosity for subcatchments**

<table>
<thead>
<tr>
<th>Sub catchment</th>
<th>Sinuosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing catchment to culverts</td>
<td>1.18</td>
</tr>
<tr>
<td>Catchment A</td>
<td>1.18</td>
</tr>
<tr>
<td>Catchment B</td>
<td>1.06</td>
</tr>
<tr>
<td>Catchment C</td>
<td>1.06</td>
</tr>
</tbody>
</table>

This slightly higher value could partly be due to an arbitrary mapping error, due to the channel being less well defined in the headwaters but is also reflective of the steeper, confined channel noted in catchment C (Section 4).
3.3.2. Pre and post drainage and peak discharge volumes

Existing inflows for five different Average Recurrence Intervals (ARI) to Basin #3205 Creek (at the top of Catchment A, see Figure A-1, Appendix A) have been estimated using a hydrological rainfall-runoff model (Table 2). Three inflow sources have been identified from the point of discharge off the GWH going down gradient – Culvert 1 (west) and Culvert 2 (east) drain both the catchment above the GWH and the GWH itself and Daintree Close contains a small sub-catchment which drains independently to Basin #3205 Creek. No modelling has been completed further down Basin #3205 Creek in catchments B and C (Figure A-1, Appendix A). Proposed inflows following drainage works from Basin #3205 outlet are also displayed in Table 2 and these values can be compared directly to the sum of Culvert 1, Culvert 2 and Daintree Close flows in the existing scenario.

Table 2  Pre and post flows contributing to Basin #3205 Creek

<table>
<thead>
<tr>
<th>ARI</th>
<th>Existing inflows to Basin #3205 Creek</th>
<th>Proposed inflow</th>
<th>Percentage increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Culvert 1 (west) (l/s)</td>
<td>Culvert 2 (east) (l/s)</td>
<td>Daintree Close catchment (l/s)</td>
</tr>
<tr>
<td>1 year</td>
<td>48</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>2 year</td>
<td>88</td>
<td>90</td>
<td>17</td>
</tr>
<tr>
<td>10 year</td>
<td>185</td>
<td>208</td>
<td>34</td>
</tr>
<tr>
<td>20 year</td>
<td>227</td>
<td>256</td>
<td>41</td>
</tr>
<tr>
<td>100 year</td>
<td>315</td>
<td>353</td>
<td>57</td>
</tr>
</tbody>
</table>

It was found that there was a greater percentage change for the 1 and 2 year ARI event peak flows than for the larger flow events. This was largely due to a change in catchment area and land use. The existing catchment area includes the headwater woodland catchment. This part of the catchment produces lower runoff, mainly due to the combination of vegetation and sandy soils. The absorption or losses for smaller events (1 and 2 year ARI events) are larger proportionally than for the larger events (10, 20 and 100 year ARI events). A change in catchment size and removal of the headwater pervious catchment results in rainfall generating more overland runoff and hence a greater flow change. For the 100 year ARI event, losses will be a smaller proportion of the total rainfall and hence generate proportionally greater runoff. In the proposed scenario, all runoff is sourced from paved impervious area, which has negligible runoff losses to soil and vegetation.
4. Geomorphological conditions

A rapid walkover survey was conducted on Basin #3205 Creek to characterise baseline conditions. This has been used to understand the current physical processes driving channel form (Section 4.1 and how the proposed changes to peak flows outlined in Section 3.3.2 will potentially impact the channel integrity (Section 4.2). Information from these two sections has then been used to identify stretches of Basin #3205 Creek that are sensitive to geomorphic change (Section 4.3) so that mitigation measures can be targeted to these particular areas.

4.1. Current geomorphological conditions

Four representative sites were selected for the rapid walkover survey (Figure 1 and Table 3).

<table>
<thead>
<tr>
<th>Site code</th>
<th>Upstream grid reference</th>
<th>Downstream grid reference</th>
<th>Chainage at Basin #3205 Creek (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0234178 E 6288069 N</td>
<td>0234182 E 6288037 N</td>
<td>200</td>
</tr>
<tr>
<td>S2</td>
<td>0234211 E 6287799 N</td>
<td>0234213 E 6287776 N</td>
<td>550</td>
</tr>
<tr>
<td>S3</td>
<td>0234255 E 6287491 N</td>
<td>0234254 E 6287495 N</td>
<td>800</td>
</tr>
<tr>
<td>S4</td>
<td>0234316 E 6287243 N</td>
<td>0234323 E 6287201 N</td>
<td>1100</td>
</tr>
</tbody>
</table>

The completed templates from the rapid geomorphological walkover assessment at these four sites, along with typical cross-sections and a schematic are contained in Appendix B.

There was no defined natural channel at S1. It is speculated that runoff in the headwater sub-catchment above the GWH culverts discharges down gradient via diffuse overland flow pathways. Transverse drainage on the north side of the GWH captures this diffuse runoff and leads to:

- A batter drain chute (Figure 2) which discharges under the road into the eastern culvert (C2), diameter 0.45m.
Figure 2  Batter drain chute
A scour protection pit, approximately 50m uphill from the batter drain which discharges under the road into the western culvert (C1), diameter 0.45m (Figure 3).

Figure 3  Western culvert (C1)
Drainage flow from the road was also channelled to both the eastern C2 culvert and western C1 culvert via the stormwater line gutter (Figure 4).

Figure 4  Flow moving down road towards culvert C2
The culverts were routed under the GWH and discharged directly out onto Daintree Close, approximately four metres below the height. At culvert C2 damage to the tarmac surface of the road was observed from the flow line (Figure 5).

Figure 5  Damage to road as a result of high flows
At culvert C1 there are large amounts of vegetation on both the up and down gradient sides of Daintree Close. Superficial damage to the tarmac road surface suggests that less flow it is discharged compared to culvert C2 (Figure 6).

![Vegetation growth on western culvert (C2)](image)

**Figure 6    Vegetation growth on western culvert (C2)**

The large gradient change indicated from the longitudinal profile (Figure 1) was confirmed to be located on the GWH and caused by cutting into the side of the hill to construct the road.
Site S2 was a ‘channelized fill’ River Style (Thompson et al., 2001). The valley setting was laterally unconfined. The channel was dry at the time of the site visit and the channel planform was a single, straight channel. There was no evidence of bank erosion and the bed material was not saturated and composed of silt. A contributory factor to channel stabilisation in catchment B was the presence of four farm dams in line with the creek pathway (Figure A-1, Appendix A and Figure 7). These would attenuate peak flows over time, leading to lower erosive force exerted by water in the channel.

Site S3 is a ‘confined valley with occasional floodplain pockets’ River Style (Thompson et al., 2001). The channel planform was single with intermediate sinuosity; there were pools and occasional rocky outcrops present. The bed material was fine sands and silts. This section of the creek would convey and supply sediment downstream. The sediment at this site would be supplied from upstream and the eroding banks (Figure 8).
The large number of knickpoints in this stretch are probably due to the resistant ironstone in the bedrock that facilitates a decrease in the upper part of the channel while allowing the lower part of the channel to steepen by slowing the rate of horizontal retreat (Figure 9; Holland et al, 1992).
Figure 9  Knickpoint formation process
(adapted from Holland et al., 1992)

This process forms ‘knickpoints’, sudden increases in channel gradient, reflective of excessive downstream erosion in a plunge pool. Figure 1 highlights multiple actual knickpoints, which indicate a concomitant increase in erosion of the downstream creek bed. Further evidence of this process operating in catchment C was observed from the walkover survey (Figure 10).
The presence of dark orange sediment in the knickpoint and plunge pool indicated iron hydroxide precipitation, caused by leaching of the resistant ironstone out of the soil profile upstream of the knickpoint and subsequent oxidation.

Site S4 is a ‘gorge’ River Style (Thompson et al., 2001). The valley setting is confined. The channel planform is a single channel with low sinuosity. There are rocky outcrops and evidence of minor bank erosion (Figure 11).
This erosion exposes a sandy-silt bank and the bed materials were composed of boulders, sands and silts. This section transports sediment delivered into the reach from further upstream due to the high channel gradient and associated increased velocities.

4.2. Pressures on channel integrity from road upgrade

The principal cause of potential geomorphic change in Basin #3205 Creek as a result of the Forty Bends upgrade would be an increase in channel velocities, leading to an increased competency for bank and bed erosion and transport. This sub-section estimates the magnitude of change in these parameters.
4.2.1. Velocity

Changes in velocity have the potential to change the character of the creek. Velocities at S2, S3 and S4 were calculated using standard hydrological equations, with the following inputs:

- ARI peak flow rates supplied by MV2L Alliance
- Channel geometry (as measured during the geomorphic walkover survey)
- Slope (calculated using the longitudinal profile shown in Figure 1)
- Mannings ‘n’ value (0.03 at S2 and 0.05 at S3 and S4 [values derived from Chow, 1959]).

As S1 is upstream of the drainage works there are considered to be no geomorphological changes at this site. Table 4 shows both existing and post drainage works estimated average channel velocities for the five different ARI event flows.

<table>
<thead>
<tr>
<th>ARI event</th>
<th>Site</th>
<th>Existing velocity (ms⁻¹)</th>
<th>Post drainage works velocity (ms⁻¹)</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1yr ARI</td>
<td>S2</td>
<td>1.02</td>
<td>1.51</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>0.91</td>
<td>1.33</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td>1.34</td>
<td>1.86</td>
<td>28%</td>
</tr>
<tr>
<td>2yr ARI</td>
<td>S2</td>
<td>1.30</td>
<td>1.67</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>1.16</td>
<td>1.47</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td>1.66</td>
<td>2.01</td>
<td>18%</td>
</tr>
<tr>
<td>10yr ARI</td>
<td>S2</td>
<td>1.76</td>
<td>1.94</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>1.54</td>
<td>1.69</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td>2.09</td>
<td>2.25</td>
<td>7%</td>
</tr>
<tr>
<td>20yr ARI</td>
<td>S2</td>
<td>1.90</td>
<td>2.05</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>1.66</td>
<td>1.79</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td>2.21</td>
<td>2.34</td>
<td>5%</td>
</tr>
<tr>
<td>100yr ARI</td>
<td>S2</td>
<td>2.14</td>
<td>2.29</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>1.86</td>
<td>1.98</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td>2.42</td>
<td>2.53</td>
<td>4%</td>
</tr>
</tbody>
</table>
There is an increase in channel velocity at all sites for all ARI events of between 4 and 33%. The greater difference from existing to proposed conditions in the 1 and 2 year ARI events compared to the 20 and 100 year ARI events correspond with changes in flow discussed in Section 3.3.2. The lowest velocity variation, and thus the lowest geomorphological impact, was calculated at S4. The 1 year and 2 year ARI events are predicted to experience significant velocity increases and this is predicted to put sustained and frequent pressure on the channel integrity of Basin #3205 Creek as the 1 year and 2 year ARI events, by their very definition, occur more frequently than the 10, 20 and 100 year ARI events.

4.2.2. Sediment entrainment

The Hjulstrom curve illustrates the relationship between sediment size and the velocity regime predicted to erode, transport and deposit channel material (Murane et al., 2006).

For S2, S3 and S4 the bed sediment size was observed to be silt, fine sand/silt, and sand/silt respectively, with particle sizes of 0.02, 0.08 and 0.2mm, respectively (Appendix B).

All three sites lie in the erosion zone for the existing scenario ARI’s as well as the proposed scenario ARI’s (Figure 12).

Figure 12  Hjulstom’s Diagram
This indicates that the sites are prone to erosion for all ARI events. It is clear that the Basin #3205 Creek is already experiencing geomorphological change, potentially as a result of current MWH road drainage and land practices in Catchments B and C (i.e. removal of natural vegetation for residential properties and farming). Sites S3 and S4 both had evidence of erosion (Section 4.1) and therefore increasing the velocities in the post drainage works scenarios is likely to increase the movement of channel sediment leading to more incised channels that migrate laterally.

The creek bed at S4 is composed of 10% boulders. Due to the heterogeneous nature of sediment at this site, the presence of this large sediment calibre has not been considered in the Hjulstom Diagram. The boulders are sourced from bank failures. The entrainment threshold value boulder size material is >2 ms⁻¹ and for the worst case of the proposed 100yr ARI the predicted velocity is 0.253 ms⁻¹. Therefore boulders are unlikely to be mobile during large storm events and are more likely to be deposited.

4.3. Stretches sensitive to geomorphological change

Section 4.1 has identified stretches of the Basin #3205 Creek that are currently experiencing bank erosion. Section 4.2 then estimated the changes in velocity and sediment entrainment predicted as a result of the drainage works. From this analysis it is clear that there is potential for geomorphological change throughout the length of the creek, downstream from the sedimentation basin, but that the middle sections containing site S2 and S3 are considered to be the most sensitive stretches due to:

- Proximity to the sedimentation basin discharge point
- Potential for exceedance of farm dam storage capacities during flood events leading to overtopping into a channel that is not regularly inundated
- Change in land practices from natural vegetation cover to residential / farm land have led to higher runoff rates in the baseline scenario. This will be exacerbated by further increases in channel velocity predicted after the drainage works, possibly reaching a threshold where sediment transport is initiated.
- The current grassed vegetation cover protects the channel from irregular inundation. As the frequency of events similar to the current peak flows increase, the land in this area might become saturated, leading to a change in the vegetation community and a reduction in structural stability of the topsoil. In addition, frequently saturated land which has vehicle movement (as noted at S2 by the vehicle access track) will lead to further disruption of the soil surface and increased erosion susceptibility.
- Confined valleys have low capacity for adjustment. Deepening and widening of the creek bed at knick points around S3 is predicted.
5. Conclusion and proposed changes to drainage design

This desktop and walkover analyses suggests that there is potential for geomorphological change in the Basin #3205 channel. Changes to the rainfall-runoff regime of the Basin #3205 catchment are predicted to have a direct effect on creek geomorphology due to a potential increase in the magnitude of peak flow events that cause bank erosion and entrainment of bed sediments.

The desktop assessment found that drainage works will cause higher peak flows discharged into Basin #3205 Creek, increasing between 20 and 180 percent. The walkover survey characterised baseline condition and provided the observations and estimates for subsequent analyses. These analyses found that average channel velocities would increase by between 4 and 33% and a related increase in sediment entrainment capacity would result. This could lead to:

- Possible changes in substrate characteristics as the result of the removal of more easily eroded materials.
- Increased rates of bed and bank erosion.
- Higher sediment transport rates.

Such geomorphological changes have the potential to alter habitat condition and stream biology (CRCCH, 2000; CRD for Freshwater Ecology, 2004).

In light of the above findings it is proposed to modify the drainage design by transferring the flows directly to Whites Creek. The water quality basin would no longer be required reducing the overall number of permanent basins to four. This transfer would increase flows to Whites Creek however due to the relatively larger size of the Whites Creek catchment, the impact of the additional flow is not predicted to be substantial.
6. References


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Appendix A - Basin #3205 Creek Map
Figure A-1  Basin #3205 Creek

LEGEND
- Chainage
- Proposal
- Existing highway
- Waterways
- Property boundary
- Permanent sedimentation basins
- Temporary sedimentation basins
- Compound sites and stockpile locations
- Potential compound
- Potential stockpile
- Potential stockpile and compound
- Tributary catchments
- Farm dams
- Site walkover locations

Whitles Creek tributary catchments and walkover observations sites

NSW Roads and Maritime Services does not warrant the site locations are accurate in all cases and it does not assume liability for any loss caused or arising from reliance upon information provided herein.
Appendix B - Fluvial geomorphology site descriptions
Appendix B

Site S1

Site setting diagram
<table>
<thead>
<tr>
<th>Project</th>
<th>MV2L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveyor</td>
<td>KN</td>
</tr>
<tr>
<td>Reach code:</td>
<td>Basin 3205 S2</td>
</tr>
<tr>
<td>Date</td>
<td>18/09/12</td>
</tr>
<tr>
<td>Time</td>
<td>13:30</td>
</tr>
</tbody>
</table>

**Drainage channel** | Creek | River | Estuary | Pond | Wetland | Lake |
|---------------------|-------|-------|---------|------|---------|------|

**Weather conditions** | Cool and cloudy (rainfall previous hour) |

**Upstream elevation (m)** | 867m |
| **Downstream elevation (m)** | 866m |

**Slope** | 1m |

### Watercourse attributes

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Width (m)</th>
<th>Max. depth (m)</th>
<th>Velocity (ms⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape description</strong></td>
<td>Slight ‘u’ shape</td>
<td>Roughness Height (m)</td>
<td>Bank erosion</td>
</tr>
<tr>
<td><strong>Instream vegetation</strong></td>
<td>100% grasses</td>
<td>100% grasses and bushes</td>
<td>Organic matter n/a</td>
</tr>
<tr>
<td><strong>Instream vegetation</strong> (% cover)</td>
<td>Emergent, floating, submerged, algae, moss)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bank vegetation</strong> (% cover)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bench vegetation</strong> (% cover)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow type

<table>
<thead>
<tr>
<th>Smooth surface flow</th>
<th>Broken standing waves</th>
<th>Unbroken standing waves</th>
<th>Chute</th>
<th>Rippled</th>
<th>Scarcely perceptible flow</th>
<th>Upwelling</th>
<th>Free fall</th>
<th>Standing water</th>
</tr>
</thead>
<tbody>
<tr>
<td>[H1]</td>
<td>[H2]</td>
<td>[H3]</td>
<td>[H4]</td>
<td>[H5]</td>
<td>[H6]</td>
<td>[H7]</td>
<td>[H8]</td>
<td>[H9]</td>
</tr>
</tbody>
</table>

### Channel Planform

<table>
<thead>
<tr>
<th>Sinuosity (straight, low, intermediate, high)</th>
<th>Straight</th>
<th>Single</th>
<th>Forked</th>
<th>Braided</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand bars</td>
<td>Gravel bars</td>
<td>Rock outcrops</td>
<td>Riparian strip</td>
<td>Floodplain connectivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Bed character

<table>
<thead>
<tr>
<th>% composition</th>
<th>Boulder</th>
<th>Cobble</th>
<th>Gravel</th>
<th>Sand</th>
<th>Fine sand</th>
<th>Silt / clay (Size 0.02mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-S</td>
<td>U-S</td>
<td>U-S</td>
<td>U-S</td>
<td>U-S</td>
<td>U-S</td>
<td>%</td>
</tr>
<tr>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>100</td>
</tr>
</tbody>
</table>

### Bed stability (packed & armoured, packed not armoured, mod compaction, low compaction, no packing)

<table>
<thead>
<tr>
<th>Packed</th>
<th>Supply</th>
<th>Deposition</th>
<th>Erosion</th>
<th>Conveying</th>
</tr>
</thead>
</table>

**Organic matter n/a**

**Logs**

**Twigs / Leaves**

**Detritus**

**Bed structure**

*Concave, 0.4m, 20°*
FLUVIAL GEOMORPHOLOGY SITE DESCRIPTION TEMPLATE

Site setting diagram

Created 04/08/2011 Dan Evans (after Thompson et al, 2011, Ag Conserve, 11, 373 – 389)
## Site S3

<table>
<thead>
<tr>
<th>Project</th>
<th>MV2L</th>
<th>Reach code: Basin 3205 S3</th>
<th>Date</th>
<th>18/09/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveyor</td>
<td>KN</td>
<td></td>
<td>Time</td>
<td>12:00</td>
</tr>
</tbody>
</table>

### Drainage channel
- Creek
- River
- Estuary
- Pond
- Wetland
- Lake

### Weather conditions
- Cool and cloudy (rainfall previous hour)

### Upstream elevation (m)
- 842m

### Downstream elevation (m)
- 832m

### Slope
- 10m

### Weather conditions
- Cool and cloudy (rainfall previous hour)

### U-S Grid ref
- 0234255
- 6287491

### D-S grid ref
- 0234254
- 6287495

### Dimensions
- Width (m): 3.95 - 1.92 = 2.03m
- Max. depth (m): 0.3m
- Velocity (ms⁻¹): US on the meandering bends and just past waterfall pool

### Shape description
- Rectangular

### Roughness Height (m)
- 0.1m

### Bank erosion
- US on the meandering bends and just past waterfall pool

### Instream vegetation
- 40% starwart (more mature than S4)
- Bank vegetation (% cover)
- 60% grasses

### Bench vegetation (% cover)
- 70% grasses
- 10% gum trees
- 20% brambles

### Organic matter n/a
- Logs: ☐
- Twigs / Leaves: ☐
- (5%) Detritus: ☐

### Flow type
- Smooth surface flow
- Broken standing waves
- Unbroken standing waves
- Chute
- Rippled
- Scarcey perceptible flow
- Upwelling
- Free fall
- Standing water

### Channel Planform
- Sinuosity
  - Straight, low, intermediate, high: intermediate
  - Form
  - Single
  - Forked
  - Braided
  - Open

### Sand bars
- Gravel bars
- Rock outcrops
- Riparian strip
  - RHB 50m, LHB 20m

### Floodplain connectivity
- Bank structure
  - Concave, convex, straight
  - Height & angle

### Floodplain land use
- Grazing, small scale cash crop

### % composition
- Boulder
  - U-S
  - D-S
- Cobble
  - U-S
  - D-S
- Gravel
  - U-S
  - D-S
- Sand
  - U-S
  - D-S
- Fine sand
  - U-S
  - D-S
- Silt / clay
  - Size 0.08mm
  - 90
  - 80

### Bed stability
- (packed & armoured, packed not armoured, mod compaction, low compaction, no packing)
- Packed

### Bed character
- Supply
- Deposition
- Erosion
- Conveying

Created 04/08/11 Dan Evans (after Thompson et al, 2011, Aq Conserve, 11, 373 – 389)
### Site S4

**Project:** MV2L  
**Surveys:** KN  
**Reach code:** Basin 3205 S4  
**Date:** 18/09/12  
**Surveyor:** KN  
**Time:** 10:35

#### Weather conditions
Cool and sunny (rainfall previous night)

#### Dimensions
- **Width (m):** 6.55-5.90=0.65m
- **Max. depth (m):** 0.02m
- **Velocity (ms⁻¹):** 0.5ms⁻¹

#### Upstream elevation (m)
835m

#### Downstream elevation (m)
829m

#### Slope
6m

#### Watercourse attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>Height: U-S 0234316, D-S 6287243</td>
</tr>
<tr>
<td><strong>Weather conditions</strong></td>
<td>Cool and sunny (rainfall previous night)</td>
</tr>
<tr>
<td><strong>Upstream elevation (m)</strong></td>
<td>835m</td>
</tr>
<tr>
<td><strong>Downstream elevation (m)</strong></td>
<td>829m</td>
</tr>
<tr>
<td><strong>Slope</strong></td>
<td>6m</td>
</tr>
</tbody>
</table>

#### Shape description
- 'V' shape

#### Roughness Height (m)
0.05

#### Bank vegetation
- 60% grasses
- 80% grasses and bushes

#### Bench vegetation
- Evidence of bank erosion undergrowth

#### Instream vegetation
- 75% emergent starwart (P5)
- Organic matter n/a

#### Bank erosion
- Evidence of bank erosion undergrowth

#### Flow type

<table>
<thead>
<tr>
<th>Flow type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chute</td>
<td>Rippled</td>
</tr>
<tr>
<td>Scarcely perceptible flow</td>
<td>Unbroken standing waves</td>
</tr>
<tr>
<td>Standing water</td>
<td>Free fall</td>
</tr>
</tbody>
</table>

#### Channel Planform

<table>
<thead>
<tr>
<th>Sinuosity</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Single</td>
</tr>
<tr>
<td>Open</td>
<td>Braided</td>
</tr>
</tbody>
</table>

#### Sand bars
- Available

#### Gravel bars
- Available

#### Rock outcrops
- Available

#### Riparian strip
- 20m bankfull

#### Floodplain connectivity
- Low, confined channel

#### Bed character

<table>
<thead>
<tr>
<th>% composition</th>
<th>Boulder</th>
<th>Cobble</th>
<th>Gravel</th>
<th>Sand</th>
<th>Fine sand</th>
<th>Silt / clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>35</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>D-S</td>
<td>Size 0.2mm</td>
</tr>
</tbody>
</table>

#### Bed stability
- Moderate compaction

#### Conveying
- 40

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Created 04/08/2011 Dan Evans (after Thompson et al., 2011, Aq Conserve, 11, 373 – 389)
FLUVIAL GEOMORPHOLOGY SITE DESCRIPTION TEMPLATE

S2_P1  S2_P2

S2_P3  S2_P4

FLUVIAL GEOMORPHOLOGY SITE DESCRIPTION TEMPLATE