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AECOM

Chapter 5.0 - Hydrology and Hydraulics

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5.0 Hydrology and Hydraulics

5.1 Overview

The proposed KBP is located within the Cubberla and Moggill Creeks and Brisbane River catchment areas.

The purpose of this chapter is to identify the potential impacts of the KBP on the hydraulic regime, water quality, and the surface water drainage of Cubberla and Moggill Creeks and the Brisbane River. The main focus of the creek study is to assess the effects of a bridge structure crossing Moggill Creek, with respect to local flooding from the Moggill Creek catchment and regional flooding due to backwater effects from the Brisbane River. Impacts on Cubberla Creek and the Brisbane River are also discussed.

5.2 Approach and Methodology

5.2.1 Hydrology and Hydraulics

The hydraulic assessment of the KBP options was performed by review of previous modelling and the use of one and two dimensional modelling software packages.

The modelling of Moggill Creek was based on the BCC MIKE11 model (Sinclair Knight Merz 1994). The methodology used for the hydraulic assessment of the impacts of the KBP on Moggill Creek included:

- hydrology for the generation of proposed inflow hydrographs was derived from a calibrated URBS model of the Moggill Creek catchment provided by BCC. The critical duration for the lower Moggill Creek catchment was identified as three hours for both the 50 year and 100 year Average Recurrence Interval (ARI) design storm events (Sinclair Knight Merz, 1994);
- a MIKEFLOOD model was constructed to represent existing conditions for the downstream reach of Moggill Creek from the confluence with the Brisbane River up to Parklane Terrace (adopted middle thread distance (AMTD)[1] of seven kilometres). The model was constructed from a digital elevation map (DEM) covering the three square kilometre area of interest and elements from the calibrated MIKE11 model. This existing conditions model formed the Base Case and was used as a reference for the definition of potential hydraulic impacts;
- calibration of the MIKEFLOOD model was by comparison of water levels and discharge to those from the calibrated BCC MIKE11 model for the critical 100 year ARI design event under existing conditions. The Base Case and all design option cases were run for the 50 year and 100 year ARI design events (with only 100 year ARI results presented here);
- two design alignments for the KBP were generated by AECOM. These two options were integrated into the models, with each option modelled with a number of bridge lengths (125 metres to 325 metres) to assess a range of impacts;
- afflux maps were produced (only the preferred option is presented here) by reference to the Base Case surface water elevation map, as illustrated in Figure 5.1, and velocity magnitude maps were produced for respective ARI design events to assist in bridge design and scour calculations; and
- mitigation measures suggested were based on the analysis of afflux and changes to water velocity.

No modelling of Cubberla Creek was performed in this assessment as it was determined that the impacts of the Centenary Motorway on Cubberla Creek outweigh the impacts of the KBP. However, a review of a previous modelling report was undertaken (Sinclair Knight Merz, 1996) to identify further investigation required for subsequent design phases. This review indicates that the major crossing of Cubberla Creek has been assessed as part of the Centenary Motorway upgrade.

[1] Adopted Middle Thread Distance (AMTD) – is the distance in kilometres along the middle of the stream from its mouth or confluence with the main river. The distances in this study were adopted from the BCC Mike 11 model.

A number of assumptions were made to obtain the modelling results for this assessment due to the detail in the available survey data. For the future design stages, it is suggested that the following areas are surveyed in more detail:

- existing structures that cross Moggill Creek at and downstream of Moggill Road Bridge near Rafting Ground Reserve;
- the waterways and drainage system (pipes and culverts) at and adjacent to the site of the western abutment of the proposed Moggill Creek Bridge; and
- cross sections of Moggill Creek downstream of the proposed bridge site.

5.2.2 Surface Water Drainage

The methodology followed in the surface water desktop investigation included:

- the boundaries and land use of the offsite catchments were determined using existing topographic data;
- existing cross drainage culverts locations and elevations were determined from the aerial surveys. Culvert sizes were obtained from the BCC Stormwater Drainage GIS;
- a preliminary estimate of the longitudinal drainage layout was determined from the KBP typical sections, horizontal and vertical design; and
- a preliminary estimate of the required water mitigation was determined using the methods outlined in the Water Sensitive Urban Design (WSUD) Technical Design Guidelines for South East Queensland (SEQ).

A number of data sources were used to carry out this feasibility investigation into the drainage requirements of the KBP including:

- *DMR Road Drainage Design Manual* (2002);
- *Queensland Urban Drainage Manual, Volume 1* (DNRW 2007);
- *SEQ Regional Plan 2005-2026*, *Implementation Guideline No. 7 WSUD Design Objectives*;
- *Water Sensitive Urban Design - Technical Design Guidelines for SEQ, Version 1* (BCC et al 2006);
- *Australian Rainfall and Runoff, Volume 2* (IEAust 1997); and
- *Water Quality Guidelines Policy 2.4.1 Water Quality* and *2.44 Stormwater management implementation guidelines for planning schemes and development assistance* (EPA nd).

In addition to the reference documents listed above, the following data have been used as part of the drainage feasibility investigations:

- aerial survey data provided by DMR;
- aerial photography provided by DMR;
- Intensity Frequency Duration data for the Kenmore area using the isopleths and geographic and skewness factors provided in Australian Rainfall & Runoff (Volume 2), 1987; and
- BCC Stormwater Drainage GIS, March 2008.

No calculations for the local discharges of flows, the capacities of the culverts or the performance of water quality devices were completed as part of the desktop study.

5.2.3 Review of Previous Information

Information from the previous studies listed below was reviewed during this study.

- *Moggill Creek Flood Study* by Sinclair Knight Merz (1994);
- *Cubberla Creek Flood Study* by Sinclair Knight Merz (1996); and
- *Kenmore Bypass Preliminary Feasibility Study* by GHD (2007).

The following calibrated models supplied by BCC were reviewed during this study.

- URBS model of Moggill Creek catchment; and
- MIKE11 model of Moggill Creek and tributaries (Gap Creek, Gold Creek).

The information gathered from this review was used in the current modelling of Moggill Creek as detailed in the following sections.

5.3 Description of Existing Environment

5.3.1 Cubberla Creek Catchment

The 10.5 km² Cubberla Creek Catchment extends from the foothills of Mt Coot-tha Reserve to the Brisbane River at Fig Tree Pocket and includes all or part of the suburbs of Indooroopilly, Fig Tree Pocket, Chapel Hill, Kenmore and Kenmore Hills. Its main tributaries are the Boblynne Street branch (north of Moggill Road at Chapel Hill) and the Akuna Street branch, otherwise known as Little Gubberley Creek. Cubberla Creek flows under the Centenary Motorway at the point where Fig Tree Pocket Road overpasses the Centenary Motorway as shown Figure 5.3.

Present land use in the catchment is dominated by urban residential with lesser areas of grazing, sporting fields, recreational reserves and remnant rainforest. Houses are generally located well back from the waterway corridor as most of the corridor is in public ownership and used as riparian parkland.

The creek's floodplain has been filled and diverted at several locations to provide parkland and sporting grounds, e.g. Cubberla Creek Reserve and Fig Tree Pocket Park. Channelisation to allow for urban development has caused higher water velocities, higher peak flows, increased in-stream erosion, less time to peak flow and less natural baseflow (BCC 2001). Previous modelling of Cubberla Creek (Sinclair Knight Merz 1996) shows that peak flows for the 50 and 100 year ARI design events at the Centenary Motorway crossing are 220 m³/s and 250 m³/s, respectively.

5.3.2 Brisbane River

The segment of the Brisbane River within the study area is an eight kilometre reach between the confluence with Cubberla Creek and the confluence with Moggill Creek (approximately 44 to 52 kilometres AMTD). This section of the river is influenced by the inputs from the Bremer River, upstream tributaries (including Cubberla and Moggill Creeks) and by downstream tidal action. River width throughout this section varies from approximately 130-200 metres. Surrounding land use is predominantly urban with a riparian strip of vegetation approximately 20-100 metres in width on each bank.

The KBP alignment runs roughly parallel to the Brisbane River, approximately 0.5-1 kilometre from its northern bank. The alignment passes through the sub-catchments of Cubberla and Moggill Creeks and the Brisbane River inter-catchment area (that area of land that drains directly into the Brisbane River). The inter-catchment area includes a drain that runs from within the KBP alignment across Sunset Road and through Kingfisher Park before discharging into the Brisbane River. The division of area between Cubberla and Moggill Creek sub-catchments and the inter-catchment area in relation to the KBP is approximately 20/30/50, respectively.

5.3.3 Moggill Creek Catchment

Moggill Creek is approximately 25 km in length and flows from the southern edge of Brisbane Forest Park near Upper Brookfield and joins the Brisbane River at Kenmore. The wider catchment includes all or part of the suburbs of Mt Coot-tha, Kenmore, Kenmore Hills, Pinjarra Hills, Brookfield, Pullenvale, and Upper Brookfield. The creek is tidally influenced from its confluence with the Brisbane River to approximately 1.5 kilometres upstream from the creek mouth (Counihan and Webb 2001). Significant tributaries of Moggill Creek include McKay Brook and Gap, Wonga and Gold Creeks.

There are a number of structures crossing Moggill Creek, but in the downstream area of interest there are four that are of note. These include the Moggill Road bridge, a set of pipes crossing immediately downstream of Moggill Road, a footbridge adjacent to the Rafting Ground Reserve, and another set of pipes crossing adjacent to Yarawa Street. The KBP alignment crosses Moggill Creek just downstream of the Yarawa Street pipes crossing and approximately 1.2 kilometres (AMTD) from its confluence with the Brisbane River, just within the tidally influenced zone.

Present land use in the catchment is dominated by rural-residential, grazing and bushland in the upper catchment area and urban-residential with lesser areas of grazing (horses and cattle), sporting fields and recreational reserves in the lower catchment.

Flood waters discharging from the upper catchment area are reportedly limited due to the presence of Gold Creek Reservoir and the largely forested nature of Gap and Gold Creeks (BCC 1997). The lower catchment area is generally more susceptible to flooding due to its largely hilly topography, urban encroachment on flood lines and the tidal influence of the Brisbane River (BCC 1997). Modelling of the local flooding of the Moggill Creek catchment shows that the peak discharge immediately downstream of the KBP crossing for the 50 year and 100 year ARI design events is 676 m^3/s and 783 m^3/s, respectively.

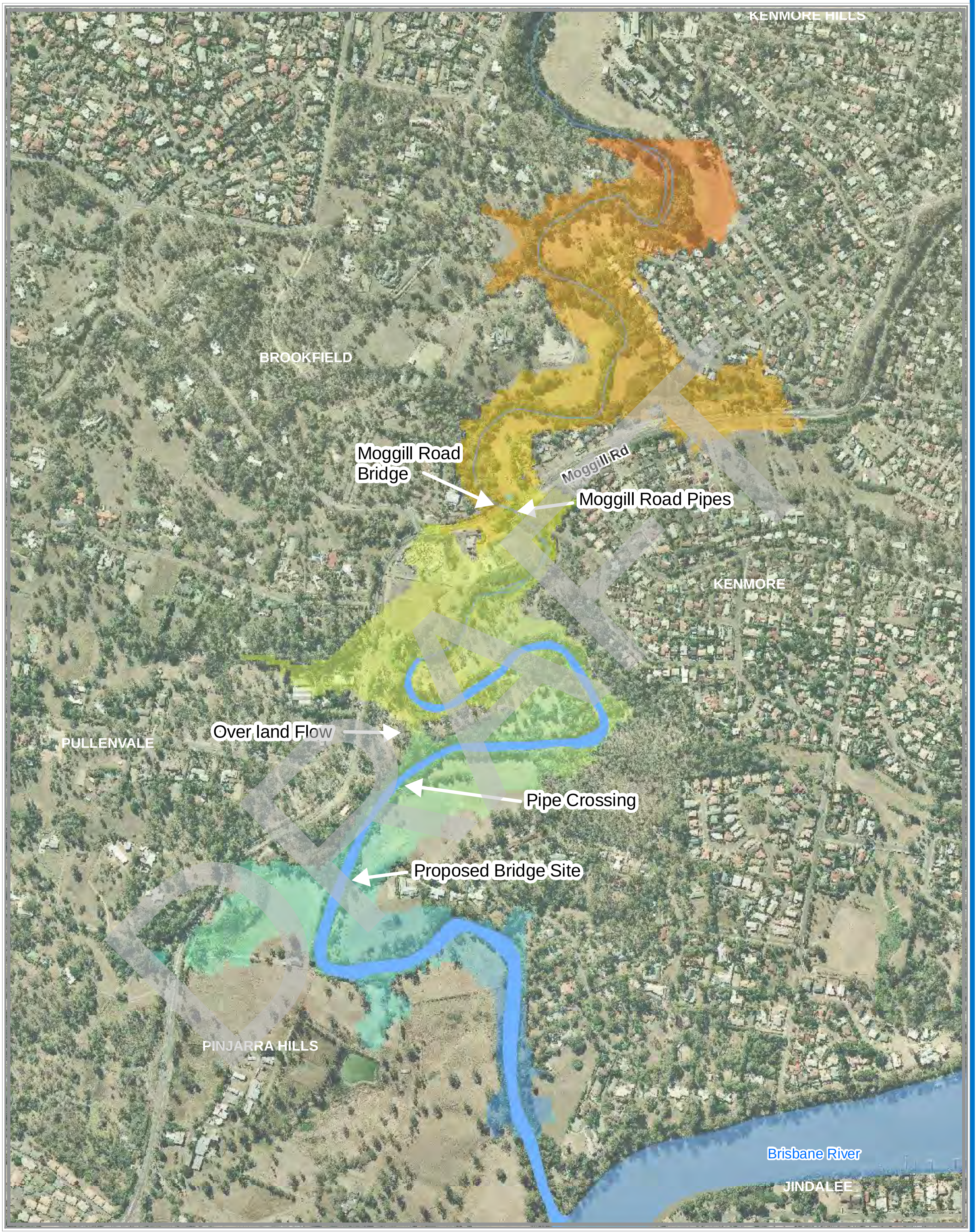
With the onset of a large flood event (i.e. a 100 year ARI storm event), the flows reach the lower catchment where they back up behind Moggill Road Bridge. Flows discharge beneath the bridge until overtopping and a breakout occur around the bridge on the eastern bank. Figure 5.1 shows the flood extent of the 100 year ARI storm event for the Moggill Creek catchment, with the Brisbane River tailwater level set to Mean High Water Spring (MHWS) 1.26 m Australian Height Datum (AHD).

Flows continue downstream and spread over the low-lying areas beyond the Moggill Creek channel down to the pipe crossing adjacent to Yarawa Street. This area has a steep western bank and a floodplain on the eastern bank that is inundated when the flows break out of Moggill Creek. Near the peak of the flood, an overland flow from the upstream floodplains develops a direct flow to a location just upstream of the pipe crossing, as illustrated in Figure 5.1.

Flows continue further downstream with some backwater effects into low lying areas. An area on the western bank near the western abutment of the proposed Moggill Creek crossing contains a number of waterways that are not well defined. The drainage system of this area requires further investigation. Beyond this, the flows discharge from Moggill Creek into the Brisbane River.

The extent of peak water levels is shown in Figure 5.1 for the 100 year ARI design event for existing conditions.

Regional flooding in the Brisbane River catchment can cause elevated water levels in the Brisbane River and consequently backwater effects in Moggill Creek. Model results from the BCC MIKE11 model showed that the water level at the Moggill Creek/Brisbane River confluence can rise to 9.84 m AHD for the 100 year ARI event. Flood extents were produced for these conditions in the Brisbane River using the MIKEFLOOD model from this assessment. Minimal inflows from the Moggill Creek catchment were assumed to highlight the impacts of the regional flooding only. The results are shown in Figure 5.2.



Maximum Surface Water Elevation (mAHD)

0	3.6 - 4	6 - 6.4	8.4 - 8.8	10.8 - 11.2
0 - 2	4 - 4.4	6.4 - 6.8	8.8 - 9.2	11.2 - 11.6
2 - 2.4	4.4 - 4.8	6.8 - 7.2	9.2 - 9.6	11.6 - 12
2.4 - 2.8	4.8 - 5.2	7.2 - 7.6	9.6 - 10	12 - 12.4
2.8 - 3.2	5.2 - 5.6	7.6 - 8	10 - 10.4	12.4 - 12.8
3.2 - 3.6	5.6 - 6	8 - 8.4	10.4 - 10.8	12.8 - 13.2

Data sources:

Roads, railway, rivers etc - Copyright 2006, MapData Sciences PTY LTD, PSMA

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KENMORE BYPASS

Local Flood Extent in Moggill Creek
100 year ARI design event
(Exisitng Conditions)

Date - 13 May 2009

Figure 5.1

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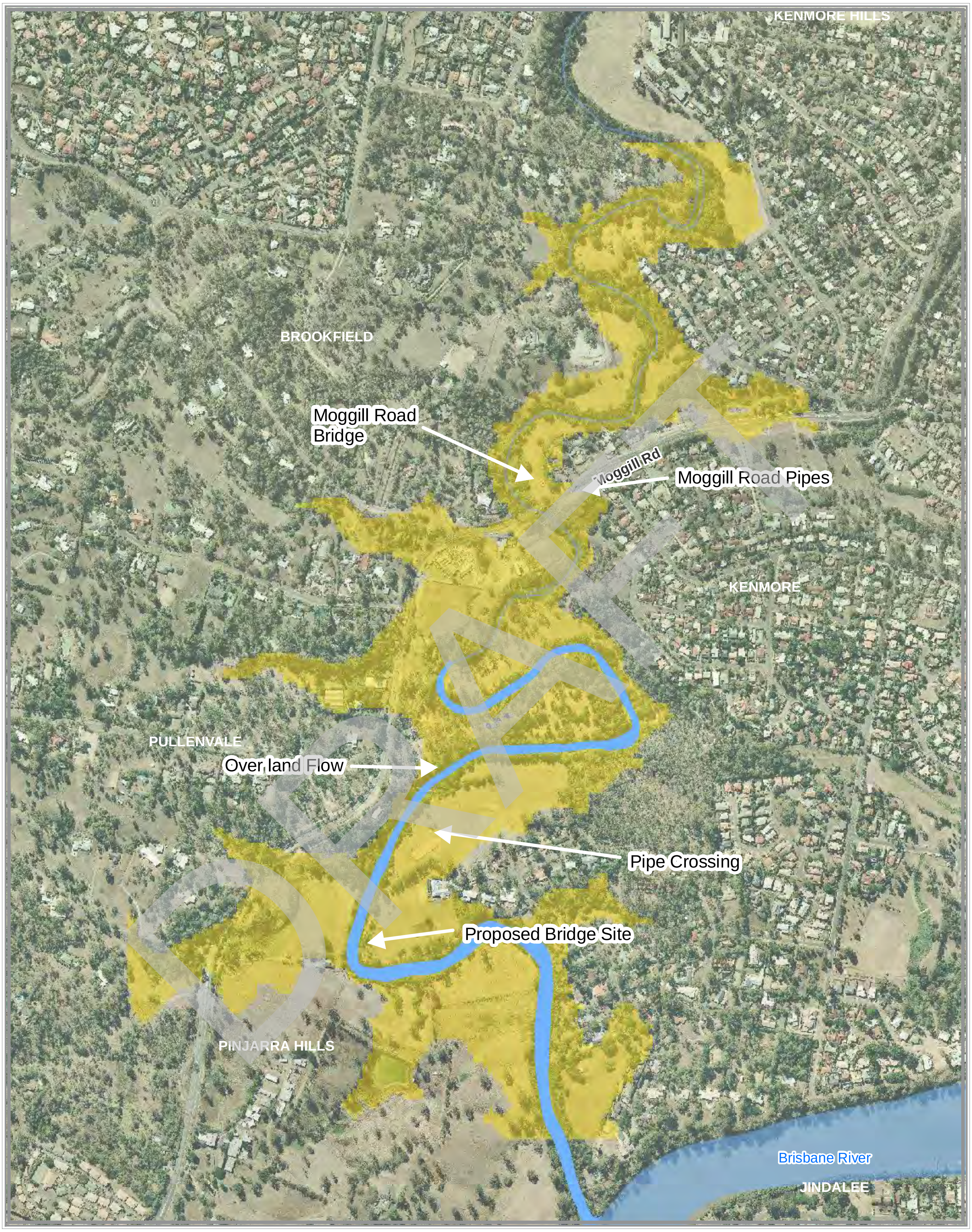

Maximum Surface Water Elevation (mAHD)

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3.6- 4, 4 - 4.4, 4.4 - 4.8, 4.8 - 5.2, 5.2 - 5.6, 5.6 - 6
6 - 6.4, 6.4 - 6.8, 6.8 - 7.2, 7.2 - 7.6, 7.6 - 8, 8 - 8.4
8.4 - 8.8, 8.8 - 9.2, 9.2 - 9.6, 9.6 - 10, 10 - 10.4, 10.4 - 10.8
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KENMORE BYPASS

Regional Flood Extent in Moggill Creek
100 year ARI design event
(Existing Conditions)

Date - 13 May 2009

Figure 5.2

5.3.4 Local Drainage

As illustrated in Figure 5.3, for the purpose of this study, the KBP is divided into four local catchment regions:

- the Centenary Motorway interchange to Kenmore Road;
- west of Kenmore Road to Gem Road;
- west of Gem Road to Moggill Creek; and
- Moggill Creek to the Moggill Road intersection.

Centenary Motorway to Kenmore Road

This region of the corridor is approximately 700 metres long and consists of a narrow valley falling west to east. The local drainage catchment in this area consists of lightly wooded open space and large residential lots. A small creek drains the valley and is conveyed under the Centenary Motorway by box culverts that connect to an open swale that flows to the north to Cubberla Creek.

Kenmore Road to Gem Road

The second segment of the corridor is approximately 1,200 metres long and ends at the high point 200 metres west of Gem Road with the low point being at Chainage 2640 opposite Kingfisher Park. The corridor here is mostly a valley with a natural channel flowing in an east to west direction. The catchment consists of residential neighbourhoods to the north and south of the corridor. The neighbourhood drainage is conveyed by overland flow and pit and pipe networks to the creek in the floor of the valley. The channel flows south across Sunset Road and into Kingfisher Park where it connects with the Brisbane River.

Gem Road to Moggill Creek

The third region of the corridor is approximately 1,200 metres in length and ends at Moggill Creek. The corridor here lies to the north of a ridge that runs to the south-west. The local drainage catchment varies from dense wooded ridge tops to grassed horse paddocks and residential neighbourhoods, and drains to Moggill Creek.

Moggill Creek to Moggill Road Intersection

The Moggill Road intersection local drainage catchment consists of large residential lots and open spaces that lie to the west of Moggill Road. The catchment is approximately two square kilometres with a small channel flowing in the bottom. The channel crosses Moggill Road through box culverts and discharges into Moggill Creek. Surface runoff from 500 metres of Moggill Road is conveyed through table drains and open channels that discharge into Moggill Creek near the KBP intersection.

5.3.5 Catchment and Water Management Plans

Land and Water Management Plans are property-based plans for irrigation and water entitlements that are approved under the *Water Act 2000*. No properties within the KBP alignment are known to be subject to these plans. Similarly, the *Water Act 2000* controls the development of works that take or interfere with surface water, overland flow water and underground water. At present, there is a moratorium on the construction of works that use groundwater. No properties within the KBP alignment are known to be within the Brisbane Aquifer Area to which this moratorium applies (DNRW 2008).

Property Plans are for the control of erosion and runoff from cropping lands and are approved under the provisions of the *Soil Conservation Act 1986*. No properties within the KBP alignment are known to be subject to these plans.

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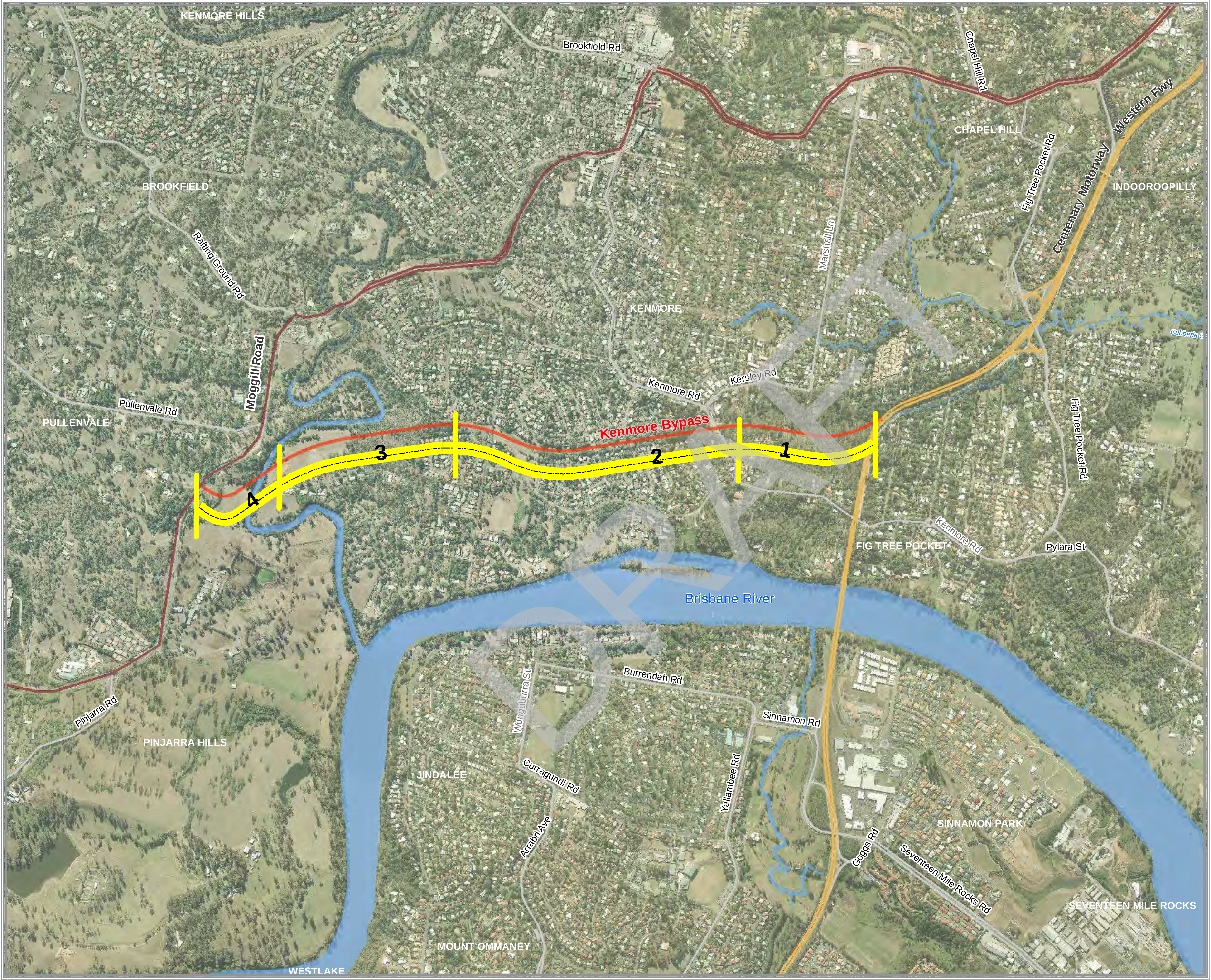

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Date - 13 May 2009

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Legend

- Centenary Motorway
- Kenmore Bypass
- Moggill Road
- River/creek

Drainage Study Areas

- 1 Centenary Mwy - Kenmore Rd
- 2 Kenmore Rd - Gem Rd
- 3 Gem Rd - Moggill Creek
- 4 Moggill Creek - Moggill Rd

KENMORE BYPASS HYDRAULICS

Drainage Study Area

Figure 5.3

5.4 Potential Impacts and Mitigation Measures

5.4.1 Potential Impacts

The construction of the KBP will necessitate modifications to existing major waterways and surface drainage. Potential impacts defined by comparison to the existing situation from the current analysis are discussed in this section.

5.4.1.1 Impacts of Proposed Alignment on Existing Environment

5.4.1.1.1 The Preferred KBP Option

The preferred bridge length opening for the KBP crossing of Moggill Creek is 325 metres with Moggill Road Option B alignment. This is based on the hydraulic analysis and the stated impact criteria contained within the *Kenmore Bypass Hydraulic Impact Assessment Report* (AECOM, 2009). This option closely replicates the existing hydraulic regime of Moggill Creek in order to minimise adverse environmental impacts and land impacts. Further, this option ensures that the existing flood immunity is retained.

5.4.1.1.2 Major Waterways

Brisbane River

The KBP crosses the inter-catchment area of the Brisbane River. There are no major streams in this area and further description of the potential impacts associated with overland flow and water quality issues is provided in Section 5.4.1.1.3.

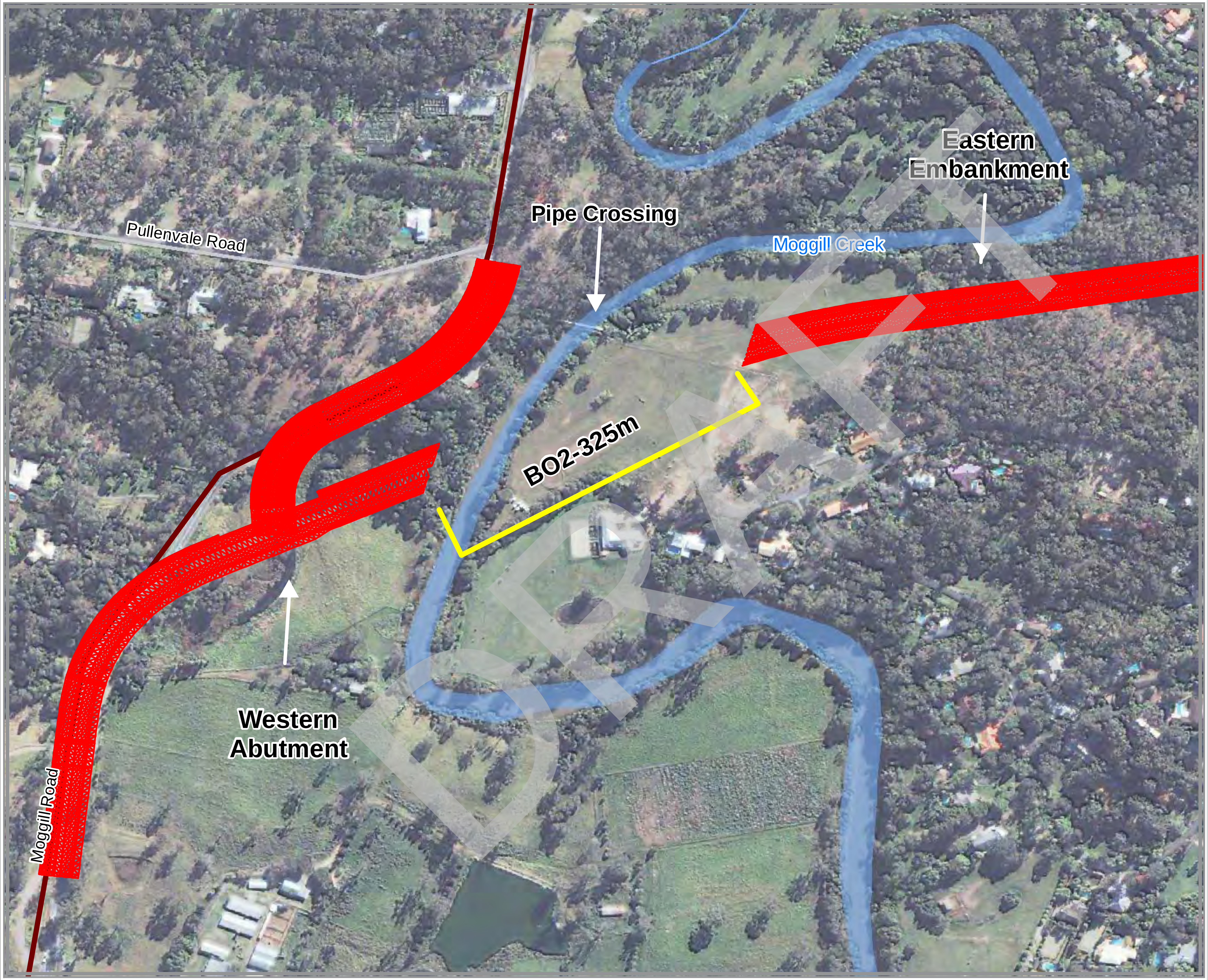
Cubberla Creek

The Cubberla Creek waterway has been heavily modified from its natural flow path in the past. The KBP alignment design does not intend to alter the existing flow path. A service road that is part of the KBP design runs adjacent to the Centenary Motorway, crossing Cubberla Creek upstream of the motorway, before connecting to Fig Tree Pocket Road.

Moggill Creek

The KBP alignment crosses Moggill Creek approximately 1.2km upstream of the confluence with the Brisbane River. The KBP Moggill Creek crossing for the preferred alignment is shown in Figure 5.4 with a bridge opening of 325 metres. The length of the proposed bridge for the preferred alignment option was selected in terms of maintaining the existing hydraulic regime (afflux, flood extent and water velocity) to minimise any adverse environmental and land impacts.

A number of important aspects must be considered in the design of the KBP alignment in relation to the hydraulic regime of Moggill Creek. These include the impact of the eastern road embankment, which runs through part of the floodplain of Moggill Creek upstream of the proposed bridge location. Also, the construction of the preferred KBP option will require the preservation of the drainage in the area proposed for the construction of the western abutment.



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MGA94 Zone 56

Date - 13 May 2009

Legend

- Kenmore Bypass
- Moggill Road
- Major Roads
- River/creek

Data sources:
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Aerial Imagery:
Copyright Qasco Surveys Pty Limited (2005).

Air Quality Information provided by ENSR Australia, Brisbane for the Kenmore Bypass Environmental Study.

KENMORE BYPASS HYDRALICS

Preferred Option
325m Bridge Opening
KBP Alignment Option B

A4 size

Figure 5.4

5.4.1.1.3 KBP Sub-Catchments and Pavement Drainage

Centenary Motorway to Kenmore Road

This portion of the KBP traverses the hillside below a ridge as it climbs to the highpoint at Kenmore Road. A low point in the KBP is located approximately at Chainage 1450. The typical road cross section of the KBP is bounded by a retaining wall and barrier on either side. The pavement surface drainage currently proposed may be a pit and pipe network flowing west to east and discharging into a small creek that is a tributary of Cubberla Creek. Offsite water flows that become trapped on the south side of the Centenary Motorway should be kept separate from pavement surface flows and conveyed by open channel to a new cross culvert under the KBP to discharge into the creek.

Kenmore Road to Gem Road

This portion of the KBP runs along a narrow corridor bounded by residential areas on either side. A low point in the KBP is located at approximately Chainage 2640. The pavement surface drainage currently proposed may be a pit and pipe network flowing to the low point and discharging into the creek that flows under Sunset Road and through Kingfisher Park. The existing culverts under Sunset Road have been observed to overtop during large rainfall events. It is recommended that the impact of the KBP discharges on the Sunset Road culverts should be evaluated during preliminary design.

The existing local drainage networks discharge into the area to be occupied by the KBP. These systems will need to be included in the KBP design. No calculations on the existing capacity of these systems have been undertaken. There are several options that are discussed by location below.

- Twilight Street Sub-Catchment – Drainage Option 1
  On the southern side of the corridor, a 1,350 mm diameter trunkline runs through the backyards of the Twilight Street neighbourhood. It may be possible to extend the pipe approximately 300 metres along the southern verge area of the corridor to outfall in Kingfisher Park. The new extended trunkline could provide a connection for other offsite networks from the intersections of Twilight Street and Aurora Crescent. Additional inlets could be placed in the verge to capture backyard flows and roof drains before they enter the KBP corridor. There may be potential conflicts with access and maintenance with this option.
- Twilight Street Sub-Catchment – Drainage Option 2
  A second option may be to capture the existing neighbourhood network in a new 700 metre trunkline in Twilight Street that would outfall into the creek at Kingfisher Park. It would be possible to connect the existing street system into one network. This would remove the existing neighbourhood stormwater trunkline from the KBP corridor and place it in the local streets. Provision would still need to be made for the capture of backyard and roof drain discharges into the verge of the KBP corridor.
- Marland Street Sub-Catchment – Drainage Option 1
  In the neighbourhood to the north of the corridor along Marland Street there are five pit and pipe systems varying from 300mm to 900mm diameter that outfall into the KBP corridor. These networks could be connected into a new trunkline running along the north side of the KBP under the proposed shared recreational path. This network would have to cross the KBP at the low point in a new culvert and outfall into the creek at Kingfisher Park.
- Marland Street Sub-Catchment – Drainage Option 2
  A second option for this area would be to run a new trunkline in Marland Street connecting the offsite local drainage systems and constructing a new culvert crossing under the KBP into Kingfisher Park. This would remove the existing trunkline from the KBP corridor and place it in the local streets.

Gem Road to Moggill Creek

This portion of the KBP corridor descends from the highpoint along the ridge to the proposed bridge crossing of Moggill Creek. The KBP is in fill through this section and is bounded by concrete barrier on either side of the carriageway. The pavement surface drainage currently proposed may be a pit and pipe network flowing east to west and discharge into Moggill Creek. An oil/spillage containment pond may be located on the south side at the low point near Chainage 3450. Offsite water flows that become trapped on the south side of the KBP should be kept separate from pavement surface flows and be conveyed by an open channel to Moggill Creek.

Moggill Creek to Moggill Road Intersection

The preferred option (Moggill Road Option B) requires Moggill Road to be widened and realigned to form an intersection with the KBP. The proposed Moggill Road intersection will primarily drain into open table drains. A pit and pipe network will need to be provided to capture kerb flows in the intersection and around the traffic islands. Flows from the roadway table drains and stormwater networks will discharge into Moggill Creek.

There is a local catchment that lies directly west of the proposed Moggill Road interchange. This catchment drains to a creek that crosses the existing Moggill Road through a set of box culverts. The realigning of Moggill Road will require this culvert to be upgraded with the possible addition of a second culvert under the KBP.

5.4.1.2 Hydrology and Hydraulic Impacts

Cubberla Creek

A crossing of Cubberla Creek by the Centenary Motorway was assessed in a previous modelling report (Sinclair Knight Merz, 1996). The alignment of the preferred KBP option crosses Cubberla Creek upstream and adjacent to the Centenary Motorway crossing. As a result, the preferred alignment was reviewed in the context of the potential impacts of the Centenary Motorway. It was concluded for this study that with minimal footprint in the waterway, the potential impacts would be similar to the KBP option and Centenary Motorway crossing combined. However, additional information is needed with respect to the design of the crossing structure before any potential impacts to existing conditions can be confirmed.

Brisbane River

Although the alignment of the KBP does not cross the Brisbane River, there is potential for indirect impacts in the Brisbane River during the construction and operational phases of the KBP via overland flow and flow from Cubberla and Moggill Creeks. These will most likely be related to the quality of surface water runoff during the construction phase, in particular from sediment and its impact on waterway turbidity. During the operational phase, it is expected that there will be an increase in surface water runoff due to the impervious area of the roadway, with an associated increase in pollutant loads from the vehicles. These water quality aspects are dealt with in more detail in Sections 5.4.2.2.1 and 5.4.2.2.2.

Moggill Creek

The Base Case model was amended to represent the embankment and bridge opening for a number of options. These cases were used to assess the hydraulic impacts of the bridge structure during local flooding in Moggill Creek (50 year and 100 year ARI design event) and regional flooding in the Brisbane River (100 year ARI water levels). The hydraulic impacts were assessed in terms of afflux, as calculated by the difference in maximum surface water elevation for the developed case and the Base Case, and changes in magnitude of water velocity. The preferred option with a bridge opening of 325 metres is presented here, with the full range of results presented in the *Kenmore Bypass Hydraulic Impact Assessment Report* (AECOM 2009).

5.4.1.2.1 Local Flooding

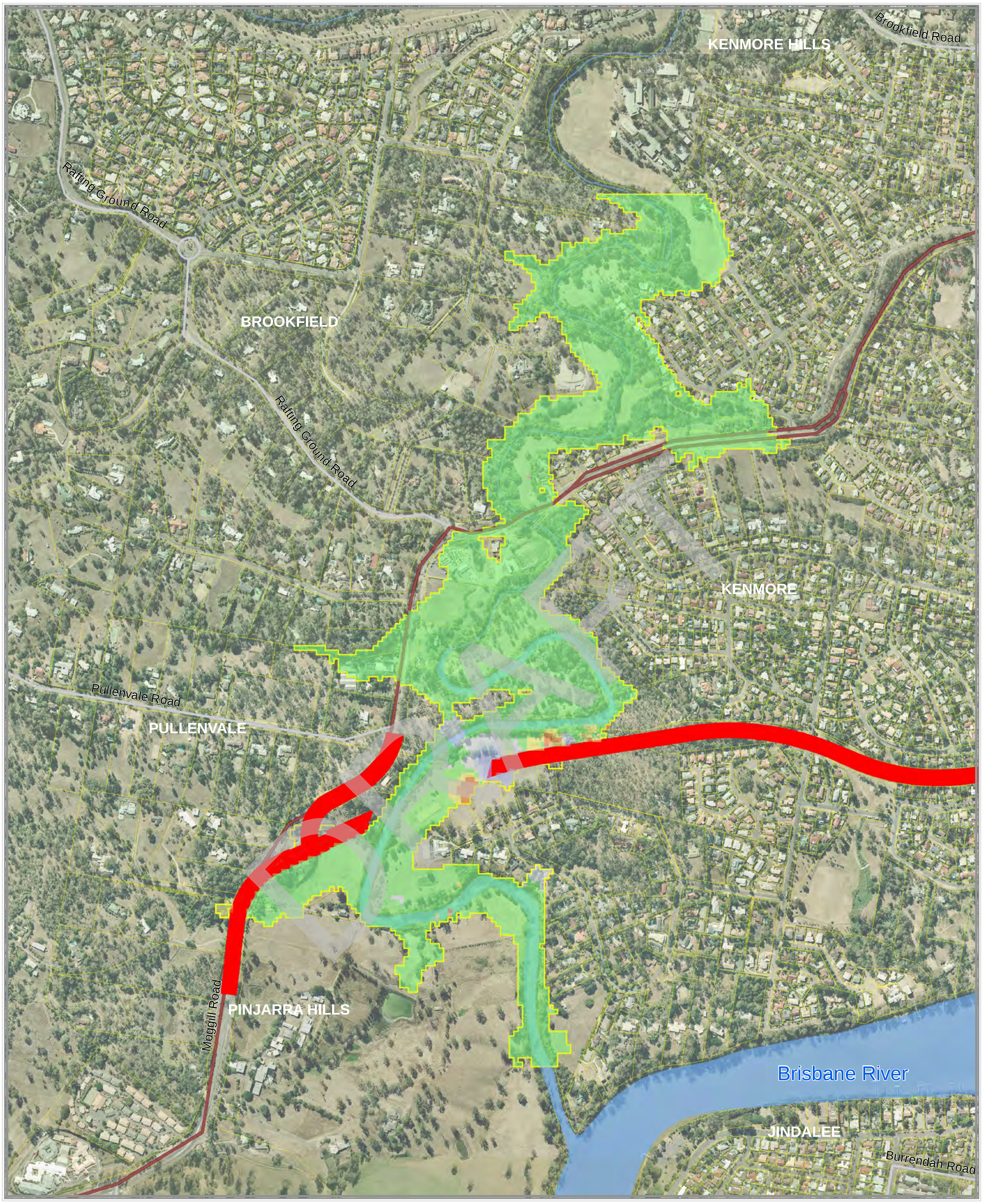
The afflux map in Figure 5.5 represents the impacts of the preferred alignment with a 325 metres bridge opening during a 100 year ARI design storm. The following are noted:

- the flood extent is the same as the existing conditions;
- a very small pocket of afflux over 0.02 metres occurs near the eastern abutment;
- a maximum afflux of 0.16 metres near the eastern abutment. However, the afflux is generally below 0.02 metres;
- the encroachment of the eastern embankment of the KBP alignment into the floodplain adjacent to Moggill Creek leads to a decrease in floodplain volume and an associated increase in afflux;

- the western abutment of the KBP Moggill Creek crossing cuts through a number of small tributaries from under Moggill Road, which have been identified for detailed drainage design and as a potential fauna movement corridor;
- the majority of area downstream of the bridge site maintains a maximum surface water elevation within ±0.02 metres of existing conditions; and
- No property impacts have been identified outside the existing flood extent.

5.4.1.2.2 Regional Flooding

The impact of the preferred KBP Moggill Creek crossing (325 metres bridge opening) on Moggill Creek for regional flooding in the Brisbane River was modelled. The regional flooding is represented as a time-series of increasing water level in the Brisbane River (supplied by BCC) to a maximum of 9.84 metres AHD (100 year ARI). The backwater flow into Moggill Creek from the Moggill Creek/Brisbane River confluence gives rise to an afflux on the downstream side of the proposed bridge site. For emphasis of the impacts of the regional flood case, inflows from the Moggill Creek catchments were maintained at minimum flow levels. The results show that the afflux attributable to the preferred KBP option due to regional flooding is less than 0.02 metres in the Moggill Creek channel compared to the regional flood Base Case and is considered negligible.



Afflux (m)

Legend

Afflux (m)					
< -1	-0.1	0.02	0.25	Kenmore Bypass	
-0.5	-0.05	0.05	0.5	100 ARI existing extent	
-0.25	-0.02	0.1	>0.5	Land Parcels	

0 125 250 500
Metres

1:8,000 (when printed at A3)

Air Quality Information provided by ENSR Australia, Brisbane for the Kenmore Bypass Environmental Study.

A3 size

GDA
MGA94 Zone 56

AECOM

KENMORE BYPASS

Afflux and flood extent for local 100 year ARI design event with preferred KBP option (325 metre bridge opening)

13 May 2009

Figure 5.5

5.4.1.2.3 Water Velocity

A number of velocity magnitudes were extracted along Moggill Creek for the preferred KBP option and the Base Case. Figure 5.6 shows the comparison of these maximum velocity magnitudes along the flow path of Moggill Creek for the Base Case and preferred KBP option with a bridge opening of 325 metres. A comparison of the in-stream water velocities shows that the preferred option replicates the existing in-stream velocity at the proposed bridge site.

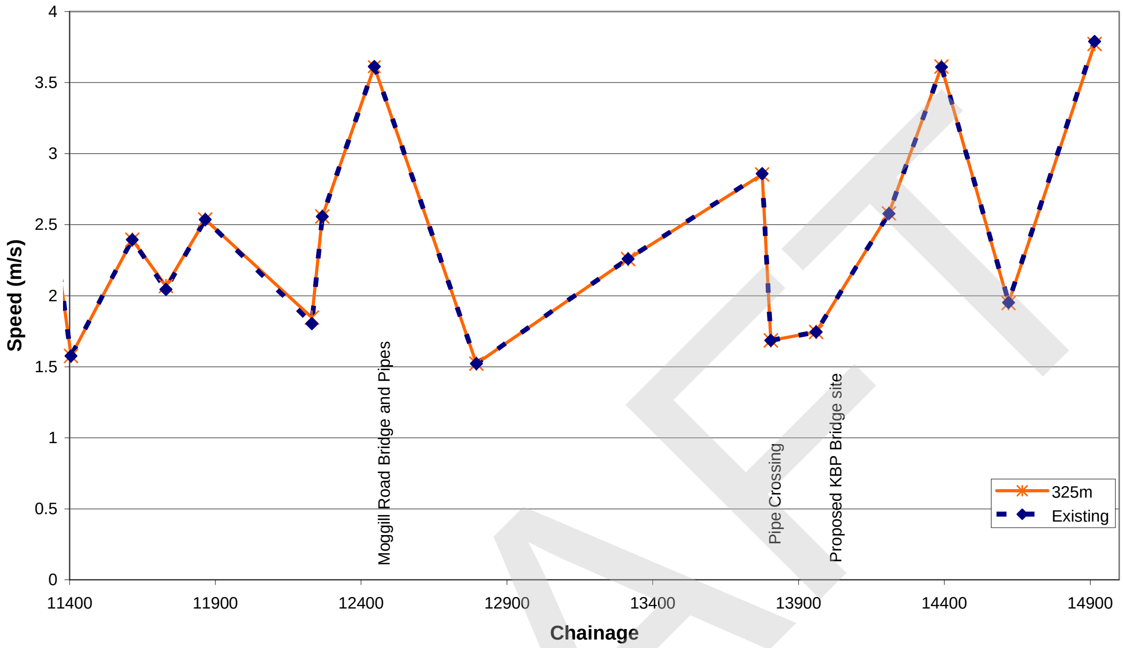


Figure 5.6: Water Velocity during Local Flooding (100 year ARI design event)

5.4.1.2.4 Surface Water Drainage

The construction of the KBP coverts a large area of natural ground to impervious area and causes a significant modification to the naturally occurring drainage regime. Redirection and modification of the drainage network may cause a change in the volume, frequency, duration and velocity of runoff. Changes to the drainage flow path may cause a diversion of runoff to a different point of discharge than that occurring naturally. Increased discharges in natural channels may cause adverse affects such as increased velocities, channel depths and sediment deposition. These changes can cause an increase in erosion of the downstream channel, loss of natural habitat and damage to downstream properties.

Importantly, the above impacts can be mitigated if not avoided through engineering design. It is a requirement that all new drainage works or modifications of existing drainage systems should be done in a manner that does not cause a worsening of the existing drainage regime properties downstream.

The impacts of any changes to the existing surface water drainage on the environment and subsequent mitigation measures required will be addressed in the detailed design phase.

5.4.2 Mitigation Measures

5.4.2.1 Hydrology and Hydraulics

Cubberla Creek

Any mitigation of afflux or increased scour potential at the Cubberla Creek crossing identified to be caused by the KBP alignment will be assessed during the detailed design phase. This may take the form of simple hydraulic calculations or modelling of the structure, depending upon the impacts of the crossing structure design.

Brisbane River

No mitigation is necessary since there are no direct impacts caused by the KBP to the hydraulic regime of the Brisbane River for either a local or regional flood event.

Moggill Creek

The impacts of the KBP preferred option on the hydraulic regime of Moggill Creek during a 100 year ARI local flooding event are:

- the extent of the afflux due to the alignment and bridge opening are localised to the floodplain adjacent to the road embankment with an anticipated maximum value of 0.16 metres. However, the afflux is generally below 0.02 metres;
- the encroachment of the eastern embankment of the KBP alignment into the floodplain adjacent to Moggill Creek leads to a decrease in floodplain volume and an associated small increase in afflux;
- the western abutment of the KBP Moggill Creek crossing cuts through a number of small tributaries from under Moggill Road that has been identified as a potential fauna movement corridor; and
- modification of the waterways in the area surrounding the proposed western abutment.

The following measures are suggested to assist in mitigating the potential impacts:

- further investigation of mitigation measures and optimisation of the Moggill Creek bridge opening of the KBP alignment during detailed design with respect to minimising afflux and construction costs;
- investigation of the reconfiguration of the KBP alignment and road embankment (elevation and batters) to minimise the displacement of floodplain volume, and hence afflux upstream of the proposed bridge site, by the eastern embankment adjacent to Moggill Creek; and
- development of an improved understanding of the existing drainage of the area in the vicinity of the western abutment/embankment, and incorporation of a design to facilitate an effective drainage solution and fauna passage.

Modelling of the backwater effects on Moggill Creek from regional floods occurring in the Brisbane River has shown afflux levels less than 0.02 metres for the main waterway for the preferred option.

Although analysis of the proposed KBP has indicated that the preferred option will have minimal impact to the existing hydraulic regime of Moggill Creek, an initial climate change risk assessment has suggested that the crossing may be subjected to additional impacts due to climate change. Chapter 15 (Climate Change Assessment) identifies an increased risk that the bridge will be exposed to extreme weather events, which may result in flood damage to the bridge and material degradation. Potential mitigation measures for the impacts of climate change will be developed if the bridge opening is determined to be at high risk to the these impacts. However, if it is determined that there is a need for an increase in bridge width or height there is room to accommodate this within the existing corridor.

In addition, from July 2008, the Environmental Protection Agency's *Climate Change Impact Statement (CCIS)* has become a mandatory inclusion for proposals submitted to Queensland Cabinet, Cabinet Budget Review Committee (CBRC) and Budget consideration. This will entail investigation into the impacts of increased rainfall and sea level rise, and will be determined in subsequent phases of the planning study.

Furthermore, during the construction phase, consideration must be given to the construction techniques with respect to bridge abutments and piers that impinge on the Moggill Creek channel and adjacent floodplain. Keeping piers out of the main channel will help minimise impacts associated with reduced waterway area.

5.4.2.2 Surface Water

New drainage works or modifications of existing drainage systems should be undertaken in a manner that does not cause a worsening of the existing drainage regime properties downstream.

New outfalls should meet the requirements of *Queensland Urban Drainage Manual (QUDM) Chapter 3.02 – Lawful points of discharge*. This states that all outfalls are under the lawful control of the Local Government or other statutory authority from whom permission to discharge has been received. It also notes that in discharging in that location, the discharge will not cause an actionable nuisance that may result in an action or claim for damages arising from that nuisance. If these requirements cannot be met, it will be necessary to obtain an alternative lawful point of discharge. This can usually be achieved by the acquisition of stormwater drainage easements or drainage reserves.

Changes to the drainage flow path may cause a diversion of runoff to a different point of discharge than that currently occurring. Increases or decreases in peak discharges should be evaluated for their potential downstream impacts. The discharge impact assessment should include the change in the physical flow regime, changes to the environment including frequency of flow, pollutant loads, sedimentation, and the legal consequences of the increase in discharge at the inlet and outlet.

Surface flows that are concentrated by an open channel or conduit should be controlled prior to discharge on a downstream system or owner. Concentrated flows should be dissipated by the use of detention or energy dissipaters.

Outfalls that connect to existing culverts and pipe networks should include an analysis of the capability of the existing system to convey new flows. When required, detention should be provided to minimise the risk of surcharging an existing downstream system.

Drainage systems should be designed following the standards outlined in *Road Drainage Design Manual* and QUDM.

5.4.2.2.1 Construction and Operation Design Requirements under the SEQ Healthy Waterways Strategy

The *South East Queensland Healthy Waterways Strategy 2007-2012* (SEQHWS) was developed through an extensive consultation process with Healthy Waterways' partners and the community. The SEQHWS comprises 12 action plans. These are a combination of issue and area based plans, and enabling plans, which will support and enable the issue and area-based plans. One of these action plans, the WSUD Action Plan, will have implications for the design and construction of the KBP. The target of this plan is, "By 2026, all developed urban land in SEQ will meet consistent regional standards for Water Sensitive Urban Design". From 2008 onwards, all urban development should consider the following regional standards for WSUD (Appendix 2 of the Plan):

- Frequent Flow Management - to minimise the change in frequency of hydrologic and water quality disturbance to aquatic ecosystems by managing the volume and frequency of surface run-off during small rainfall events.
- Waterway Stability Management - to control the impacts of urban development on channel bed and bank erosion by limiting changes in flow rate and flow duration within the receiving waterway; and
- Stormwater Quality Management - to control the impacts of urban development on pollutant loads discharged to receiving waters in the post-construction period.

Table 5.1 below summarises the Water Quality Objectives (WQO) for these three Standards.

Table 5.1 WQO and WSUD Measures

Regional Standard	Objective	WSUD measure
Frequent Flow Management	Capture the first 15 mm/d of rainfall runoff.	Retention ponds; and Infiltration measures.
Waterway Stability Management	Limit post development 1-year ARI discharge to pre-development (undeveloped) 1-year ARI discharge.	Sedimentation basins; Bioretention swales and basins; and Constructed wetlands.
	Limit post development 100 year ARI discharge to pre-development (undeveloped) 100 year ARI.	Detention ponds.
Stormwater Quality Management Achieve the following reductions in total pollutant load	90% reduction in gross pollutants.	Gross pollutant traps.
	80% reduction in TSS; 60% reduction in total phosphorous; and 45% reduction in total nitrogen.	Swales and buffer strips; Bioretention swales and basins; Sedimentation basins; Constructed wetlands; and Proprietary hydrodynamic separators.

These three design objectives may be met through the design and construction of the KBP using a combination of water treatment options in accordance with the *Water Sensitive Urban Design Technical Design Guidelines for SEQ* (BCC et al 2006). Consideration should also be given to the methods outlined in the *Road Drainage Design Manual* Chapter 4 and QUDM Chapter 11.

It is recommended that, where feasible, all permanent water quality treatment structures should be designed for the adequate control of discharge, pollution, and sediment in the 1-year ARI event and 100 year ARI event. Peak discharges for both these events should be limited to the undeveloped discharges.

5.4.2.2.2 Potential Mitigation Locations

Off Site Flow Management

Where possible, offsite flows should be kept separate from KBP drainage to minimise the size and quantity of detention and treatment. The exact location and type of water quality treatment devices will be finalised during the detailed design stage.

Centenary Motorway to Kenmore Road

The potential for detention of peak flows and water quality treatment could be provided in the infield area between the northbound off ramp from the Centenary Motorway and the KBP mainline. Alternatively, a hydrodynamic oil/grit separator or gross pollutant trap could be provided at the end of the pit and pipe network prior to discharge. Offsite “clean” water flows draining to the north that become trapped against the KBP could be conveyed by an open channel to a culvert under the KBP to discharge into the creek. The location for such devices should be chosen to provide adequate maintenance access.

Kenmore Road to Gem Road

The narrowness of the KBP corridor in this area precludes many types of WSUD. Stormwater flows discharge directly into the creek in Kingfisher Park from the pit and pipe network. The best options for water quality treatment here may be to provide a hydrodynamic oil/grit separator or gross pollutant trap at the outfalls prior to discharge into the creek. These could be constructed in the verge or in the park. The location should be chosen to provide adequate maintenance access.

Gem Road to Moggill Creek

The KBP will be constructed on fill as it nears Moggill Creek. Due to the proximity to Moggill Creek, oil spillage containment of 40,000 litres should be provided. There is the potential for detention or sedimentation ponds to be constructed in the area to the south of the KBP at the base of the batter slopes with an open table drain outlet to the creek. Potential maintenance access may be available from Yarawa Street.

Moggill Creek to Moggill Road Intersection

The Moggill Road intersection will be mostly drained by open channels. These channels should be constructed using the principles of WSUD, which include minimising slopes and providing adequate vegetation. If necessary, small check dams may be provided to flatten grades and minimise velocities.

Cross Drainage

The KBP will require either modification of existing, or construction of new, cross drainage culverts. Potential culvert crossings occur near the Centenary Motorway, Kingfisher Park, Moggill Creek and Moggill Road.

Consideration should be given to upstream and downstream conditions when improving or constructing new drainage crossings. The upstream side of the culvert should be checked for changes in afflux and the impact on surrounding structures. Upstream afflux should be evaluated for the total area of inundation to ensure it is entirely contained within the KBP corridor. Adequate freeboard should be given on the upstream side, with at least 100 mm freeboard between the designed flood level and the immunity levels of the adjacent Centenary Motorway, service roads and properties. Impacts and overland flow paths of large flows in excess of the project design storm should be considered.

Considerations should include the likelihood of debris blockage, relative elevation of adjacent property and the path of discharge overflows. In the absence of a clear overflow path the potential impacts of ponding upstream of the culvert should be determined. Upstream ponding should be evaluated for relative water levels and the extent and duration of the area to be inundated. Culverts that are not upgraded to current immunities should be evaluated for potential long term impacts. These impacts can include sediment deposition on the upstream side, increased times and areas of inundation and the potential impacts of ponded water on the KBP batters and retaining walls. Cross drainage should be designed following the standards outlined in the *Road Drainage and design Manual* and QUDM. All culvert outlets should be assessed to ensure that they have a lawful point of discharge.

5.5 Summary

5.5.1 Hydrology and Hydraulics

The potential impacts of the KBP on the hydraulic regime of Moggill Creek have been modelled and reported. The impact of the KBP alignment on Cubberla Creek require further investigation and is dependent on the final design of the KBP structure crossing Cubberla Creek, although the potential impacts are expected to be minimal. No direct impacts to the hydraulic regime of the Brisbane River have been identified.

Cubberla Creek

Key issues include:

- further investigation of the modelling of the existing Centenary Motorway crossing of Cubberla Creek (Sinclair Knight Merz 1996) for the 100 year ARI design event, which reports a discharge of 250 m^3/s at the crossing; and
- the degree of complexity of further investigation of the impact on flow and afflux, which will depend upon the final design of the KBP crossing of Cubberla Creek.

Moggill Creek

Based on the *Kenmore Bypass Hydraulic Impact Assessment Report* (AECOM 2009), the preferred option for the Moggill Creek crossing is a 325 metres bridge opening with the Moggill Road Option B alignment. This option was selected in the interests of maintaining the existing hydraulic regime (afflux, flood extent and water velocity). The preferred KBP option has been investigated with respect to the impacts on the hydraulic regime of Moggill Creek during local and regional flood events.

Key issues include:

- the extent of the afflux due to the alignment and bridge opening are localised to the floodplain adjacent to the road embankment with an anticipated maximum value of 0.16 metres. However, the afflux is generally below 0.02 metres.
- the encroachment of the eastern embankment of the KBP alignment into the floodplain adjacent to Moggill Creek leads to a decrease in floodplain volume and an associated small increase in afflux;
- the western abutment of the KBP Moggill Creek crossing cuts through a number of small tributaries from under Moggill Road that has been identified as requiring a potential fauna movement corridor; and
- modification of the waterways in the area surrounding the proposed western abutment with the requirement of detailed drainage design.

The following measures are suggested to assist in mitigating the potential impacts itemised above.

- further investigation of mitigation measures and optimisation of the Moggill Creek bridge opening of the KBP alignment during detailed design with respect to minimising afflux and construction costs;
- investigation of the reconfiguration of the KBP alignment and road embankment (elevation and batters) to minimise the displacement of floodplain volume, and hence afflux upstream of the proposed bridge site, by the eastern embankment adjacent to Moggill Creek; and
- development of an improved understanding of the existing drainage of the area in the vicinity of the western abutment/embankment, and incorporation of a design to facilitate an effective drainage solution and fauna passage.

Surface Water Drainage

The potential construction and operation impacts of the KBP include drainage from the KBP and the concentration of off site overland flows into the lower sections of Cubberla and Moggill Creeks and the Brisbane River. Present water quality within Cubberla Creek and Moggill Creek catchments are of a higher standard generally, meeting WQO under the *EPP (Water)*; however, the Brisbane River catchment is poor as indicated by the failure to meet several WQO. Further details can be Chapter 3 (Surface Water Quality).

Key issues identified for further investigation include:

- The KBP will cause changes to the existing drainage flow paths potentially creating a diversion of runoff to a different point of discharge than that currently occurring. It is recommended that existing catchment discharge rates be determined and capacities of downstream channels evaluated, with mitigation being provided for increased discharges to existing creeks and stormwater networks.
- The KBP will add a significant area of impervious pavement to a catchment presently in a mostly natural condition. Increases in imperviousness will cause an increase in the frequency and volumes of low flows which may result in a disruption to the downstream aquatic habitat without appropriate mitigation. It is recommended that detention is provided for increased frequency and volume of discharges for the 1-year ARI in accordance with guidelines set out in the WSUD technical manual.
- The increased imperviousness has potential to cause an increase in pollutant loads to the adjacent streams, creeks, and rivers. It is recommended that water quality mitigation of first flush runoff is provided for pavement surface drainage networks in accordance with guidelines set out in the WSUD technical manual.
- The increase in peak discharges for large events may cause downstream channel bank and bed erosion. It is recommended that detention is provided for the increased frequency and volume of discharges for the 100 year ARI in accordance with guidelines set out in the WSUD technical manual.
- The existing culverts under Sunset Road should be evaluated for their ability to convey increased flows from the KBP.

A summary of all the potential impacts and proposed mitigation measures can be found in Table 5.2.

This chapter has identified that potential risks to water quality due to the construction of the KBP are mostly related to the increase in imperviousness from the new pavement area. If the recommended mitigation measures outlined above are followed, the project will have a minimal impact on the adjacent waterways.

Table 5.2: Potential Impacts and Mitigation Measures

Reference Code	Project Phase	Potential Impact	Potential Mitigation Measures
HH 01	Design	The Moggill Creek bridge may impact the afflux, floodplain volume and drainage in the surrounding areas.	Further investigation will optimise the Moggill Creek bridge opening of the KBP alignment with respect to afflux and costs.
HH 02			Changes to the alignment of the eastern embankment within the Moggill Creek floodplain and the possibility of balancing culverts
HH 03			Investigation of displaced floodplain volume by the eastern embankment adjacent to Moggill Creek on afflux.
HH 04			Development of an understanding of the existing drainage of the area in the vicinity of the western abutment/embankment, and incorporation of a design to facilitate an effective drainage solution and fauna passage.
HH 05	Design	Afflux and/or increased scour potential along Cubberla Creek.	Further investigation of the impact of the KBP alignment on Cubberla Creek.
HH 06			Simple hydraulic calculations or modelling of the KBP structure at the point of Cubberla Creek crossing.
HH 07	Design	Worsening/interception of existing surface water drainage regime and suitable capacity/standard of new drainage networks.	New drainage works or modifications of existing drainage systems should be done in a manner that does not cause a worsening of the existing drainage regime on downstream owners and property.
HH 08			New outfalls should meet the requirements of QUDM Chapter 3.02 – Lawful points of discharge.
HH 09			Increases or decreases in peak discharges should be evaluated for their potential downstream impacts. The discharge impact assessment should include the change in the physical flow regime, changes to the environment including frequency of flow, pollutant loads, sedimentation, and the legal consequences of the increase in discharge at the inlet and outlet.
HH 10			Surface flows that are concentrated by an open channel or conduit should be controlled prior to discharge on a downstream system or owner. Concentrated flows should be dissipated by the use of detention or energy dissipaters.
HH 11			Outfalls that connect to existing culverts and pipe networks should include an analysis of the capability of the existing system to convey new flows. When required, detention should be provided to minimise the risk of surcharging an existing downstream system.

Reference Code	Project Phase	Potential Impact	Potential Mitigation Measures
HH 12			Drainage systems should be designed following the standards outlined in the *Road Drainage and Design Manual* and QUDM.
HH 13			Maintain separation between off-site surface water run-off and roadway drainage to minimise the size and volume of detention and treatment.
HH 14			Convey existing flows, trapped against the KBP, by an open channel to a culvert under the KBP to discharge into a nearby creek.
HH 15			First flush run off provided for in pavement surface drainage networks.
HH 16	Design	Release of gross pollutants in surface water flows discharging directly into nearby creeks.	Provision of hydrodynamic oil/grit separators or Gross Pollutant Traps (GPT) at surface water outfalls prior to discharge into creeks.
HH 17	Design	Release of hydrocarbon contaminants into nearby waterways.	Provision of oil spillage containment for 40,000 litres in detention or sedimentation ponds. Space is available to the south of the KBP at the base of the batter slopes by the Gem Road – Moggill Creek crossing.
HH 18	Design	High velocity run-off in open channels from the Moggill Road intersection.	Minimise slopes and provide adequate vegetation in the channels. If necessary, small check dams may be provided to flatten grades and minimise velocities.
HH 19	Design	Climate Change	Design of structure over Moggill Creek to consider climate change effects.
HH 20	Construction	Impingement on the Moggill Creek channel and adjacent floodplain.	Avoid, where possible, constructing new features (i.e. piers) in the main channel of Moggill Creek.