9.8 Construction surface water management and soils

An assessment of the surface water management and soils issues associated with the construction of the M2 Upgrade project has been undertaken and is presented below. This assessment is supported by *Technical Paper 6 – Water management* (Volume 2).

Director-General's Requirements	Where addressed
General construction impacts – the environmental assessment must consider the potential impacts associated with the construction of the project, and present a management framework for construction works to ensure that impacts are mitigated, monitored and managed. The environmental assessment must include consideration of, and a management framework for:	*Chapter 7, Chapter 9, Appendix F*
• *Erosion, sedimentation, water quality and riparian management issues for works in and around watercourse crossings. The environmental assessment must specifically consider how construction of the project would be undertaken and managed to minimise the potential for impacts on riparian vegetation, fish passage and water quality in watercourses for the duration of the construction works.*	*Sections 9.8.2, 9.8.3, Technical Paper 6*

The purpose of this assessment was to identify potential impacts and mitigation measures pertaining to flooding, stormwater, erosion and sedimentation and water quality. The objectives of this assessment included:

- Quantify the nature and extent of potential impacts due to the construction phases of the project, including the identification of sources of polluted water at project sites during construction.
- Identify appropriate mitigation measures to address and ameliorate impacts.

9.8.1 Existing environment

Geology and soils

Within the length of the M2 corridor there are two major geological formations being Hawkesbury Sandstone and the overlying Ashfield Shale member of the Wianamatta Group. The interface between the two formations may be marked by the presence of the Mittagong Formation.

Relief in the Ashfield Shale occurs towards the west of the M2 Motorway, and is generally undulating with rounded ridges and hill crests. The Hawkesbury Sandstone relief to the east tends to be fairly rugged with rolling to very steep hills with steep or benched side slopes.

There are five major soil landscapes occurring throughout the corridor, namely:

- Glenorie Landscape (gn) soils developed on the Wianamatta Group Shales. Typical depth up to two metres with friable dark brown loam topsoil. The erodibility of the surface soils is low.
- West Pennant Hills Landscape (wp) on Wianamatta Group Shales which are generally less than two metres in depth. The erodibility of the surface soils is low.
- The Lucas Heights Landscape (lh) on the Mittagong Formation with the depth commonly less than one metre and a high soil erosion hazard.

- The Gymea Landscape (gy) in the southern section of the Lane Cove River valley and in the upper valley of Terrys Creek. The soils are shallow (less than one metre) and the erosion hazard is high to extreme.
- The Hawkesbury Landscape (ha) in the northern section as well as the rugged valleys of Devlins Creek, the soils are mostly within and less than 0.5 metres depth. These shallow soils in conjunction with the steep terrain have an extreme erosion hazard.

Aquatic environment

The M2 Motorway traverses through three main catchment areas of Darling Mills Creek, Devlins Creek and Terrys Creek whilst a number of smaller tributaries located towards the eastern end of the M2 Motorway (including Mars, University, Shrimptons and Porters Creeks) also form part of the Lane Cove River catchment. Within the limits of proposed widening works the M2 Motorway is crossed by around 26 local drainage lines, which are served by transverse drainage structures comprising a combination of large concrete arches and box or pipe culverts. Large multi span bridge structures well above the normal water level are used to cross the three main creek waterways.

This section describes the aquatic environment, and is summarised from Section 9.5.1 and Technical Paper 3. Native aquatic submerged and emergent vegetation is not abundant within the creeks of the study area. This is likely to be as a result of the chiefly rocky substrate found here, high water velocities during heavy rainfall and competition from introduced species. During ecological surveys of the areas that would be affected by the proposed upgrade, the only commonly encountered native aquatic plants were Bull Rush (*Typha orientalis*) and knotweeds (*Persicaria spp*.), which were found in small patches along the creeks, chiefly in disturbed areas.

The detention basins within the M2 corridor contain an artificial assemblage of emergent native aquatic plants including *Eleocharis sphacelata*, Marsh Club-rush (*Bolboschoenus fluviatilis*) and Jointed Twig-rush (*Baumea articulata*) which were planted when the basins where constructed.

During ecological surveys of the areas that would be affected by the M2 Upgrade project, no assemblages of native aquatic plants were found during flora and fauna surveys (conducted for this environmental assessment) that could be described as native vegetation communities. No aquatic plant species of conservation significance were recorded or considered likely to occur within the M2 corridor or surrounds. A variety of aquatic weeds (for example, Water Milfoil (*Myriophyllum aquaticum*) and Watercress (*Rorippa nasturtiumaquaticum*)) are found along the waterways of the study area. Of these, three species are listed as noxious weeds. Noxious aquatic species recorded in the waterways include:

- Long-leaf willow primrose (*Ludwigia longifolia*).
- Ludwigia (Ludwigia peruviana).
- Sagittaria (Sagittaria platyphylla).

Prior to residential development in surrounding areas, the creeks of the locality are likely to have supported a diverse community of insects, fish, frogs, birds and mammals. The creeks are degraded to varying degrees as a result of a number of factors including increased erosion due to the concentration of stormwater flows, weed invasion, polluted catchment runoff and the presence of exotic fish species. As a result of this condition, frogs, fish and aquatic invertebrates that are sensitive to these forms of disturbance are unlikely to persist in these waterways. Nonetheless, a variety of disturbance tolerant fauna species remain.

The present condition of the creeks of the M2 corridor varies from highly modified to near-natural. The section of Darling Mills Creek crossed by the M2 corridor appears to be in relatively moderate condition, with low turbidity, little evidence of sedimentation and a low level of weed invasion. This area is likely to be inhabited by many species of native fish. It is also likely to be inhabited by the introduced

fish, the Plague Minnow (*Gambusia holbrooki*) though the population density of this species is likely to be relatively low due to the higher water quality and intact riparian vegetation which favour native fish species. The Eastern snake-necked Tortoise (*Chelodina longicollis*) is also likely to be found here. Recent frog surveys conducted along this section of Darling Mills Creek detected the Green Stream Frog (*Litoria phyllochroa*), Peron's Tree Frog (*Litoria peronii*), Striped Marsh Frog (*Limnodynates peronii*) and Common Eastern Froglet (*Crinia signifera*).

The other creeks of the study area are more disturbed and are likely to contain a lower diversity and abundance of fish and frog species with the Plague Minnow becoming increasingly dominant in more disturbed areas.

The potential for viable fish habitat and fish passage along the majority of non-perennial and semi-perennial watercourses crossed by the M2 Motorway is considered to be low, for reasons outlined above. Additional obstructions to fish movement within the M2 corridor exist where waterways pass beneath the M2 Motorway via culverts. During low flow conditions, the streams of water flowing through the culverts are broad but very shallow and may limit the passage of some fish species. Higher water velocity and turbulence during rainfall events and a lack of pooled areas for fish to rest between bouts of swimming may also limit fish movement through the culverts. The extremely low light level within culverts may also create a non-physical barrier for some fish species that may avoid dark areas during daylight hours (Fairfull and Witheridge 2003). Larger in stream structures (for example, the retarding basin wall near Loyalty Road, North Rocks and weirs on the Lane Cove River) lower in the catchments of these creeks are also potential barriers to fish passage.

No threatened or protected aquatic invertebrate or fish species have been recorded in the waterways of the M2 corridor. Introduced fish species recorded in the locality include Goldfish (*Carassius auratus*), Common Carp (*Cyprinus carpio*) and Plague Minnow (*Gambusia holbrooki*). Goldfish and Common Carp are not likely to be abundant in the small rocky streams of the study area, but the Plague Minnow is found in all of the creeks, especially in disturbed areas. This species is listed as a Key Threatening Process due to its detrimental impacts upon tadpoles and frog eggs.

Water quality

Water quality monitoring for the M2 Motorway site began between July and December 1994 (prior to the original Motorway construction). Water samples collected downstream of the M2 Motorway were used to established background total suspended solids (TSS) averages for wet (128 mg/l) and dry (8 mg/l) conditions (sampling conducted by Bill Rooney, 1994). A water quality monitoring program was initiated in 1997-98 following the commencement of the operation of the M2 in May 1997. The objectives of the monitoring program were to examine water quality to check for conformance with recommended quality limits and to quantify changes in water quality so as to identify long term impacts that may be associated with the M2 Motorway construction.

Subsequent long term sampling results following original construction of the (post M2 Motorway construction) by HLA Envirosciences (2008) have calculated the median and average values to range between 5 milligrams/litre to 13 milligrams/litre (median) and 11 milligrams/litre to 32 milligrams/litre (average). Comparison of these results for the two alternative periods suggests that construction of the existing M2 Motorway has not had significant impact on the water quality of downstream receiving waters.

While TSS is only an indicator of potential contaminants and water quality, the long term monitoring results tend to suggest minimal discharge or transfer of suspended solids from the M2 Motorway, which may exacerbate sedimentation of the downstream receiving waters. The current operational M2 Motorway activities are therefore having minimal impact on the general water quality of the various tributary watercourses through which it traverses.

Within the limits of the proposed project widening, 31 water quality basins were originally provided to treat the low flow runoff draining from the existing M2 Motorway pavement surface via the stormwater pipe drainage networks. Low flow runoff (first flush) or contaminated spills washed from the road surface are directed through bifurcation pits which separate and divert the water into the basins for containment and treatment. The first flush of runoff typically contains the higher concentration of sediments and larger particulate matter (waste materials from vehicles such as brake pad wear and metals) which tend to settle out of the water more readily when temporarily stored in the basin. Fluid type materials washed from the surface (such as fuels and oils) are less dense and tend to float on the water surface allowing them to also be contained in the basin by use of special outlet arrangements. The locations of the basins are shown in Figures 1 to 5 of Technical Paper 6.

The sampling of the existing water quality basins, which are meant to treat the 'first flush' of runoff from the pavement surfaces, also suggest that the basins are performing their intended function in helping to protect the quality of the receiving waters. The July 2007 HLA Envirosciences report detailing the sampling of water downstream of the basins found marginal exceedances of the Australian and New Zealand Environment Conservation Council (ANZECC) freshwater criteria for zinc and copper at eight of the ten locations sampled. However, the report considered it was likely (but subject to further confirmation) that these exceedances were actually representative of regional water concentrations. The elevated readings within the basins for some elements such as copper and zinc as well as the polycyclic aromatic hydrocarbons (PAHs) suggest that these pollutants are being captured and retained in the basins in accordance with the design functional intent (SESL, 2008).

The M2 Motorway operator has indicated that the existing basins are generally working satisfactorily and aside from the ongoing build up of litter requiring regular cleaning, the basins were drained and de-silted once (in 2005) since the M2 Motorway became operational in 1997. The excavated sediment material was retained in a suitable storage area of the works depot within the M2 corridor.

With regards to spill incidents, the M2 Motorway operator advises that there have not been major spill incidents on the M2 Motorway with the potential to threaten the surrounding environment since operations began. There have been some minor instances of contaminants falling from trucks (such as chemicals or paints etc) and obviously some small oil and fuel leaks resulting from motor vehicle accidents. Such spills/incidents are quickly dealt with by the M2 Motorway response team, which has a special action plan and spill containment kit to deploy so that the potential for any contaminants to reach the drainage system and downstream environment is minimised. As a further safeguard, the existing M2 Motorway drainage systems have been designed to direct low flows, including fluid spills or wash down volumes, into the water quality basins where the contaminated runoff can be retained and appropriately dealt with.

The existing flooding environment is described in Section 10.1.1, and in Technical Paper 6.

9.8.2 Impact assessment

Proposed upgrade works

A brief description of the proposed upgrade works pertaining to surface water drainage elements structures within each of the Precincts is outlined below. A full description is provided in Section 6.3.9 and Technical Paper 6.

Prior to construction commencing, it is also proposed that, if required, the existing basins would be drained to allow for cleaning and de-silting to ensure the full capacity and effectiveness is available. A similar maintenance exercise would then be undertaken at the completion of construction so that the basins would be properly prepared for ongoing operational conditions.

Precinct 1 – Abbott Road to Windsor Road

Drainage works for Precinct 1 predominantly involve the adjustment of existing inlet pits with associated pipes to drain the pavement area of the new west facing ramps at Windsor Road.

Precinct 2 – Windsor Road to Pennant Hills Road

In this precinct the following works are proposed:

- Inlets and pipe culverts would be extended.
- New retaining walls built.
- New culverts are to be built parallel to and across the M2 Motorway.
- Eleven water quality basins require modification.
- One or two additional bridge piers may be required within or adjacent to a tributary of Darling Mills Creek or Darling Mills Creek itself.

Precinct 3 – Pennant Hills Road to Beecroft Road

In this precinct the following works are proposed:

- A gabion wall and open channel requires re-construction or modification.
- Culverts require extending.
- Reconstruction of the existing scour protection after works.
- Two water quality basins require modification.
- One or two additional bridge piers may be required within or adjacent to a tributary of Devlins Creek.

Precinct 4 – Beecroft Road to Terrys Creek

In this precinct the following works are proposed:

- Relocation or reconfiguration of parts of the local street pit and pipe elements away from the M2 corridor.
- A box culvert is to be extended.
- Reconstruction of scour protection measures as well as 30 metres of the existing concrete/rock mattress open channel.
- Modifications to a water quality basin to capture and treat the tunnel wash down water.

Precinct 5 – Terrys Creek to Lane Cove Tunnel

- A box culvert is to be extended.
- A vertical retaining wall must be built in a concrete channel.
- Reconstruction of a new concrete channel to reduce flood levels.
- A precast concrete arch under the M2 Motorway requires extending by 12 metres.
- Six existing water quality basins require augmentation.

Temporary stream crossings may be required for some work sites. However, the need for temporary stream crossings and locations for these have not yet been determined.

Soils

Erosion and sedimentation impacts were considered through an assessment of the proposed works in relation to soil characteristics. The proposed works involve excavation and soil disturbance in many locations, resulting in exposure of underlying soils, which has the potential to lead to erosion and sedimentation in downstream water bodies. Such excavation and soil disturbance would be required for widening works, construction of new piers for bridges, retaining walls, installation of stormwater drainage infrastructure and the augmentation of culverts and water treatment basins.

These construction activities pose the greatest risk where they occur near waterways, on steep slopes or on land subject to high flow or flooding. The potential for sediment transport and sedimentation issues is influenced by factors such as severity of storm events, the slope and footprint of disturbed area and the management controls that are implemented.

A preliminary assessment of areas more likely to be prone to erosion due to the construction works has been undertaken. Maps showing the results of the assessment are included in Appendix D of Technical Paper 6. The potential erosion risk has been categorised as either high or medium or low depending on the nature of the site conditions and the type of construction works being undertaken. Most of the corridor has been identified as either a low or moderate erosion risk. Areas of high risk have generally been identified where bridge widening works are proposed in steep land or works are required in or adjacent to the creek waterways.

Other factors that were considered in the assessment include; ground conditions (rock or soil), erodibility, slope, extent of clearing required, location of works relative to sensitive receiving environments, piers/piling works, fill earthworks or retaining wall. In this instance, a proportion of the project involves widening of existing cut batters/faces. These cut batters are typically comprised of rock and the disturbed face would drain down to the motorway. The dirty water runoff can then be readily managed with a treatment train of appropriate measures to reduce the risk of sediments being transported to the downstream receiving environment.

Water quality

The M2 Motorway's existing surface water collection and management system for the M2 Motorway would be modified as part of the proposed upgrade.

Soil is the most likely potential contaminant of water quality and can impact water quality during the construction phase if runoff is allowed to mobilise exposed underlying soils. This can result in increased erosion and sedimentation, which is influenced by the severity of a storm event, the slope and footprint of the disturbed area, in conjunction with the management measures being implemented. Management techniques employed to control and deal with runoff from the site works during construction also have the potential to concentrate flows and increase erosion leading to water quality issues for the receiving waters downstream. Other potential construction contaminants may include:

- Building waste and litter.
- Acids and chemicals from washing processes.
- Accidental spills of construction fuels or chemical materials.
- Disturbance of contaminated soils.

Water quality impacts would be primarily due to:

- General work –sediment would be collected by the existing M2 Motorway drainage system and directed into the basin.
- Basin works – inlet and outlet modifications.
- Culvert and bridge works – these works around watercourses may affect water quality outside of the existing drainage system.
- Earthworks associated with local road network connections – which may not be captured by the existing drainage system.

Flooding

Potential impacts to flooding from the proposed widening construction works may result from site establishment and preparation works as well as earthworks and drainage works. As the existing culvert structures are the only means to convey upstream catchment flows across the M2 Motorway, facilitation of the construction works is likely to result in some temporary obstruction of the waterway flow path. This obstruction may be caused by temporary bunding or diversions of the waterway, the placement of construction equipment or materials within the flow area, stockpiles or access roads and work platforms. There is the potential for such obstructions to result in the localised redistribution or concentration of flows (increased velocities) and depending on the circumstances this may increase flood levels upstream and temporarily impact on adjoining properties. Where piers may be required to be constructed in Darling Mills Creek or a tributary of Devlins Creek, the Piers would not adversely increase hydraulic impacts (flood levels or velocities).

Fish passage

The impacts of construction on fish passage are considered to be minimal. Fish passage across the M2 Motorway is currently highly restricted in many places due to the presence of culverts. Additionally for the Lane Cove River, a retarding basin and weirs further restrict fish passage.

The M2 Upgrade project would not introduce more culverts to the waterways, but would lengthen or extend culverts in seven of the 26 locations where culverts occur. Given the existing highly restricted nature of fish passage on site, and the short-term nature of obstructions across water flow paths during the construction works period, it is considered unlikely that fish passage would considerably worsen.

Riparian vegetation

The impacts of construction for works in and around watercourses on riparian vegetation are considered in Section 9.5.3 and Technical Paper 3.

High erosion risk compound locations – bridge works

Four of the proposed compounds are located within areas where the risk of potential erosion and sedimentation impacts is considered to be high. These high risk compounds include the three proposed compounds at Darling Mills Creek, Devlins Creek and Terrys Creek immediately beneath the three main viaducts at and the tunnel compound at Sutherland Road. These proposed compounds are considered to be high risk as they are in immediate proximity of watercourses.

The proposed compounds at Darling Mills Creek, Devlins Creek and Terrys Creek are required to support the proposed bridge widening works. At these locations worksites are required to facilitate piling works, pier construction and the widening of the bridge decks. As work to construct the bridge piers must occur from the ground level beneath the bridges, work sites must be established at these

locations, in the immediate vicinities of the watercourses. The use of these locations for works areas would therefore be unavoidable.

Due to the nature and limited accessibility of these proposed work locations, compounds would be established around these work sites to support the bridge works. These compounds would potentially include lay down and storage areas, site offices and temporary ablution facilities for use by the construction personnel involved in the works.

The proposed Darling Mills Creek and Terrys Creek compound sites are located within valleys with steep sided slopes. This topography limits the potential locations where works areas and compounds could be established. The small areas of relatively level or gently sloping ground immediately adjacent to the watercourses at the proposed work locations provides the only suitable potential locations for these compounds.

The proposed Devlins Creek compound site is characterised by gentler slopes. However, the available area for potential compounds locations is still constrained. The work site must be located immediately underneath the existing bridge decks and adjacent to the creek. As with the other bridge works locations, a compound would be set up around the work site.

Due to the proximity of these compound locations to the watercourses and the works that would occur at these locations there would be a high potential for erosion and sedimentation of the adjacent watercourses. Ground disturbance would occur during establishment of the work areas, whilst undertaking the proposed construction work and due to the movements of vehicles and plant within the compounds. Some riparian vegetation would also require clearing to create the necessary space in which to undertake the proposed works. Stable hard stands would be installed at these locations to facilitate the safe movement of the heavy construction equipment needed to undertake the proposed construction work. The potential for ground disturbance at the proposed sites would increase the potential for soil erosion and sedimentation of the adjacent watercourses.

The adjacent topography would also increase the risks associated with erosion and sedimentation at these locations. The steep surrounding areas would potentially deliver surface water run-off from adjacent areas to the site perimeters in significant quantities, increasing the potential for erosion within the proposed compounds. Surface water run-off within the sites would have the potential to transport sediment and other contaminants, such as fuel and oils spills from construction vehicles and plant, into the adjacent watercourses. Detailed site specific management strategies would be required to manage these potential impacts.

High erosion risk compounds – the tunnel compound

The proposed Sutherland Road tunnel compound would be located immediately adjacent to Devlins Creek. As such there would be an elevated risk of erosion and sedimentation in the creek due to the use of this compound.

To facilitate the tunnel widening works, a compound is required with potential access to and from the motorway in close proximity to the tunnel. This compound would be used as a staging point for tunnel widening activities, mechanical/ electrical modifications to tunnel and other associated works. Site facilities and offices, temporary spoil stockpile areas, equipment and materials storage and lay down areas and mechanical and electrical workshops would also be required at this proposed compound.

Due to the specific requirements of this compound, there are limited options for potential site selection. This site is considered to be the only viable option in close proximity to the proposed tunnel widening works. Furthermore, this site has previously been disturbed and utilised as a construction compound.

The erosion and sedimentation risks associated with this site are largely due to the close proximity to Devlins Creek. Whilst the site is relatively flat and has a limited upstream catchment area, the site would be cleared and graded, a hardstand would be installed and the site would be subject to vehicular and construction plant movements. As such there would be the potential to disturb the soil, liberate sediment and alter the hydrology of the area during compound establishment and use, all of which may increase the risk of erosion and sedimentation of Devlins Creek. Detailed site specific management strategies would be required to manage the potential impacts.

Other compounds

Other potential construction compounds are outlined in this document. A preliminary analysis of these potential locations indicates that none are in areas that are considered to be particularly high risk in terms of potential erosion and sedimentation impacts. This is largely due to the fact that they are not in close proximity to watercourses. However, these sites still have the potential to be in close proximity to entry points to the local stormwater system. Site establishment, the use of the compounds for stockpiling, vehicular and plant movements around the site have the potential to create ground disturbance. If sediment from these proposed compound sites was to enter the adjacent stormwater system there would be the potential for sedimentation issues in downstream waterways.

9.8.3 Mitigation measures

Soils and water quality

Construction activities would be undertaken and managed to minimise the potential for construction impacts on soils and water quality. Soils and water quality are considered together for this purpose, since the management measures are often the same.

As a general guiding principle for both design and construction, soil erosion and water quality mitigation and management measures would be implemented in accordance with the requirements of:

- Water Policy and Code of Practice for Water Management (RTA 1999).
- Managing Urban Stormwater - Soils and Construction Volumes 1 and 2 (often referred to as The Blue Book - Landcom 2004 and 2006).

A summary of measures likely to be implemented for both the construction phases is provided below. The control and mitigation of potential surface water quality impacts during the construction phase would be defined in a Soil and Water Management Plan (SWMP) prepared as part of the CEMP. An outline of the CEMP is provided in the Construction Environmental Management Framework (refer to Appendix F).

The SWMP would be developed to incorporate the most appropriate or 'best practice' controls and measures in accordance with *The Blue Book* requirements. The SWMP would be continually updated to suit the changing needs as the project works progress. Due consideration would also be given to the extent of works and situation relative to the sensitivity of the surrounding environment in relation to the construction activity. Typical mitigation measures to be considered and implemented where relevant include:

- Minimising disturbed areas and re-vegetating or stabilising such areas as soon as practical as the works progress.
- Utilising cleared vegetation for mulching wherever possible to minimise erosion and filter runoff to trap coarse sediments.
- Installation of appropriate erosion control measures such as silt fencing, straw bales, check dams, temporary ground stabilisation, diversion berms or site regrading.

- Divert clean water runoff away from the works or disturbed areas wherever possible.
- Utilisation of existing water quality basins or installation of new temporary sediment basins as appropriate.
- Installation of permanent scour protection measures required for the operational phase as soon as practical.
- Providing bunded areas for storage of hazardous materials such as oils, chemicals and refuelling areas.
- Work platforms or access tracks required through waterway areas would be constructed of large clean rock material wrapped or underlain with geofabric.
- Employ a qualified soil conservationist to advise on appropriate controls and to monitor the implementation and maintenance of such measures.
- Engage site staff through tool box talks or similar with appropriate induction on soil and water management practices.
- Work method statements would be prepared for waterway works with particular emphasis on the early implementation of erosion and scour protection requirements.
- If the construction of piers is required within or near waterways, these would be shaped and oriented with the direction of flow, where practical.
- To reduce the potential for erosion, permanent diversion of small channels in localised areas might be considered for situations where the permanent works (such as bridge piers) may be required adjacent to or partially obstructing the waterway.
- If temporary stream crossings are required, these would be built in accordance with *Managing Urban Stormwater - Soils and Construction* (Landcom 2008).

Erosion and sediment loads would gradually diminish after construction as the disturbed areas are remediated and the revegetation of batters starts to establish and hold the soils.

Flooding

Managing potential flooding impacts during construction needs to minimise the risks to the surrounding environment as well as the works themselves. Appropriate mitigation measures to be implemented would vary depending on the nature of the risks and sensitivity of the particular situation but would include consideration of the following:

- Temporary diversion or pumping of low flows around the works area.
- Minimising the need or extent of obstructions required to be placed within the waterway area.
- Programming or staging construction associated with creek/channel works or the transverse culverts to minimise the total time that works are undertaken in the vicinity of watercourses and thereby minimise the risk exposure.
- Ensuring construction equipment (or excess materials) is removed from the waterway or floodplain areas if wet weather is approaching and at the completion of each day's work activity.
- Strategically placing temporary levees or bunds to contain potential impacts and minimise the risk to surrounding properties, which may otherwise be affected.
- Installation of erosion and sediment control measures, in accordance with a CEMP across work areas, where potential flooding and diverted stormwater flow may create a risk of sedimentation or contamination from works in progress.

Fish passage

Managing the impacts of construction works on fish passage is closely linked to those employed for the management of flooding impacts as described above.

Riparian vegetation

The mitigation measures for construction of works in and around watercourses pertaining to the management of riparian vegetation are considered in Section 9.5.4 and Technical Paper 3.

High erosion and sedimentation risk compound and work locations

Due to the increased potential from erosion and sedimentation impacts at the identified high risk compound and work sites, detailed erosion and sediment control plans (ESCPs) containing specific management strategies and control measures would be prepared for each of these sites. These plans would be developed prior to the commencement of construction with the assistance of a soil conservation officer. These plans would be reviewed throughout the duration of works at these locations and updated as required to address any management strategy deficiencies or to adapt to changing site use and conditions.

These plans would be developed with consideration of the following principles, strategies and controls:

- Erosion and sediment controls would be installed prior to or simultaneously with clearing and site establishment activities.
- Clearing extents would be limited where practicable to minimise ground disturbance and maintain soil stability.
- Clearing limits would be delineated, signposted and shown on site plans prior to the commencement of clearing activities .
- Stabilisation measures would be implemented for disturbed ground or areas with high erosion potential immediately up-slope for proposed compound and work locations wherever practicable .
- Clean water from upslope areas would be intercepted and diverted around the compound and work locations wherever practicable.
- Dirty water would be collected from the compound and work locations and filtered or appropriately treated prior to leaving the site perimeter.
- Options for capture and reuse (for dust suppression and the like) of surface water run-off from the proposed compound and work locations would be investigated at each location and implemented where practicable.
- Discharge/outlet points for diverted clean water would be stabilised to prevent scour, erosion and sedimentation.
- Revegetation and stabilisation of disturbed areas as soon as practicable following the disturbance (and completion of works) to promote surface stability and minimise erosion potential.
- Any temporary creek crossing required would be designed and constructed in accordance with *Managing Urban Stormwater - Soils and Construction* Volumes 1 and 2 (often referred to as The Blue Book - Landcom 2004 and 2008).
- The storage of any potential contaminants at compound or work locations would be in an appropriately bunded and covered area and would be located as far as practicable from the waterways.