Upper Black Snake Creek Improvement Plan

A Total Water Cycle Management Approach to the Management of the Upper Black Snake Creek Catchment

FINAL REPORT
August 2014

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INTRODUCTION

The Black Snake Creek catchment in South East Queensland is located approximately 55 km south west of Brisbane and 17 km north west of Ipswich. Sponsored by the Ipswich City Council this Plan has been developed in conjunction with local representatives to address community concerns.

Water related issues in terms of flooding, rising salinity levels and declining water quality are impacting, or have the potential to impact significantly on the environmental, social and economic future of the region and the community of Marburg.

This Plan presents three separate but closely related action plans designed to build the resilience of both the landscape and the community. The three action plans presented are:

1. Local Flood Risk Mitigation
2. Salinity Mitigation
3. Landscape Restoration and Water Quality Improvement

The focus of this Plan is the upper catchment area which falls within the Ipswich City Council local government area although many elements of the action plans are applicable to the entire catchment (refer Figure 1). The Plan is preceded by numerous studies of the catchment and supported by a number of technical and investigative reports undertaken as part of the plan development which are presented as appendices to this document. The three key water related issues identified and their associated action plans all have important implications for both residents within the catchment and the broader community of South East Queensland. Table 1 summarises some of the key local and regional implications associated with each of the water issues.

Action can be initiated to mitigate the risks from flooding, salinity and water quality. This will require investment from the local community, business and governments within and outside the region. However this investment will ultimately save significant costs in the longer term through protecting existing land and infrastructure values and diminish the need for alternative infrastructure solutions.

This Plan provides a coordinated approach for this investment and importantly has been developed with input from key stakeholders with a vested interest in attaining the catchment improvements sought by the plan. It provides a strong basis for ongoing collaboration between these stakeholders in the further development and delivery of implementation actions.

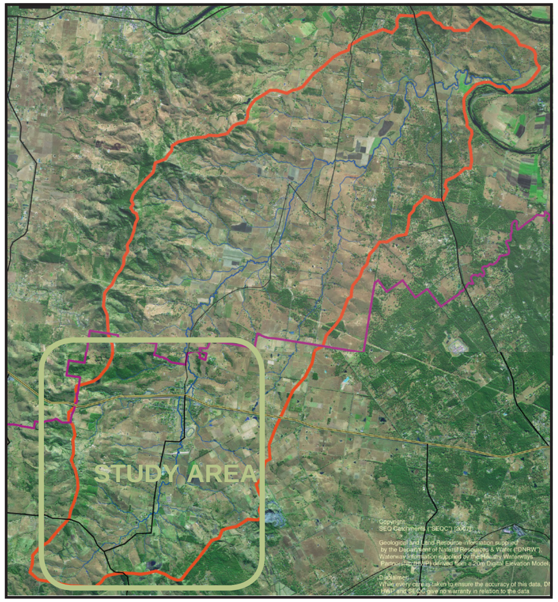

Figure 1 - the Plan's focus area is in the upper catchment area of Black Snake Creek (plan adapted from SEQ Catchments Ltd (2008))

Table 1 – Local and regional impacts associated with key water related issues

Issue	Local Impacts	Regional Impacts
Flooding	⁄ Loss of life ⁄ Human health risk ⁄ Property destruction ⁄ Diminished property values ⁄ Disruption of community activities ⁄ Disruption of business activities	⁄ Clean up costs ⁄ Impacts on regional transport infrastructure ⁄ Impacts on regional water supply
Salinity	⁄ Diminished agricultural production ⁄ Reduced land value ⁄ Impacts on local infrastructure ⁄ Loss of future economic opportunities	⁄ Cost of regional potable water supply ⁄ Impacts on downstream water based businesses ⁄ Reduced regional agricultural productivity
Water Quality	⁄ Human health risk ⁄ Loss of future opportunity ⁄ Impacts on stock ⁄ Loss of environmental amenity	⁄ Risk to regional potable water supply ⁄ Downstream environmental impacts

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RATIONALE FOR INVESTMENT IN THE BLACK SNAKE CREEK CATCHMENT

Issues related to environmental degradation in the Black Snake Creek catchment have been comprehensively studied and documented. Extensive clearing in the 19th century has created the basis for severe flooding, salinity and water quality issues. While the catchment is small in nature, the extent of its potential downstream impacts are significant. The catchment's location above and proximity to the Mt Crosby Water Treatment Plants that supply more than 50% of the capacity of the South East Queensland water grid means that investment of public and private funds in the catchment is both prudent and efficient.

A fundamental tenet of modern natural resource management is that of treating problems at their source rather than addressing symptoms. In this case for example, the option of treating the symptoms of historical land clearing in the Black Snake Creek catchment is demonstrably more cost efficient than managing the issues at the region's major water treatment plants.

Securing funding to address the water issues in the catchment will be of great benefit to the local community and can have multiple benefits in terms of water quality and salinity. In respect of public funding for flood mitigation works, it is recognized that significant public funds have already been expended in the catchment through the construction of a large food detention basin upstream of the Marburg township in 2002. The detention basin is credited by Marburg residents for protecting the town from significant flood damage during two recent extreme flood events in 2008 and 2011. It is unlikely that further public expenditure in the catchment on such large scale flood mitigation infrastructure will occur again. Investment in further flood mitigation works is therefore likely to be through local funding sources targeting specific hot spot issues such as local drainage deficiencies.

The catchment community is embracing the need for environmental restoration and the area is slowly moving away from its mostly denuded state thirty years ago. However the region requires external investment to accelerate the rate of restoration.

Any expenditure of public and private funds should aim to achieve the maximum outcome across a range of values and issues and be of benefit to the community at large. Expenditure in the Black Snake Creek catchment fulfils this and represents a significant return on investment to the population of South East Queensland.


Cleared floodplains and midslopes with remnant vegetation on the upper slopes


Detention basin spillway


Eroding waterways exposing saline groundwater


Stable sections of waterway providing shallow chain of pond habitats

Plate 1 - Images depicting current state of the Upper Black Snake Creek catchment

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DEVELOPING THE PLAN

A participatory planning process has been undertaken to develop this Plan which has focused on:

- developing a common catchment understanding
- developing and testing preliminary catchment management and investment actions with stakeholders
- developing a priority action plan to describe actions and implementation pathways to manage the understood issues in the catchment.

This plan is the start of the process to be taken forward by Council and the relevant stakeholders to achieve future improvements in flooding, salinity and water quality and landscape restoration in the Black Snake Creek catchment.

Figure 2 presents an overview of the process to date and identifies actions to be carried forward using the outcomes of this plan.

This process is also reflected in the structure of this report:

- Section 4 - Provides a summary of the catchment understanding
- Section 5 - Presents the preliminary action plans
- Section 6 - Presents the priority action plan and also provides an overview of how these could be taken forward.

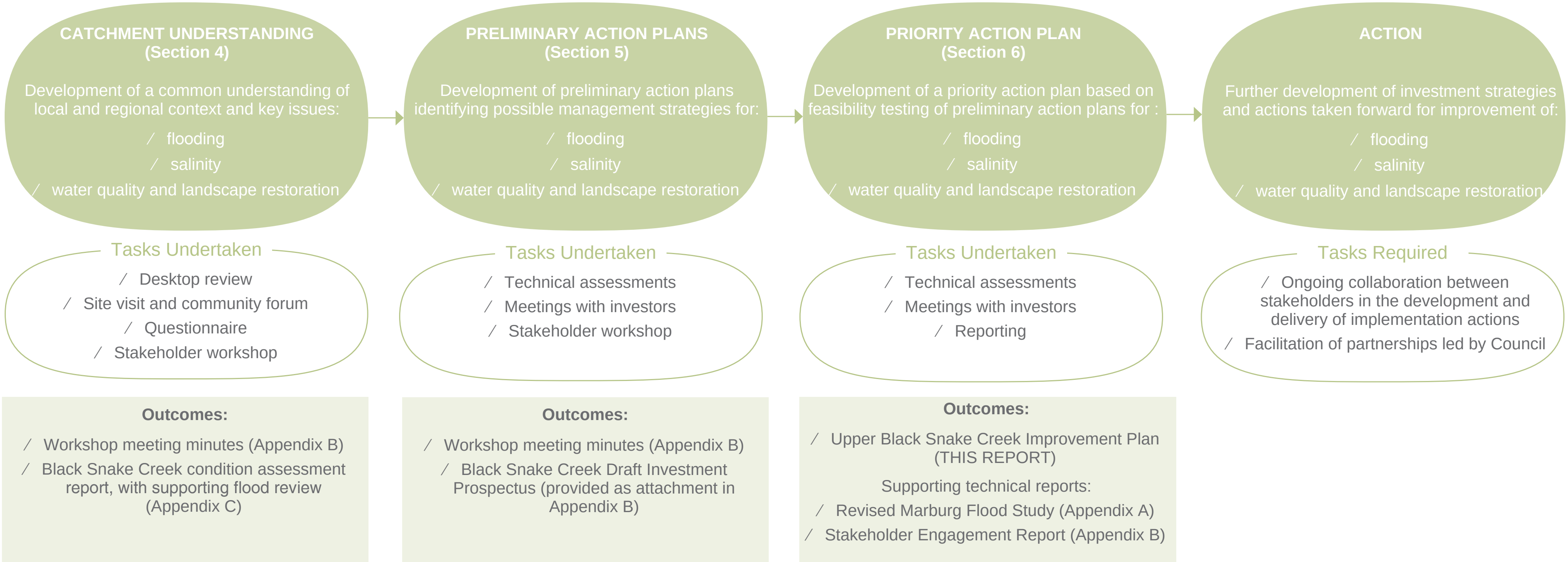

Figure 2 – Summary of the Upper Black Snake Creek Catchment Improvement Planning Process

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The Catchment in Context

4

THE CATCHMENT IN CONTEXT

This section of the report presents an overview of the catchment context, describing its location, historic natural condition and current setting. Section 5 describes the current catchment condition in more detail.

Black Snake Creek Location

The Black Snake Creek flows through the townships of Marburg, Glamorgan Vale and Fairney View before discharging to the mid Brisbane River above the Mt Crosby Weir (Figure 3).

The Mount Crosby Weir is the offtake point for the two major water treatment plants that provide more than fifty percent of the capacity of the South East Queensland water grid making salinity and water quality issues in the Black Snake Creek catchment regionally important.

The Black Snake Creek catchment is one of the closest catchments discharging into the Mount Crosby Weir pool meaning that detention times are short. Saline discharges from the catchment have previously required the weir pool to be flushed through additional discharges from the Wivenhoe Dam.

The catchment has been identified as a key risk to the operational continuity of the Mount Crosby Water Treatment Plants because of its salinity and pathogen loads.

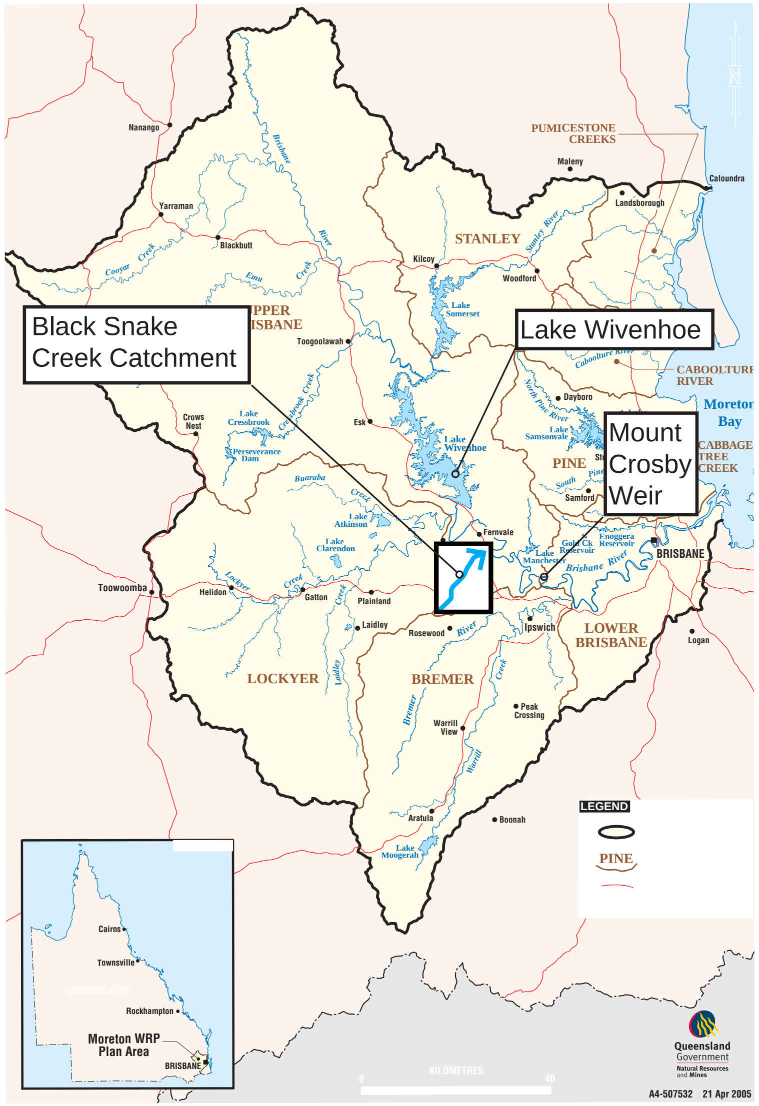

Figure 3 - Location of the Black Snake Creek catchment within the mid Brisbane River catchment area

(map adapted from Water Resource (Moreton) Plan map – available: http://www.nrm.qld.gov.au/wrp/pdf/moreton/moreton_map.pdf)

Black Snake Creek Catchment Historic Condition

The Black Snake Creek was recognised by traditional owners and early European settlers as a source of pure water. The catchment was historically covered by dense dry, rain and vine forests indigenous to the area (Rosewood Scrub). Vegetation consisted of small areas of hoop pine forests on the upper slopes, large areas of brigalow on the low and steep hills and blue gum forests on the alluvial flats closer to the creek (Figure 4). Vegetation across the catchment would have slowed run off, protected waterway habitats and managed groundwater levels. In its natural state the Black Snake Creek would have resembled a chain of ponds set within an actively engaged floodplain.

Geologically the Black Snake Creek catchment is part of the Clarence-Moreton Basin bounded by the Ipswich Fault to the east and the Esk trough to the north. Geological formations found in the catchment include Gatton Sandstone, Koukandowie Formation, Walloon Coal Measures, Basalt and Alluvium (Figure 5). In the higher areas of the catchment groundwater moves vertically through the catchment until it reaches the comparatively impermeable Walloon Coal Measures. At this point of contact the fresh ground waters move laterally to emerge as freshwater seepages. Salinity and salt loading in the catchment is most significantly associated with the Walloon Coal Measures. Seepages of saline groundwater occur on hillslopes where water flows from this geology layer encounter layers of rock with reduced permeability.

The shallow chain of ponds system found in the alluvium and typical of the catchment prior to large scale landscape modification would not have been deep enough to intersect the saline groundwater level.

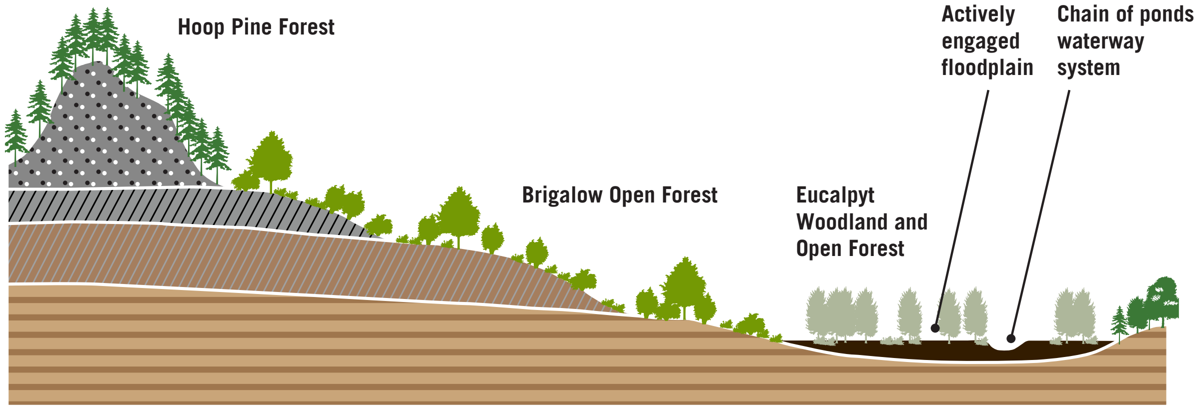

Figure 4 – Cross section of Black Snake Creek showing pre-disturbance vegetation and geomorphic condition

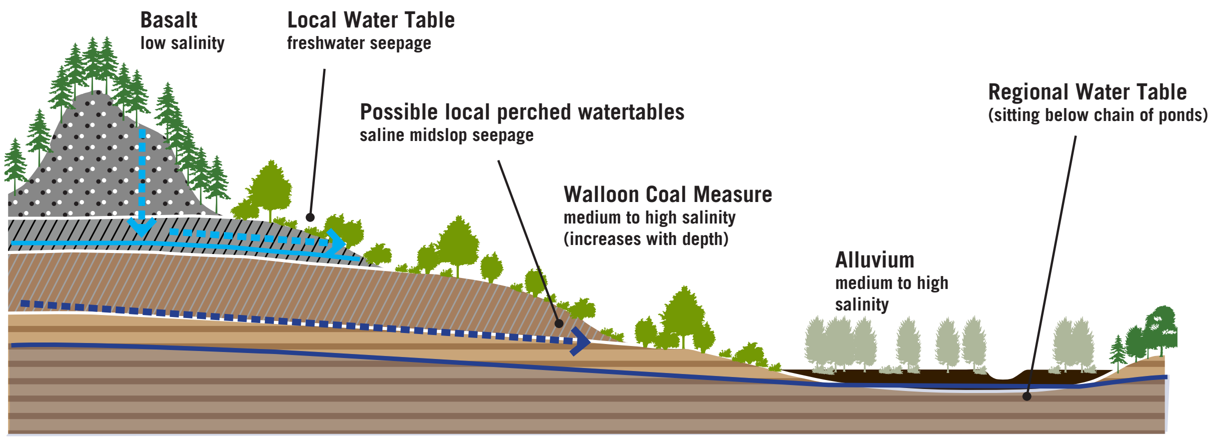

Figure 5 – Cross section of Black Snake Creek showing pre-disturbance geology and hydrogeology

Vegetation clearing in the time since European settlement for timber, cane, cropping, dairying and grazing has led to a highly modified landscape and many of the water related issues under examination in this Plan. Only small disconnected pockets of remnant vegetation remain in the catchment and are mostly restricted to the higher and steeper slopes.

Upper Catchment Setting

Landuse in the upper catchment is currently dominated by grazing. Other current landuses include rural residential, urban and other agricultural activities. The vast majority of the catchment is in private ownership. The catchment is broadly zoned as township and rural in the Ipswich City Council Planning Scheme. Within the urban designation there is some scope for further residential development. A transitional area on the southern edge of the township has been set aside for equestrian related rural living activities. Within the rural zoning there are areas to the east and the west of the township designated as rural living.

The economy of the region has traditionally been dominated by agricultural pursuits. The decline in the regional dairying industry has led to the majority of land now being used for grazing and rural lifestyle purposes with those landholders seeking productive returns achieving limited and variable outcomes. Many residents now commute regularly to Ipswich and Brisbane for employment. Population growth within the Ipswich City Council area is likely to have a significant impact on the township and the rural landscape. The population of Ipswich is predicted to increase from its present level to 435,000 people by 2031 (according to the SEQ Regional Plan). This population growth is likely to place greater demands on the Black Snake Creek Catchment to provide opportunities for rural living, recreation and small scale agricultural activities such as poultry, turf, nurseries, kennels and horse related activities.

Marburg, the main township in the area covered by this Plan, is home to approximately 560 people. While the average age of residents is 37, the 2011 Census identified Marburg had a higher percentage of seniors and lower percentage of younger residents when compared to other areas across Ipswich. Less than half the population is currently in the workforce. More than 80% of residents are property owners. In the 2011 Census it was reported that more than one third of residents were not living in the township five years ago with most new residents relocating from elsewhere in the Ipswich City Council area.

Marburg is partly located within the Black Snake Creek floodplain. In 2002 a large flood detention basin was constructed on Black Snake Creek upstream of Marburg to reduce the impact of flooding on the town.

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Preliminary Action Plans

Preliminary Action Plan 1
Managing Local Flood Risk

Investment Driver:

To address catchment hydrology and stormwater infrastructure deficiencies contributing to local flooding

Assets at Risk:

- Marburg township
- Roads and other infrastructure

Outcomes Sought:

- Community flood readiness (Community Flood Plan as part of Council's Marburg Disaster Management Sub-Plan)
- Optimising existing flood storage and conveyance infrastructure
- Extension of lifespan of existing infrastructure
- Removal of current system blockages
- Future development in appropriate areas

Investors and Stakeholders:

- Ipswich City Council
- Department of Transport and Main Roads
- Landholders
- Department of Local Government Community Recovery and Resilience

OVERVIEW OF THE FLOODING ISSUE

Marburg has experienced a number of recent flood events in 2008, 2009, 2011 and 2013. The 2008 and 2011 events were considered significant events whereas the 2009 and 2013 events were only moderate events.

The two major flood mechanisms that affect Marburg are creek flooding and overland flow. Creek flooding is caused when the passage of floodwater down a catchment exceeds the creek channel capacity. Overland flow flooding occurs when the capacity of local stormwater drainage infrastructure is exceeded by storm runoff.

The Upper Black Snake Creek catchment can be divided into three sub-catchments based on the topography and tributaries. These are the main channel, the eastern tributary and the western tributary. These sub catchments are shown in Figure 6.

The following sub-sections describe the flooding behaviour within each of the three sub-catchments and detail specific key investigation areas within each sub-catchment to address known flood problems.

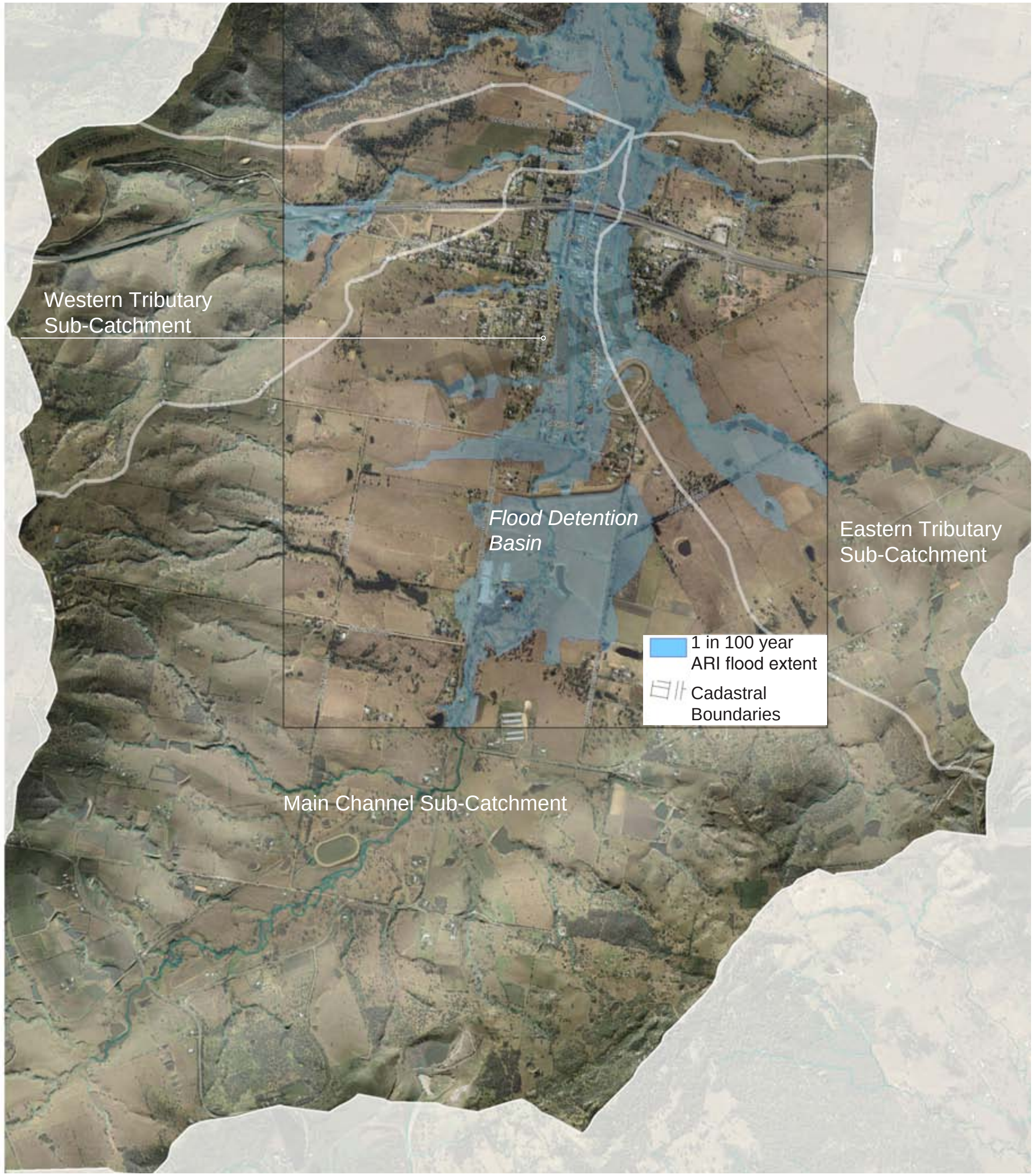


Figure 6 – Map showing flood sub-catchments, detention basin location and adopted 1 in 100 year ARI flood extent

Main Channel Sub-Catchment

The main channel sub-catchment is estimated to have a critical duration of 2-4.5 hours to the detention basin (Parsons Brinkerhoff 2012). The critical duration at a location in the catchment is the duration of storm that results in the greatest flood depth at that location.

Critical flood mechanisms are influenced by several man-made and natural structures. The first of these structures is the detention basin immediately upstream of the township of Marburg, completed in 2002. The detention basin has a capacity of 1145 ML (1.145 x 106 m^3) to the overflow spillway level and is designed to attenuate (reduce) the flood peak associated with a 100 year ARI (Average Recurrence Interval) flood event such as the flood of 2011 for example. Smaller more frequent flood events pass through the detention basin with only limited attenuation.

The detention basin employs a bank of culverts (4 x 1800 mm diameter concrete reinforced pipes) located in the base of the detention basin and an overflow spillway to control the rate of release of flood waters from the basin. The discharge capacity of the culverts is approximately 75 m^3/s before the overflow spillway is engaged. The peak outflow from the detention basin in the 2011 flood event was estimated to be 128.3 m^3/s (Parsons Brinkerhoff 2012) and comprised of 78.3 m^3/s discharged through the bank of culverts and 50 m^3/s over the spillway. The detention basin discharges to a trapezoidal engineered channel 1.5 m deep on average and approximately 50 m wide which conveys flows north through the township of Marburg. This channel has an estimated capacity of 65 m^3/s which can be exceeded in more extreme floods such as the 2011 event where the discharge from the detention basin was double the channel capacity.

The November 2008 storm event was estimated to be between a 20 and 50 year ARI event. Community responses indicate significant flooding occurred within the township with at least two buildings being inundated and several properties being flooded. The flooding from Black Snake Creek is likely to have been exacerbated by backwater effects of the Edmond Street bridge, with floodwaters breaking out of the creek, bypassing the bridge culverts and flowing down Edmond Street and likely meeting floodwaters from the eastern tributary. The combined flows then propagate down Queen Street and re-join the main channel near the Warrego Highway.

The predicted detention basin behaviour in the 2008 event is displayed in Figure 7. This shows the detention basin effectively attenuated the peak flow from approximately 170 m^3/s to 70 m^3/s. This attenuation ensured a lower maximum flow rate and reducing the risk and consequences of the flooding.

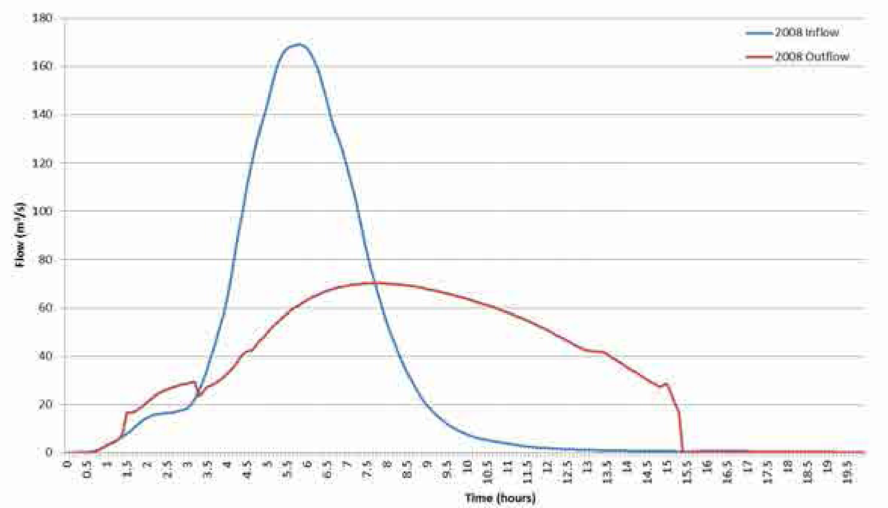


Figure 7 – Predicted attenuation achieved due to the detention basin in November 2008

The basin outflows slightly exceeded the estimated channel capacity and are in excess of the Edmond Street bridge capacity. The flood impacts in Marburg would have been much more severe in the 2008 flood event, particularly as the peak occurred in the night, if the detention basin was not in place.

The heaviest rainfall totals within the Ipswich City Council local government area were recorded in Marburg during the January 2011 flood event. These totals are comparable with and in some areas exceed those of Grantham in the Lockyer Creek. The 2011 event is estimated to be in excess of a 100 year ARI event for the upper catchment. Significant flooding occurred in Marburg as a result of backup of floodwaters behind the Edmond Street bridge and break-out flows from the eastern tributary as with the 2008 flood event. The detention basin again helped reduce the impact of the flood event on the township. It has been estimated that it attenuated flows from 230 m^3/s to 120 m^3/s (Figure 8).

Another man made structure which influences flooding in the main channel sub-catchment is the Edmond Street bridge which is located mid distance along the engineered channel and has an estimated design capacity for only the 2 year ARI flood event. Because of this limited capacity, the bridge forms a known and significant flow obstruction along the flood channel, causing flows to backwater behind the structure and culverts. Anecdotal evidence gathered suggested that vehicles (with the exception of a tractor) were unable to cross the bridge in 2011 due to both the depth and velocity of the floodwaters presenting a potential hazard to people and vehicles.

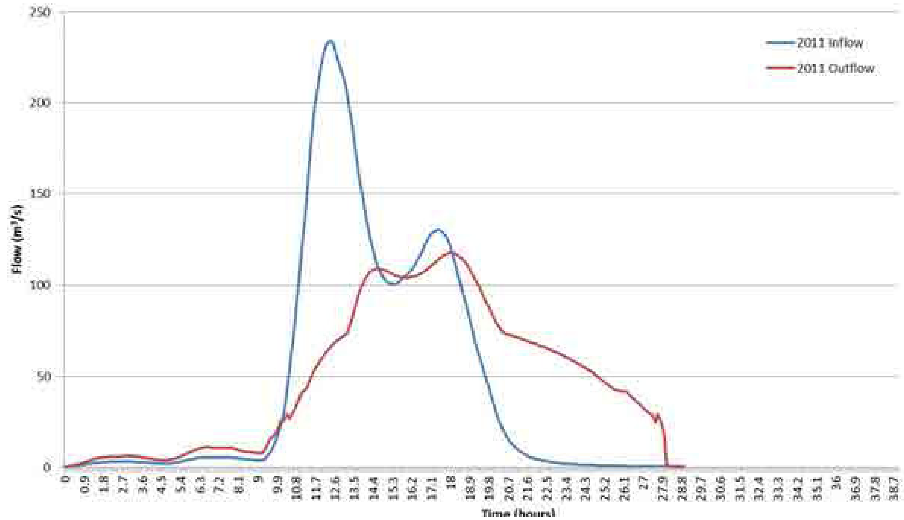


Figure 8 – Predicted attenuation achieved due to the detention basin in January 2011

Flood waters then break out before the bridge and flow over Queen Street before joining the eastern tributary near Kennedy Street. This exacerbates flooding in the eastern tributary and low lying land south of the Warrego Highway with properties on Queen Street being affected from all sides with floodwater.

Downstream of the Edmond Street bridge the floodwater propagates north under the Warrego Highway and meets both the eastern and western tributaries in low lying open land west of George and Queen Streets.

Main Channel Sub-Catchment Investigation Areas

There are 2 key investigation areas within the main channel sub-catchment:

1. Investigation Area 1 - channel and flows downstream of the detention basin
2. Investigation Area 2 - Edmond Street bridge

The location of these investigation areas are shown in Figure 9 and described in the following pages.

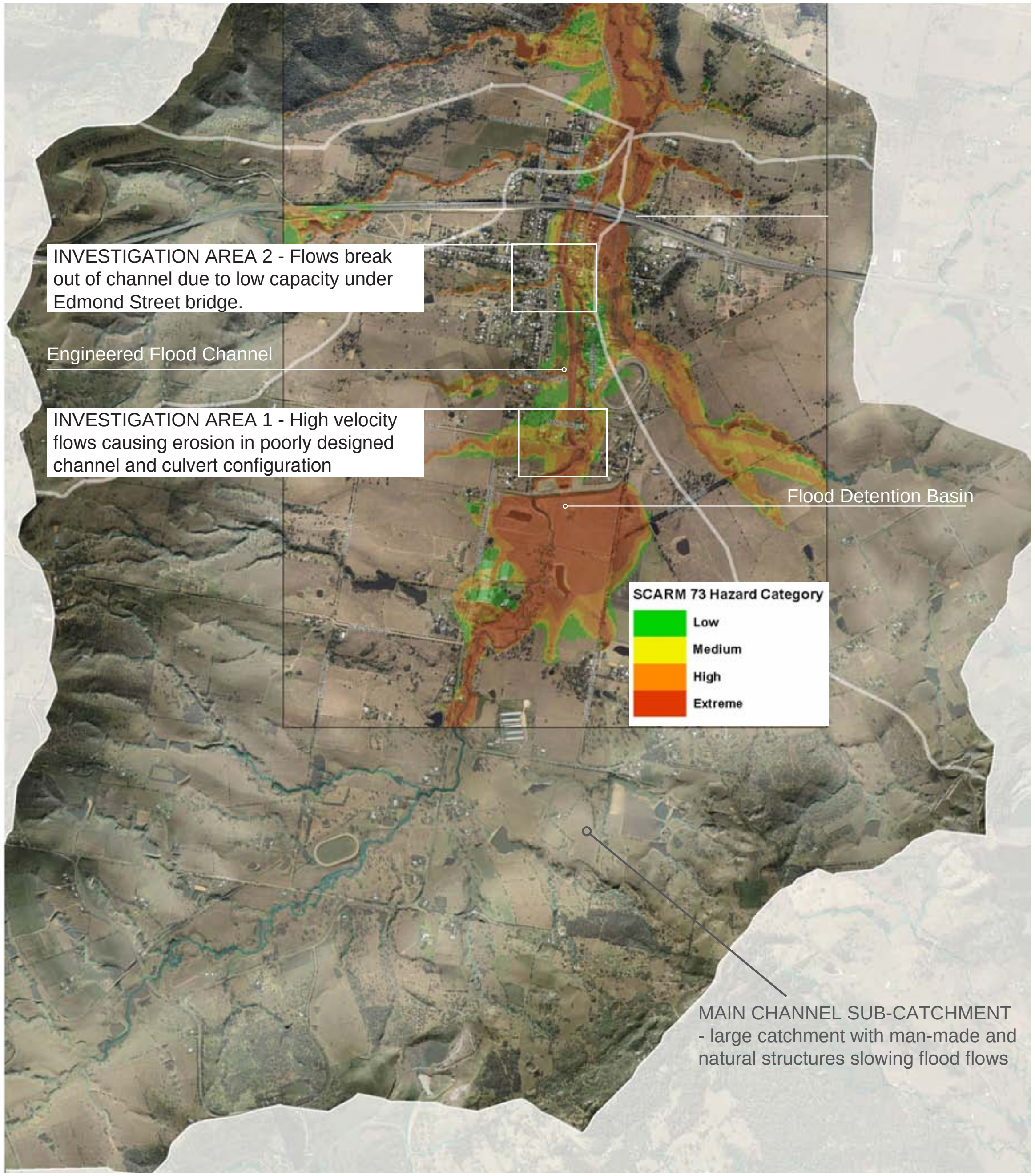


Figure 9 – Flood risk issues and key investigation areas in the main channel sub-catchment

Key Investigation Area 1: Corner of Rosewood-Marburg Road and Queen Street

Description of flooding behaviour

- The detention basin releases flows into the engineered channel at high velocity (approximately 1.5 m/s in the 100 year ARI + Climate Change 2100 scenario (CC2100) and 1.1 m/s in the 5 year ARI.
- The topography of the creek bed dictates a 90° turn upstream of Rosewood-Marburg Road.
- The indirect route currently taken by flood flows entering the culverts under Rosewood-Marburg Road and the suboptimal alignment of the culverts relative to the direction of flow is causing excessive energy losses immediately upstream of the culverts with consequential erosion impacts (observed) and is likely to be resulting in more frequent inundation of Rosewood-Marburg Road than should be the case.
- The high velocity and tight turn induces erosion on the eastern bank of the channel and has established an active headcut in the channel bed.

Discussion

- Anecdotal evidence also suggests that the western culvert is not utilised effectively during flood events. This is supported by modelled velocities in this area. This issue is also illustrated on the flood hazard mapping indicating low hazard through the culvert in the 100 year ARI + CC2100.
- There is anecdotal evidence that indicates that significant erosion debris is transported and deposited on the road surface.
- If left unmanaged, the active headcut erosion will in time progress and impact the detention basin outlets.

Possible Mitigation Measures

- **Channel and culvert re-alignment** - This mitigation measure would require the redirection of the channel to flow northwards to the main engineered channel not east toward the bend. It would also require the re-alignment of the culverts under Rosewood-Marburg Road. At present the culvert alignment is thought not to be hydraulically optimised.
- **Erosion control** - Current bed and bank erosion should be addressed as part of the channel and culvert works addressed above. In the event that these works are delayed or do not happen, there is an immediate need to implement grade control structures to address the risk of further progression of the existing headcut erosion towards the detention basin. Bank stabilisation works also need to be undertaken on the eastern bank (e.g. laying back banks and rock armouring). These mitigation measures could minimise soil erosion from the bed and eastern bank of the creek before the culverts. It could also minimise sediment deposited on the road surface. Erosion control would manage and minimise a symptom of the channel layout but not address the cause.

Key Investigation Area 2: Edmond Street Bridge

Description of Flood Behaviour

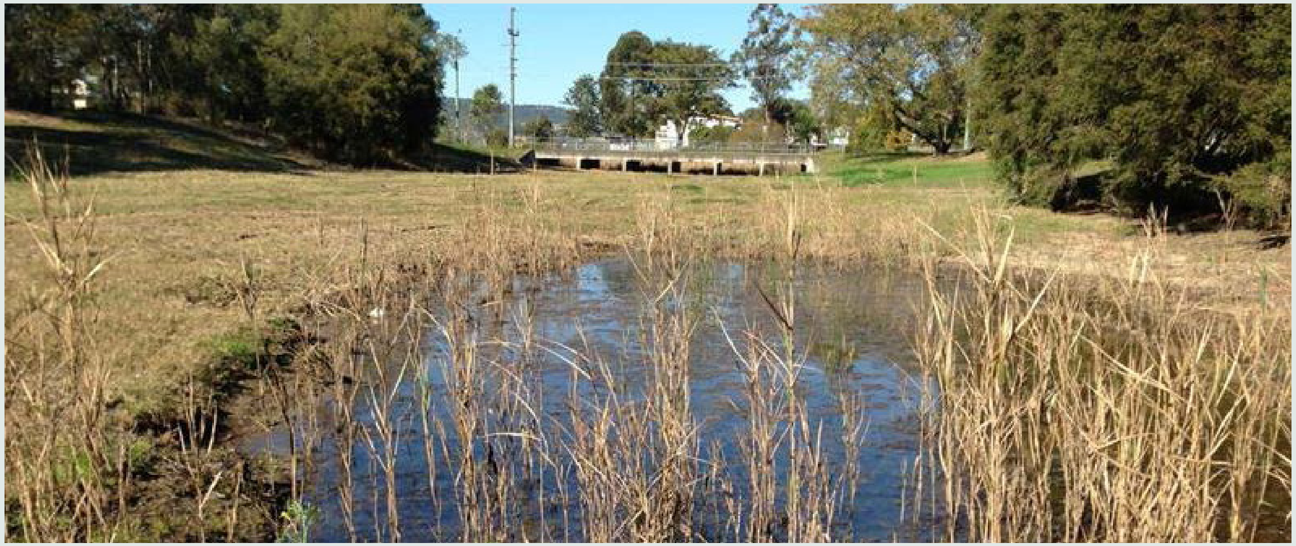
- In the 100 year ARI + CC2100 flood event, floodwaters from the detention basin flow downstream through the engineered channel running parallel to Queen Street until the Edmond Street bridge. The floodflow remains largely within both the engineered and natural channels until the bridge.
- The bridge consists of 6 x 1200 x 300 Reinforced Concrete Box Culverts (RCBC) (dimensions from Council). However inspection using site photo and Google Earth suggests the culverts are larger and they are estimated to be 6 x 3800 x 1000 RCBC. Based on this an estimation of the culvert capacity is 50 m^3/s. 2 year ARI flows are estimated to be 44 m^3/s and 5 year ARI flows 52 m^3/s. Therefore the Edmond Street bridge's flood immunity is estimated to be less than the 5 year ARI.
- As the capacity of the culverts is exceeded, floodwater backs up and breaks out both south of Edmond Street near lot 90 and north near the playground and shed off Queen Street. The breakout flows east though the centre of town to meet the eastern tributary.
- Flow from a minor tributary upstream of Moriarty Lane joins the Black Snake Creek directly upstream of the bridge. The culvert under Moriarty Lane has been estimated as 600 mm diameter. It is expected that this minor tributary experiences backwater effects when water is backed up behind Edmond Street bridge.

Discussion

- The bridge is a major control structure and the low flood immunity causes significant impacts through the town
- Mapping of flood hazard for the 100 year ARI + CC2100 design flood event shows that the extreme hazard category is largely confined to the main channel of Black Snake Creek. The resulting breakout flow from the low flood immunity of the bridge structure results is a high hazard on Queen Street, with model results estimating velocities of up to 1.4 m/s. However the estimated flood depths remain low, typically less than 0.5 m in the Q100+CC2100.

Possible Structural Mitigation Measure

- **Increase capacity under the bridge** - The effective width under the bridge and hence the ability to increase the flow underneath is a function of the surrounding topography. Edmond Street is low-lying between Main and Kennedy Streets and a bridge upgrade would likely require the redesign of Edmond Street between these two points. The upgrade of Edmond Street in itself could cause embankment effects on flooding unless pared with other mitigation measures in this area. This option has been considered previously but discounted as prohibitively expensive.
- **Optimise the benefits provided by the existing detention basin** by investigating the practicality and feasibility of making minor adjustments to the basin's storage and discharge characteristics to gain greater control of smaller floods to reduce the frequency of flows breaking out of the downstream engineering channel and exceeding the capacity of the Edmond Street Bridge.



Eastern Tributary Sub-Catchment

The eastern tributary's sub-catchment is approximately four times smaller than the main channel sub-catchment and has a critical duration of 1-2 hours to Marburg. The tributary has no formal attenuation and flows through predominately flat land. The only major flow controls are the culverts under Edmond Street and the Warrego Highway. Anecdotal evidence suggests that the culvert capacity under Edmond Street was exceeded in the 2008 and 2011 flood events with water depths reported in the area of up to 1 m deep in 2008 to a property on Edmond Street. In 2011 it was reported that there was around 200 mm of floodwater across Edmond Street which was flowing very fast.

Anecdotal evidence also suggests that during the construction of the Warrego Highway, the area upstream of the highway was used to deposit excess fill. This placement of fill has encroached upon the eastern tributary's floodplain storage and is restricting the passage of flows to the culvert under the Warrego Highway. This is causing flood flows to be directed towards properties along Queens Street.

Key Investigation Area 3 examines these issues as shown in Figure 10 and described in the following section.

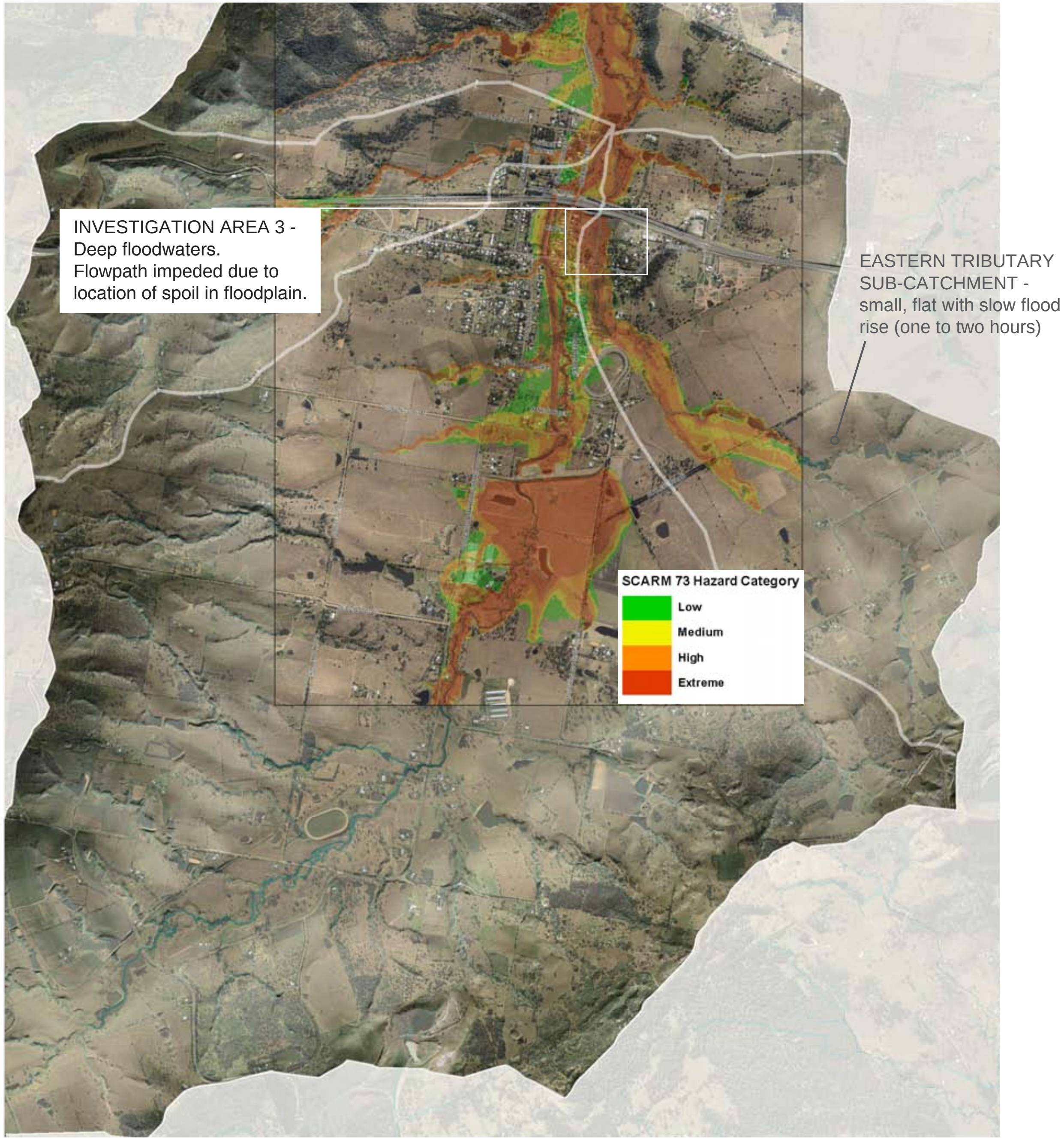


Figure 10 – Flood risk issues and key investigation area in the eastern tributary sub-catchment

Key Investigation Area 3: South of Warrego Highway, near Edmond and Kennedy Streets, including eastern side of Queen Street

Description of Flooding Behaviour

- Flooding is caused by eastern tributary catchment runoff and breakout flow from Black Snake Creek. Floodwaters initially enter the area though culverts under Edmond Street and flow north to the Warrego Highway. Due to the lack of hydraulic gradient the floodwaters fan and pond directly south of the highway. The culverts have been estimated from photographs at 5x900 mm diameter.
- As the capacity of the culverts under Edmond Street is exceeded, floodwaters from the Eastern Tributary break out on the western side of 63 Edmond Street. It is estimated these culverts have a capacity less than the 5 year ARI.
- It is well known that the flood immunity of the main Edmond Street bridge (See Key Investigation Area 2), is low and as floodwaters break out from behind the bridge they merge joining with floodwaters from the eastern tributary.

Discussion

- High hazard categorisation in this area is largely due to the depth of the floodwaters rather than velocity. The flood model does however indicate that flow is significant over Edmond Street in the area of the culverts (100 year ARI + CC2100)
- The model results indicate that properties in close proximity to the eastern tributary are inundated. Survey points are required to confirm this as building flood levels are not included.

Possible Mitigation Measures

- **Channelise Eastern Tributary**- This option would see the flow path north from the Edmond Street to the major culvert under the Warrego Highway more clearly defined. Review of the digital elevation model (DEM) indicates a large mound of earth in the middle of what once may have been the flow path. This mitigation measure may reduce flood extent north of Edmond Street, reducing the impacts on nearby properties on Queen Street as well as Edmond Street. Through channelisation, the flood flow could travel with reduced impediments out to the confluence with Black Snake Creek.
- **20 metre width riparian remediation** along the eastern tributary upstream from the Marburg showgrounds. This option involves increasing the hydraulic roughness of the eastern tributary floodplain through riparian vegetation plantings to reduce flood conveyance and increase flood storage with the intended benefits of delaying the arrival and reducing the peak flow rate of flood flows at the Edmond Street culverts. Preliminary hydraulic model investigations (refer attached Flood Study Report) indicate a 20 m width of riparian remediation along the eastern tributary when combined with channel improvement works between Edmond Street and the Warrego Highway can reduce the depth of flooding through the eastern parts of Marburg in frequent flood events (<5 yr ARI) (refer Appendix A - Flood Study Report).

Western Tributary Sub-Catchment

As the smallest and steepest of the three sub-catchments, the western tributary is highly channelised in the upper reaches (unlike the eastern tributary) and has very short critical duration (less than an hour). Flows in this area rise and fall faster than the other two sub-catchments. The corollary of this is that although flows are quite ‘flashy’, floodwater would retreat relatively quickly unless significant backwater effects from Black Snake Creek were acting on the tributary. The rate of rise and potentially high velocities near James, George and Queen Streets poses a considerable hazard to people and property. This corroborates with experience of flooding expressed by local property owners.

The tributary has minor storage and attenuation as the channel widens west of George Street. After propagating over George Street and through low rectangular culverts, the channel moves through a grassed drainage easement between George and Queen Streets. The easement has very limited capacity, with dwellings closely neighbouring the flow path. Culverts underneath Queen Street channel flow east to join Black Snake Creek. The Queen Street roadway acts as a minor embankment.

Key Investigation Area 4 examines these issues as shown in Figure 11 and described in the following section.

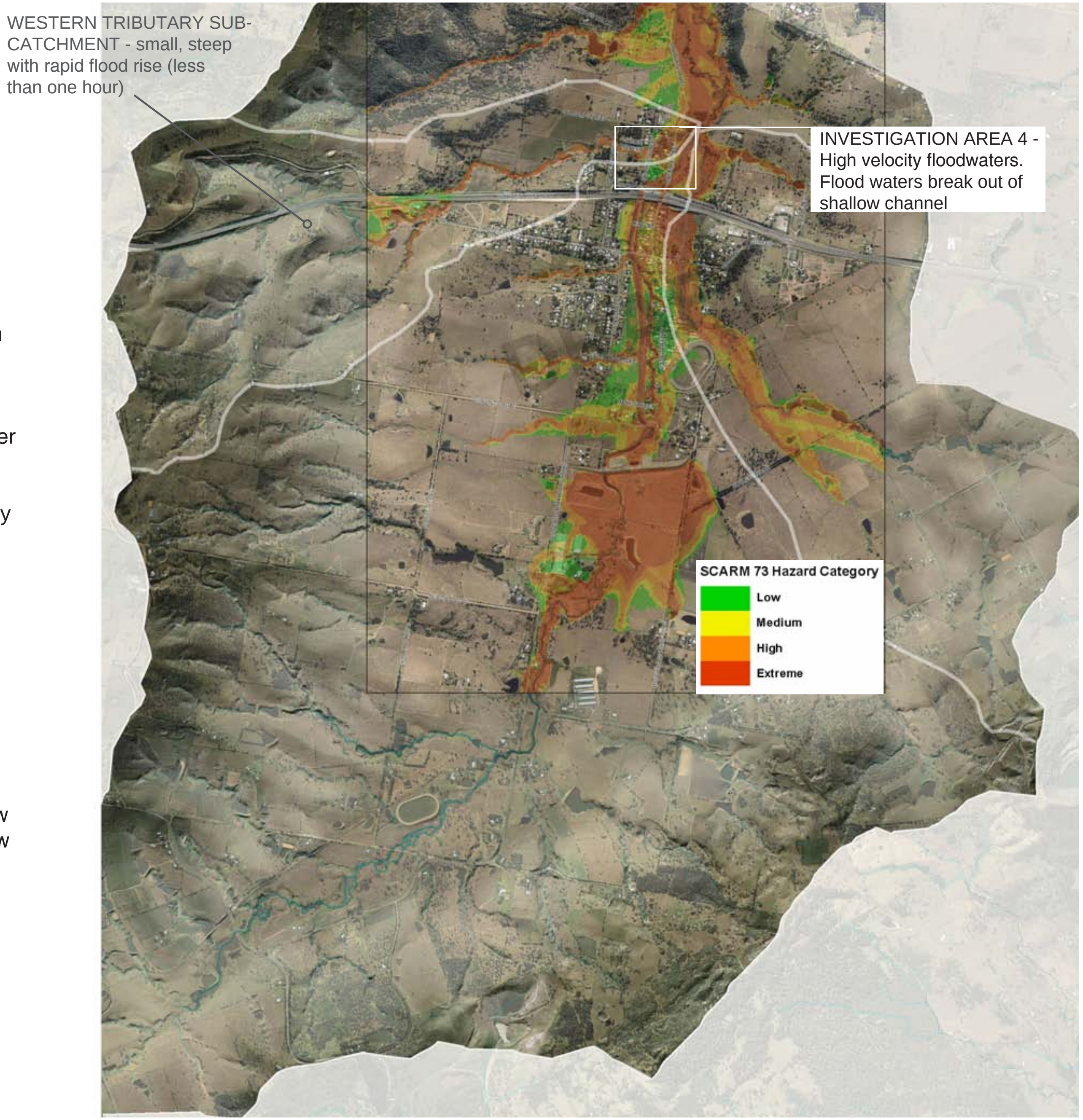


Figure 11 – Flood risk issues and key investigation area in the western tributary sub-catchment

Key Investigation Area 4: North of Warrego highway, near George and James Streets

Description of flood behaviour

- Flooding of property and buildings attributed to western tributary catchment runoff and not Black Snake Creek.
- Catchment is comparatively steep, resulting in peak level at James Street 2 hrs after the onset of the 100 year ARI, 3 hour duration storm.
- As the upper reaches of the catchment are channelised, flooding largely remains in creek upstream of James Street.
- As the local topography flattens out downstream of James Street, the channel banks become very flat. The channel/easement downstream of James Street is really only a minor depression. As a result, floodwaters fan out to shallower depths (less than 0.7 m deep out of bank in the 100 year ARI + CC2100). Floodwaters cross Queen Street before joining Black Snake Creek.
- The area contains high flood hazard (100 year ARI + CC2100) which extends out of the easement and surrounds several properties posing a potential risk to people and property.

Discussion

- Velocities are high (greater than 1.5 m/s in the 100 year ARI + CC2100 and approximately 1 m/s in the 5 year ARI event.
- Although hazard and velocity in this area are high, floodwaters begin to retreat before the peak in Black Snake Creek, typically after 3 hours in the 100 year ARI + CC2100.
- Houses are largely raised above peak flood levels in this area of town, reducing potential damage due to flooding.
- The culvert under Queen Street has been estimated at 600 mm diameter. The capacity of this culvert is exceeded in events greater than the 5 year ARI.

Possible Mitigation Measures

- **The western tributary could be diverted** north of William Street to join Black Snake Creek in a newly constructed flood relief channel. This could potentially reduce the flood risk to people and property in the area. However, it should be noted that the lack of hydraulic gradient and open topography suggest that any flood relief channel would have to be large and deep enough to minimise breakout flows. The channel would in some aspects act as a detention basin, retaining and attenuating flows. Preliminary hydraulic model investigations (refer attached Flood Study Report) indicate a constructed flood relief channel can significantly reduce the extent and depth of flooding in the north west of Marburg but would require significant earthworks and associated costs with only a small number of benefited properties.

FLOODING PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Develop Marburg Community Flood Plan	The purpose of the flood plan is to ensure that in a future flood event the community is sufficiently warned, prepared and knows what actions to take.	⁄ Ipswich City Council ⁄ Community Groups and Members ⁄ State Government Departments	⁄ Reduced risk to community members	⁄ Community unprepared in future flooding event ⁄ Potential loss of life	⁄ This action is low cost and can be undertaken as part of a broader Ipswich City Council community resilience program.
Optimise existing detention basin and outlet to moderate smaller flows	The detention basin outlet has been designed to manage (attenuate) only large infrequent flood flows. More frequent floods pass through the basin with little reduction in the flood peak and exceed downstream culverts. This action investigates if the detention basin outlet can be modified to improve the basin performance for more frequent floods whilst preserving the performance for large infrequent floods.	⁄ Ipswich City Council ⁄ State Government	⁄ Reduction in small scale local flood events	⁄ Ongoing impacts from moderate flood events	⁄ Preliminary hydraulic model investigations indicate it will be difficult to reconfigure the existing detention basin to improve its performance in moderating frequent nuisance flooding in Marburg without impacting the basin's performance for mitigating the impacts of infrequent extreme flood events (refer attached Flood Study Report). ⁄ Consequently this action has not been taken forward into the priority action plan.
Replace inadequate culverts and infrastructure	Several culverts transferring flood flows were considered to be undersized and should be replaced where practicable and cost effective. Critical weaknesses at Queens Street bridge, Edmond Street and Louisa Street.	⁄ Ipswich City Council ⁄ State Government (DTMR)	⁄ Reduced levels of local flooding	⁄ Ongoing impacts from moderate flood events	⁄ Replacement of undercapacity culverts and infrastructure should be investigated and where practicable and cost effective, upgraded. ⁄ Preliminary hydraulic model investigations indicate the low lying topography may limit the effectiveness of culvert and bridge crossing upgrades (refer attached Flood Study Report).

FLOODING PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Remove existing blockages to flood flow on eastern tributary	During highway construction spoil was deposited in an area which blocks flows from the eastern tributary of Black Snake Creek and contributes to local flooding.	⁄ Department of Transport and Main Roads (via letter to Premier's office) ⁄ Ipswich City Council	⁄ Reduced localised flood impacts	⁄ Ongoing impacts from moderate flood events	⁄ Investigations have shown that this option can help provide minor flood mitigation benefits that are largely confined to the lower order flood events. Due to the flat topography of the area, it is unlikely these works will result in significant improvements in flood reduction in higher order flood events. ⁄ It is recommended that this action is undertaken by DTMR as rectification of their previous actions in placing spoil within a watercourse/flowpath.
Undertake revegetation of midslopes areas and along the riparian corridor of the eastern and western tributary to slow flood flows	Lack of vegetation in the catchment increases volume and velocity of flood water. Investment should be sought to reestablish vegetation in key areas and delivered through an investor-landholder-facilitator partnership. Additional investment to be sought through environmental offsets.	⁄ West Moreton Landcare ⁄ SEQ Catchments ⁄ Landholders	⁄ Reduced volume and velocity of flood waters ⁄ Improved amenity ⁄ Improved water quality	⁄ Ongoing flood impacts in Marburg	⁄ Preliminary hydraulic model investigations (refer attached Flood Study Report) indicate a 20 m width of riparian remediation along the eastern tributary when combined with channel improvement works between Edmond Street and the Warrego Highway can reduce the depth of flooding through the eastern parts of Marburg in frequent flood events (<5 yr ARI). ⁄ Revegetation on private property will likely require financial and planning incentives combined with planning and/or commercial protection of works undertaken.

FLOODING PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Re-alignment of upstream channel and culverts at Rosewood-Marburg Road to reduce the frequency of flooding and address existing erosion	Channel works are required to remove current sharp bend to direct flows to culverts in a more efficient manner. As part of these channel works, realignment of the culverts under Rosewood-Marburg Road is also required to improve hydraulic efficiency. The existing bed and bank erosion also needs to be addressed to protect and maximise the utility and lifespan of the upstream detention basin which represents a significant public investment. The abovementioned channel works would likely address this issue. However, if this is not undertaken in the near future, the erosion issues will need to be addressed separately.	⁄ Ipswich City Council ⁄ SEQ Catchments ⁄ Landholders ⁄ DTMR	⁄ Improved hydraulic efficiency of channel and culverts ⁄ Extension of detention basin utility and lifespan ⁄ Reduced sediment loads in waterway	⁄ Continued more frequent flooding of Rosewood-Marburg Road. ⁄ Sub optimal asset utility and life span for detention basin.	⁄ These works will have multiple benefits, including the protection of a vital and valued public asset in the upstream detention basin and can be co-invested to share costs across stakeholders.
Planning Scheme regulations to avoid inappropriate development within flood constrained areas	Areas of 'as-of-right' development exist in flood prone areas within Marburg. Council should seek to implement a transferable development right program to ensure that inappropriate development does not occur. Mechanisms such as no loss of flood storage and conveyance and the setting of minimum habitable floor levels above the adopted flood regulation line are other planning mechanisms to control development in flood prone areas.	⁄ Ipswich City Council ⁄ Landholders	⁄ Appropriate development in flood prone areas	⁄ Further development within flood prone area	⁄ The current Ipswich City Council Planning Scheme makes provision for avoiding inappropriate development in floodprone areas and allows for the implementation of a transferable development right program.

FLOODING PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Flood relief channel on western tributary	Potential to divert flows through a channel developed in old flow line to move flood waters away from properties.	⁄ Ipswich City Council ⁄ Landholders ⁄ State Government	⁄ Reduced localised flood impacts and risk to residents	⁄ Ongoing impacts from flood events	⁄ Preliminary hydraulic model investigations (refer attached Flood Study Report) indicate a constructed flood relief channel can significantly reduce the extent and depth of flooding in the north west of Marburg but would require significant earthworks. This is likely to be at a significant cost which may not be justified given the relatively small number of affected properties, the majority of which are elevated. Whilst this action is unlikely to be fully publically funded, it may be implemented under a co-investment model or fully privately funded.

Preliminary Action Plan 2
Salinity Mitigation

Investment Driver: To reduce regional and local impacts (costs) of increasing catchment salinity in a location where there is community and Council support providing security of investment to ensure real outcomes can be achieved

Assets at Risk:

- Regional water supply quality
- Regional water quality dependent industries (e.g breweries)
- Productive lands of Black Snake Creek valley
- Transport infrastructure

Outcomes Sought:

- Restored productive local lands
- Improved regional water supply quality
- Geomorphologically restored creek system
- Improved land management practices
- Landscape restoration benefits (e.g. carbon lock-up)

Investors and Stakeholders:

- Seqwater
- SEQ Catchments
- Landholders
- Queensland Urban Utilities
- Ipswich City Council
- Australian Government
- West Moreton Landcare

OVERVIEW OF THE SALINITY ISSUE

The Black Snake Creek catchment has been identified as an area suffering significantly from salinity. Wide-scale historical clearing from the late 1800s has contributed to the ongoing salinity issue. Salinity impacts directly on the local community through reduced opportunities for agricultural production, declining land values and damage to existing infrastructure. Highly saline water leaving the catchment and entering the mid Brisbane River impacts on the operation of the water treatment plants which supply more than 50% of water to the greater Brisbane area. Available management responses to increasing salinity in the existing conventional water treatment plants are limited and even small variations in the electrical conductivity of the final potable water produced can impact severely on industrial and medical final users.

Many studies have investigated the salinity issues in the mid Brisbane River catchment area, including Black Snake Creek. Changes in land uses within the catchment since the late 1800s, such as land clearing and farming, have altered the landscape vegetation cover and hydrology. This has also contributed to the salinity problems across the catchment (Watkinson 2013). Ellis & Bigwood (2006) identified and mapped 654 ha of land affected by severe salinity using field inspections, terrain analysis and aerial photograph interpretation (Figure 12).

Figure 12 also highlights the relationship between salinity issues and the alluvium across Black Snake Creek. Surface salinity in the flat alluvial plains is generated by shallow water tables which have a high concentration of dissolved salts (Ellis & Bigwood 2006).

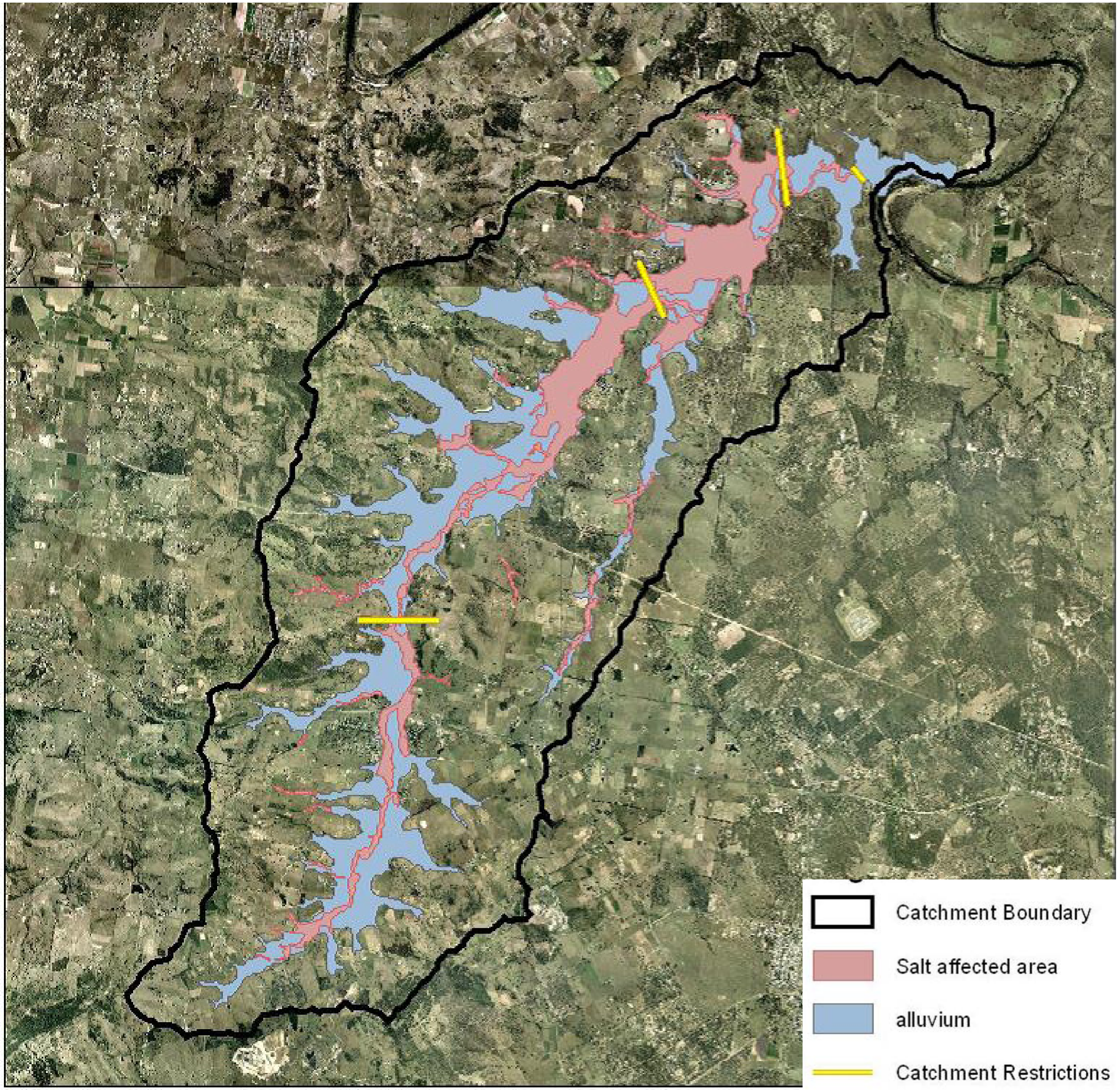


Figure 12 - Location map of salt affected areas within Black Snake Creek Catchment (from Ellis and Bigwood, 2006)

Monitoring of groundwater levels in the catchment indicates a rising trend in groundwater levels at nearly all of the sites monitored in the catchment (RPS 2011 and data from Bob Hampson).

The 2013 paper, Brisbane River Groundwater identified that the 2011 Brisbane floods had a major effect on groundwater in relation to salinity issues in the mid Brisbane catchment. It is understood that during the drought Black Snake Creek's groundwater levels were too low to produce groundwater seepage and therefore there was very little input of brackish or saline water to Lockyer Creek or Brisbane River (Watkinson 2013). However, during this time of limited groundwater recharge (prior to 2011), it is understood that pumping of the alluvium within the catchment continued for use on-farms and resulted in the lowering of groundwater levels to a level which caused upwards discharge of bedrock water into the alluvium (Watkinson 2013). Following the floods in 2011, the groundwater levels rose upwards causing the brackish or saline water to connect with the alluvial creeks, allowing saline groundwaters to mix with surface waters that flow into the Brisbane River (Watkinson 2013). This was a unique situation where a combination of limited groundwater recharge and continued extraction lowered the groundwater table to a level where saline inflows into the alluvium groundwater occurred and resulted in a pulse of salinity surface flows once recharge occurred in 2011.

The geology of the catchment also results in catena form salinity processes occurring in the alluvium. Catena salinity occurs when groundwater discharge occurs on lower slope positions where the impermeable soils of the alluvium restrict water movement. The geology in the mid slopes also results in saline seepages when groundwater which has passed through the Walloon Coal Measures discharges to the surface.

Figure 13 shows the primary salinity mechanisms within the Upper Black Snake Creek catchment – Basalt form salinity on the upper slopes, saline mid-slope seepage and catena form salinity within the alluvium of the valley floor (Ellis & Bigwood 2006). Of these mechanisms, Basalt form salinity does not appear to be contributing significant salt outbreaks, with the mid-slope and catena form salinity in the valley floor considered to be responsible for the greatest salt loading within the upper catchment. This assumption was confirmed by site observations made in August 2013.

Key actions to combat existing and future salinity issues revolve around lowering groundwater tables and minimising the opportunity for saline groundwater to enter the freshwater system.

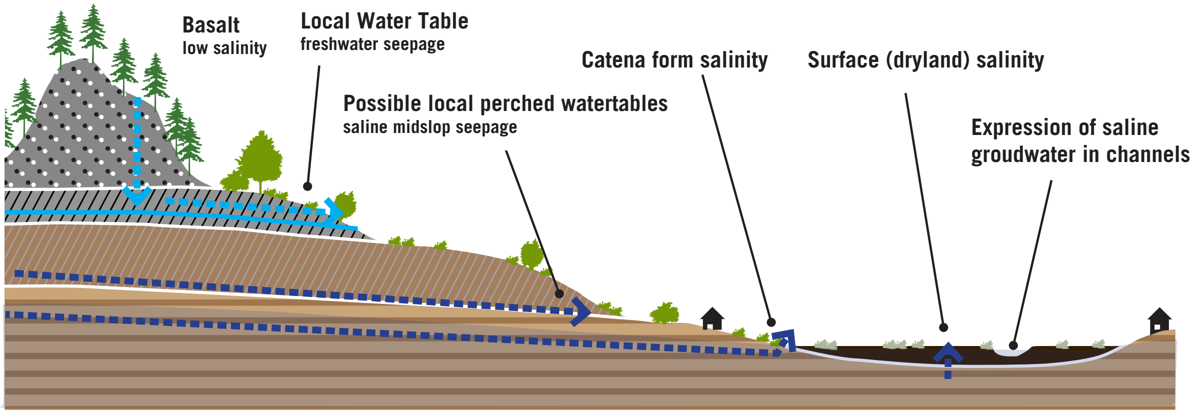


Figure 13 – Salinity processes in Black Snake Creek Catchment

SALINITY PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Artificial lowering of shallow groundwater table and re-use of brine	Investigate options to lower shallow groundwater table artificially to prevent land salinisation in locations of highest vulnerability. Salt interception schemes are large-scale groundwater pumping and drainage projects that intercept saline water flows and dispose of them, generally by evaporation. In the Murray Darling Basin there are 18 salt interception schemes currently operating. At the Buronga groundwater salt interception scheme salt collection from evaporation ponds is harvested by SunSalt in commercial quantities.	⁄ Seqwater ⁄ SEQ Catchments ⁄ Landholders ⁄ Ipswich City Council	⁄ Lowered groundwater ⁄ Lessening of salinity outbreaks ⁄ Improved water quality	⁄ Ongoing loss of productive land ⁄ Continuing risk to regional water supply	⁄ The required engineering technologies and land area for disposal need to be further investigated and costed to inform more detailed feasibility assessments. ⁄ This action does not address the issue of long term, hydrologic balance and would provide a short-term solution only and not applicable during extended drought conditions.
Restore deep rooted trees	Deep rooted vegetation will play a key role in lowering groundwater. This is a long term solution which addresses the hydrologic balance but requires suitable scale and also requires successful establishment and maintenance of the vegetated areas to be successful. This revegetation can be delivered through an investor-landholder-facilitator partnership. Additional investment to be sought through environmental offsets.	⁄ Seqwater ⁄ SEQ Catchments ⁄ Landholders ⁄ West Moreton Landcare ⁄ Ipswich City Council ⁄ Somerset Regional Council	⁄ Lowered groundwater ⁄ Lessening of salinity outbreaks ⁄ Improved water quality ⁄ Reducing surface runoff volumes and velocities ⁄ Improved visual amenity	⁄ Ongoing loss of productive land ⁄ Continuing risk to regional water supply	⁄ Revegetation of private property will likely require financial and planning incentives combined with commercial and/or planning protection of works undertaken.
Undertake geomorphic restoration of creek channel	Steeply incised areas of the Black Snake Creek have the ability to intercept saline groundwater areas. Restoration works should be informed through the development of natural channel designs for the works which are developed based on an understanding on the cause of the erosion. These works can be delivered through an investor-landholder-facilitator partnership. Additional investment to be sought through environmental offsets.	⁄ Seqwater ⁄ SEQ Catchments ⁄ Landholders ⁄ West Moreton Landcare ⁄ Ipswich City Council	⁄ Reduced salinity levels in Black Snake Creek ⁄ Improved water quality ⁄ Bed and bank stability ⁄ Improved creek habitats ⁄ Improved visual amenity	⁄ Increasing salinity levels in Black Snake Creek ⁄ On-going bed and bank instability resulting in sediment loading in creek.	⁄ Restoration works on private property will likely require financial and planning incentives combined with commercial and/or planning protection of works undertaken.

SALINITY PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Develop landholder guidebook for salinity and water quality management	The purpose of the guidebook is to build the capacity of landholders to reduce salinity risk through landscape management. Key components to include grazing land management and the management and construction of farm dams.	⁄ West Moreton Landcare ⁄ Seqwater ⁄ SEQ Catchments ⁄ Ipswich City Council ⁄ Somerset Regional Council	⁄ Improved landholder capacity ⁄ Improved vegetation coverage ⁄ Reduced risk from new farm dams intercepting saline groundwaters	⁄ Continuation of management practices leading to land degradation	⁄ This guidebook can be easily developed based on a range of existing guidelines, including the “Salinity management handbook” (DERM, 2011).
Community landscape asset vision	To develop a shared vision for the Black Snake Creek catchment landscape that recognises it as a valued asset that accords with regional environmental values.	⁄ West Moreton Landcare ⁄ Ipswich City Council ⁄ Landholders ⁄ Seqwater	⁄ Improved landscape asset value that accords with regional environmental values ⁄ Shared understanding of future condition and expected outcomes	⁄ Continual poor perception of landscape values ⁄ No clear and common direction for future works in catchment	⁄ This vision can be developed in conjunction with the development of an updated Community Plan for Marburg.
Community capacity building program	Develop and deliver training to build capacity for landscape regeneration activities (e.g. green army).	⁄ SEQ Catchments ⁄ West Moreton Landcare ⁄ Ipswich City Council ⁄ Commonwealth Government ⁄ Landholders ⁄ Seqwater	⁄ Enabled community to undertake landscape regeneration activities	⁄ Limited resources to undertake actions	⁄ There are a number of active and passionate community groups in the region who could help lead this with financial support.
Encourage landholder planting and preservation of existing vegetation on private lands	Provide landholders with suitable tree species (e.g. salt tolerant) under Councils Free Tree Scheme and encourage protection of existing vegetation under Council’s Bushland Conservation Scheme.	⁄ SEQ Catchments ⁄ West Moreton Landcare ⁄ Ipswich City Council ⁄ Landholders ⁄ Seqwater ⁄ Somerset Regional Council	⁄ Engaged community ⁄ Revegetation / protection of endemic species ⁄ Improved scenic amenity	⁄ Lack of resources and support for landholders	⁄ This can be done making use of existing Council resources.

Preliminary Action Plan 3 Landscape Restoration and Water Quality Improvement

Investment Driver: To reduce water quality impacts at the local and regional level

Assets at Risk:

- Human health
- Regional water supply quality
- Environmental amenity
- Recreational opportunities
- Commercial operations

Outcomes Sought:

- Local and regional water quality risk reduction
- Local human health
- Restored and more productive mid slope lands
- Stabilised drainage system in local areas

Investors and Stakeholders:

- Seqwater
- SEQ Catchments
- Landholders
- Queensland Urban Utilities
- Ipswich City Council
- West Moreton Landcare

OVERVIEW OF THE LANDSCAPE RESTORATION AND WATER QUALITY ISSUES

Water quality monitoring data gathered from the Black Snake Creek shows elevated levels of pathogens (E. coli and Enterococci), nutrients, total suspended solids and total dissolved solids. This is typical of an un-sewered catchment with mostly agricultural land uses. Poor water quality is a risk to local and regional aquatic ecosystems, the economic value of industry reliant on healthy waterways, and human health.

The proximity of the Black Snake Creek catchment to the Mount Crosby Water treatment plants and the lack of a physical barrier such as a major water storage (i.e. dam/weir) to increase detention time means that the catchment is considered a key risk to the safety of the regional water supply. Seqwater works under direction of the Australian Drinking Water Guidelines which demand a multiple barrier approach to the management of risk. Pathogens and viruses are regarded as the highest risks to human health. The catchment is regarded as the first barrier to protecting potable water quality with the logic being that viruses and pathogens should be limited where possible from initially entering the water source.

Septic systems operating in a frequently flooded, saline landscape are at risk of early structural and operational failure with commensurate environmental impacts. It is therefore important that landholders have a good understanding of how these systems are operating and that they are maintained and managed appropriately.

Queensland Urban Utilities works under the South-East Queensland Water (Distribution and Retail Restructuring) Act 2009, Water Supply (Safety and Reliability) Act 2008, Environmental Protection Act 1994, and the Water EPP 2009. These prescribe standards for the operation of wastewater systems including licensed discharge criteria for protection of waterway environmental values. Whilst not currently supported in the legislation, bubble licenses (a single discharge license that includes multiple operations) and water quality offsets (the trade in units of pollution reduction between two or more parties) are currently being considered by the State Government. Despite the current lack of reticulated sewerage networks in the catchment, under these arrangements, Queensland Urban Utilities may be able to employ water quality offsets and bubble licenses to achieve environmental optimisation across its wastewater systems.

The reduced catchment vegetation cover as well as the creation of catchment impoundments (e.g. road crossings, on-line dams and detention basin) has influenced the flow dynamics and sediment transport in the upper catchment, creating a dominance of valley fills (Figure 14) (Brierley and Fryirs, 2005; Brooks et al, 2003). These valley fills have likely evolved due to a reduction in vegetation cover increasing the availability of sediment and an increase in runoff flow volumes increasing the amount of sediment entering waterway corridors. Once sediments are transported to the waterway corridor, impoundments on most waterways cause sediment to build up in the valley thus reducing the ability of sediments to move through the system. This creates a build-up of sediment on the upstream side of the impoundments. On-line dams attenuate small-medium flood peaks, reducing flood velocities and volumes in the channel, reducing transport capacity. Impoundments may change the local base level of the waterway, initiating vertical aggradation immediately upstream (dam deltas; see page 211, Brierley and Fryirs, 2005).

The valley fills are highly prone to incision. Incision is caused in the catchment due to a number of factors, including:

- the over steepening of channel grades through the straightening of the channel
- reduction in sediment supply due to numerous dams and impoundments
- road infrastructure installed below the bed level causing head cut erosion
- limited /absence of floodplain and riparian vegetation, reducing channel roughness and bed and bank stability, and an increase in run-off volumes and velocities.

There are some areas of the catchment where the valley fills are still intact (generally on the mid-slopes). These systems are not very resilient to erosion however (Figure 15) and should be protected from incision and further degradation through riparian planting and stormwater and overland flow management. It is possible that a chain of ponds morphology will naturally develop with the reinstatement of appropriate riparian vegetation in these areas.

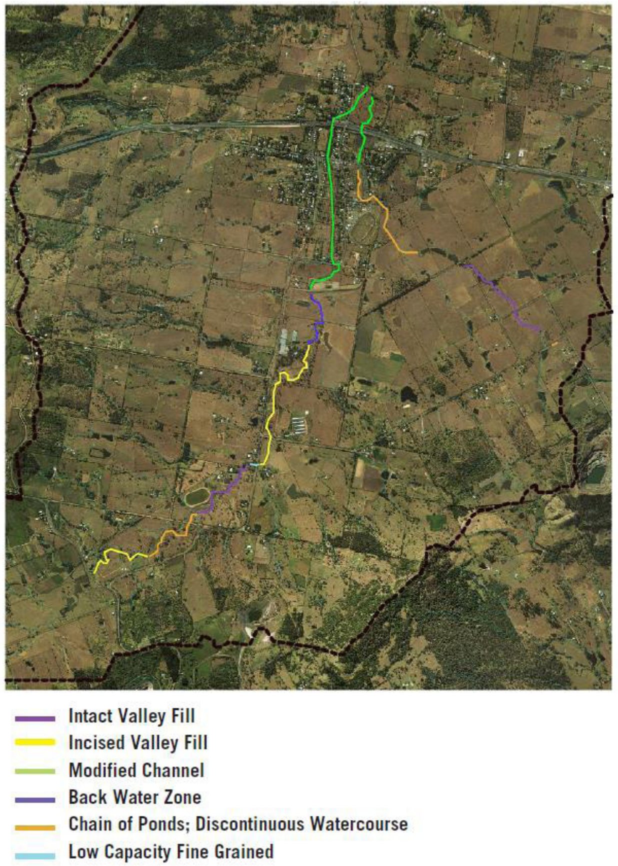


Figure 14 - Current geomorphic condition of Black Snake Creek waterways

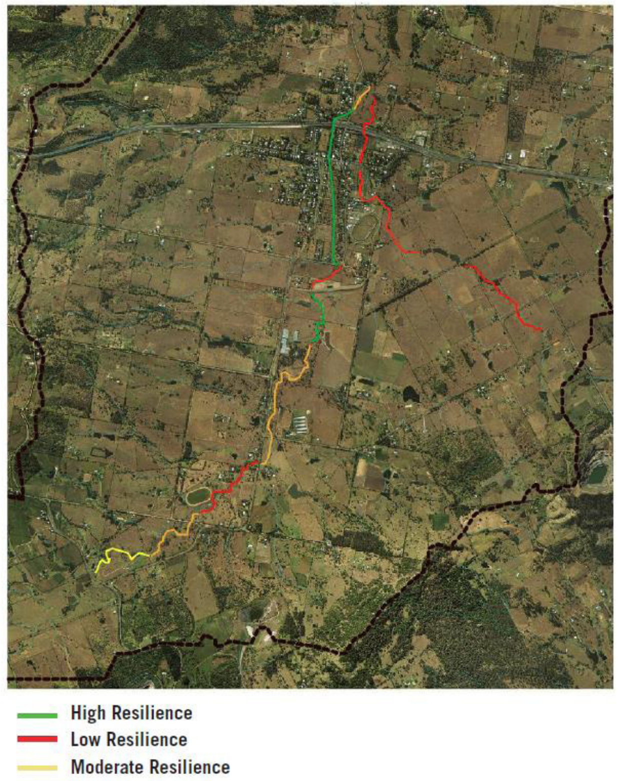


Figure 15 - Overview of assessed Black Snake Creek waterways and their resilience

The areas already undergoing incision are considered to have moderate resilience. It is unlikely that the incision has reached a hard boundary, and as such has the potential to incise further. However, in most instances, upstream propagation of incision is somewhat limited (in the short term) due to road crossings, flood detention dams and farm dams. It should be noted however, that the erosion head downstream of the flood detention basin poses a significant risk to the functionality of the outlets in the flood detention basin, as well as to the stability of the basin wall itself. Mitigation should be undertaken as soon as possible whilst there is still sufficient area to undertake works within the channel.

The trapezoidal engineered channels in the downstream reaches, are considered to be the most resilient to change. These sections are over widened and have a large capacity for flood flows. These channels are likely to promote deposition given sufficient sediment supply. However, with limitations in sediment supply throughout the catchment, in-set low-flow channel development may occur. These channels have limited geomorphic diversity.

There is limited groundwater data available for the Black Snake Creek catchment. A review of available data by RPS (2011) identified the electrical conductivity for five bores ranged from 9661 μS/cm to 55000 μS/cm with mean and median values of 22302 and 13370 μS/cm respectively. No groundwater quality information was available for bores within the outlying parts of the catchment rim (i.e. basalt caps).

Community water quality monitoring is occurring on three waterway reaches within the Upper Black Snake Creek Catchment. RPS (2011) also undertook some snapshot surface water sampling in the upper catchment in 2011. In summary, this monitoring data have shown that the waterways are alkaline and saline. The electrical conductivity for the three monitoring sites ranged from 1730 μS/cm to 21800 μS/cm. Initial snapshot monitoring undertaken by RPS also recorded electrical conductivity values in this range. Subsequent snapshot monitoring however by RPS after approximately 130 mm of rainfall (which would have produced appreciable stream flow) recorded much lower electrical conductivity values (between 236 μS/cm and 930 μS/cm). These measurements highlight how rainfall and creek flow dilutes the salinity levels in the surface water. However during this time, these flows move quickly into the Brisbane River.

Council has also undertaken microbial contamination and source tracking investigations for the Upper Black Snake Creek catchment (on 30th October 2012 and 6th March 2013). Monitoring sites were both within the Marburg township area and upstream. The primary purpose of these samples was to test for faecal contamination levels and to conduct microbial source tracking to identify potential origins of contamination as being either human, animal or waterfowl (gull) in both dry (October 2012) and wet conditions (March 2013).

The results from the six microbial samples showed very high concentrations of E. coli and Enterococci at many of the sites in the catchment. There was no significant pattern associated with rainfall and creek flows, with some of the sites having elevated levels and some recorded lower contamination levels. In both sampling events however, all contamination was traced mainly to animal sources, with two sites recording small concentrations of waterfowl (gulls) microbes during March 2013. No sites recorded contamination associated with humans suggesting no septic leaks at the location or time of sampling. The limited nutrient data sampled by RPS (2011) identified levels of nitrogen and phosphorus above recommended guideline values. It is understood that Seqwater also undertake water quality monitoring of Black Snake Creek at the end of the catchment (monitoring point at Farnie Brook Bridge on the Brisbane Valley Highway). This monitoring includes monthly water quality profiles for turbidity, conductivity, temperature, dissolved oxygen and pH and ongoing telemetered measurements of some parameters and a water level gauge.

Figure 16 summarises the key water quality risk issues across the Black Snake Creek catchment area. Key actions to address these issues involve restoring landscape functionality in key areas of the catchment such as in the mid slopes and riparian areas and protecting existing areas of high value landscape functionality.

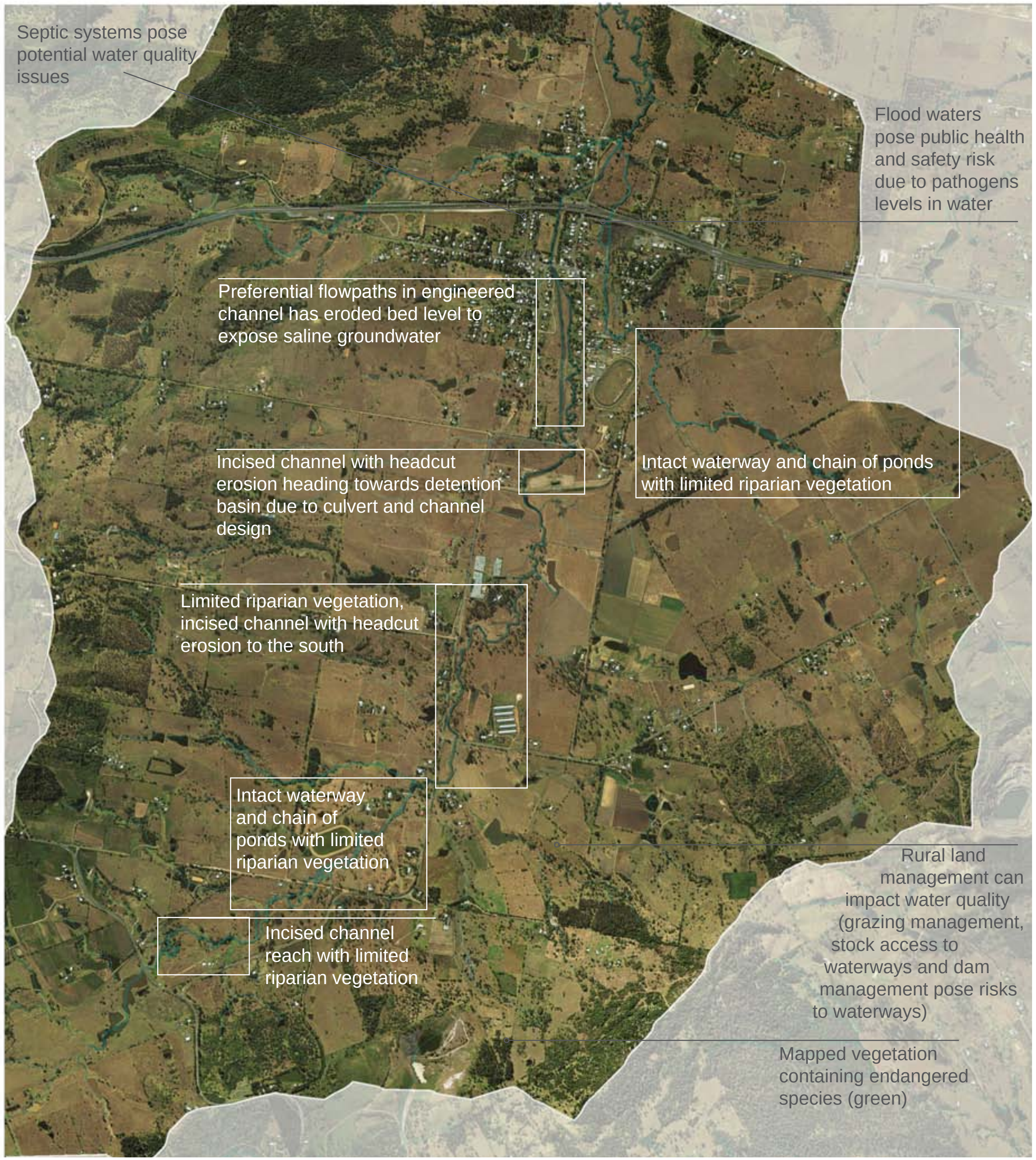


Figure 16 – Summary of water quality risk issues across the Black Snake Creek catchment

WATER QUALITY PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Undertake landscape restoration	Improved management of mid slope lands and the restoration of vegetation are a key component in achieving water quality improvement. A program of restoration delivered through an investor-landholder-facilitator partnership should be implemented. Funding from major beneficiaries to be supplemented through environmental offsets and government grants. Potential for allowing vegetation conditioned subdivision of larger lots to create limited rural living land supply. Risks such as bushfire will be considered when undertaking restoration planting.	⁄ SEQ Catchments ⁄ Seqwater ⁄ Landholders ⁄ West Moreton Landcare ⁄ Ipswich City Council ⁄ Somerset Regional Council	⁄ Reduction of water quality risk ⁄ Reduced flood flow velocities ⁄ Lowered groundwater ⁄ Lessening of salinity outbreaks ⁄ Improved visual amenity	⁄ Continuing risk to regional water supply ⁄ Continuing high flood flow velocities	⁄ Revegetation of private property will likely require financial and planning incentives combined with commercial and/or planning protection of works undertaken.
Restore / re-create floodplain wetlands	Return wetland functions to areas of floodplain impacted by frequent inundation and shallow groundwater (including salt affected lands). A program of restoration delivered through an investor-landholder-facilitator partnership should be implemented to deliver. Funding from major beneficiaries to be supplemented through water quality offsets and government grants.	⁄ SEQ Catchments ⁄ Queensland Urban Utilities ⁄ Seqwater ⁄ SEQ Catchments ⁄ Landholders ⁄ West Moreton Landcare ⁄ Ipswich City Council	⁄ Reduced risk to human health ⁄ Reduced risks to regional water supply ⁄ Reduced flood velocities	⁄ Ongoing risk to regional water supply ⁄ Ongoing risk to human health ⁄ Ongoing risk to stock health	⁄ Restoration and creation of floodplain wetlands will likely require financial and planning incentives combined with commercial and/or planning protection of works undertaken.
Implement protective riparian fencing and restoration program	Adequate riparian vegetation and fencing to exclude stock from streams will reduce water quality risks. A program of restoration delivered through an investor-landholder-facilitator partnership should be implemented. Funding from major beneficiaries to be supplemented through water quality offsets and government grants.	⁄ Queensland Urban Utilities ⁄ Seqwater ⁄ Ipswich City Council ⁄ SEQ Catchments ⁄ Landholders ⁄ West Moreton Landcare ⁄ State Government ⁄ Somerset Regional Council	⁄ Reduced risk to human health ⁄ Reduced risks to regional water supply ⁄ Reduced flood velocities	⁄ Ongoing risk to regional water supply ⁄ Ongoing risk to human health ⁄ Ongoing risk to stock health	⁄ Fencing and revegetation of private property riparian lands will likely require financial incentives combined with planning protection of vegetation works undertaken.

WATER QUALITY PRELIMINARY ACTION PLAN

Action	Description	Stakeholders	Benefits	Implications of No Action	Feasibility
Develop septic system management education program	All residences in the catchments rely on domestic waste water treatment plants. The shallow groundwater of the region and ongoing flood events means septic systems are an area of high risk. Council should implement program of inspection, education and upgrading to minimise risk. On-going waterway monitoring should also be used to identify if systems are not being maintained appropriately across the catchment.	⁄ Ipswich City Council ⁄ Queensland Urban Utilities ⁄ Seqwater ⁄ Landholders	⁄ Reduced human health risk ⁄ Delay or avoidance of costly sewering of town ⁄ Reduced risk to regional water supply	⁄ Ongoing risk to human health ⁄ Risk to regional water supply	⁄ The development of this education program to help landowners identify if their septic system is not operating correctly can be easily based on existing programs such as NSW's Department of Local Government's 'Easy Septic Guide'.
Monitor water quality to strengthen understanding of water quality issues (e.g. source of pollutants)	Community water quality monitoring is currently being undertaken in the region and should continue to be supported. Seqwater is also currently monitoring water quality at the downsteam end of the catchment. Coordination and publication of this information is required to help inform future water quality actions. Given the diversity of land uses (including intensive horticulture and agriculture activities) ongoing microbial monitoring should continue, and where possible, allow for results to be linked back to specific land uses to inform appropriate actions to be undertaken across the catchment.	⁄ Seqwater ⁄ West Moreton Landcare ⁄ Landholders ⁄ Ipswich City Council	⁄ Up-to-date water quality trend information to inform management decisions	⁄ Lack of knowledge regarding water quality trends	⁄ Monitoring is already being undertaken by the community and just requires ongoing support. It is understood Seqwater are also undertaking water quality monitoring. There needs to be some coordination and communication of monitoring outcomes.
Future sewerage management infrastructure	Sewering of Marburg is dependant on future population growth and outcomes from water quality monitoring programs. There may be a need at some stage to undertake a strategic plan for sewerage management in the township.	⁄ Queensland Urban Utilities ⁄ Ipswich City Council ⁄ Seqwater	⁄ Understood direction for future sewerage management in Marburg ⁄ Water quality protection	⁄ Ongoing water quality risk ⁄ Suboptimal long term sewerage management outcomes	⁄ Sewering of the Marburg township is considered to be prohibitively expensive at this stage. However, strategic planning should be undertaken to examine all options including lower cost alteratives such as centralised pump-out facilities (e.g. Somerset Dam Township).

6

Planning for the Future

PLANNING FOR THE FUTURE

This section of the report presents the proposed priority action plan for the improvement of the Upper Black Snake Creek catchment based on a consolidated understanding of the key water issues and catchment constraints as summarised in Figure 17.

Investigations have been undertaken to develop these priority actions based on a first order feasibility assessment of all of the actions presented in the preliminary action plans (Section 5).

These actions have also been developed in consultation with key stakeholders and are aimed at improving the current catchment condition with specific focus on flooding, salinity and water quality issues.

The tables identify possible implementation pathways to enable these actions. Many of the actions identified will require ongoing collaboration between key stakeholders to further develop and deliver these actions.

Figure 18 presents a map which locates the priority actions across the Upper Black Snake Creek Catchment.

Key

Salt affected areas (black hatching)

Alluvium - areas at risk of salinity (blue)

Q100 Flood extent (dashed line)

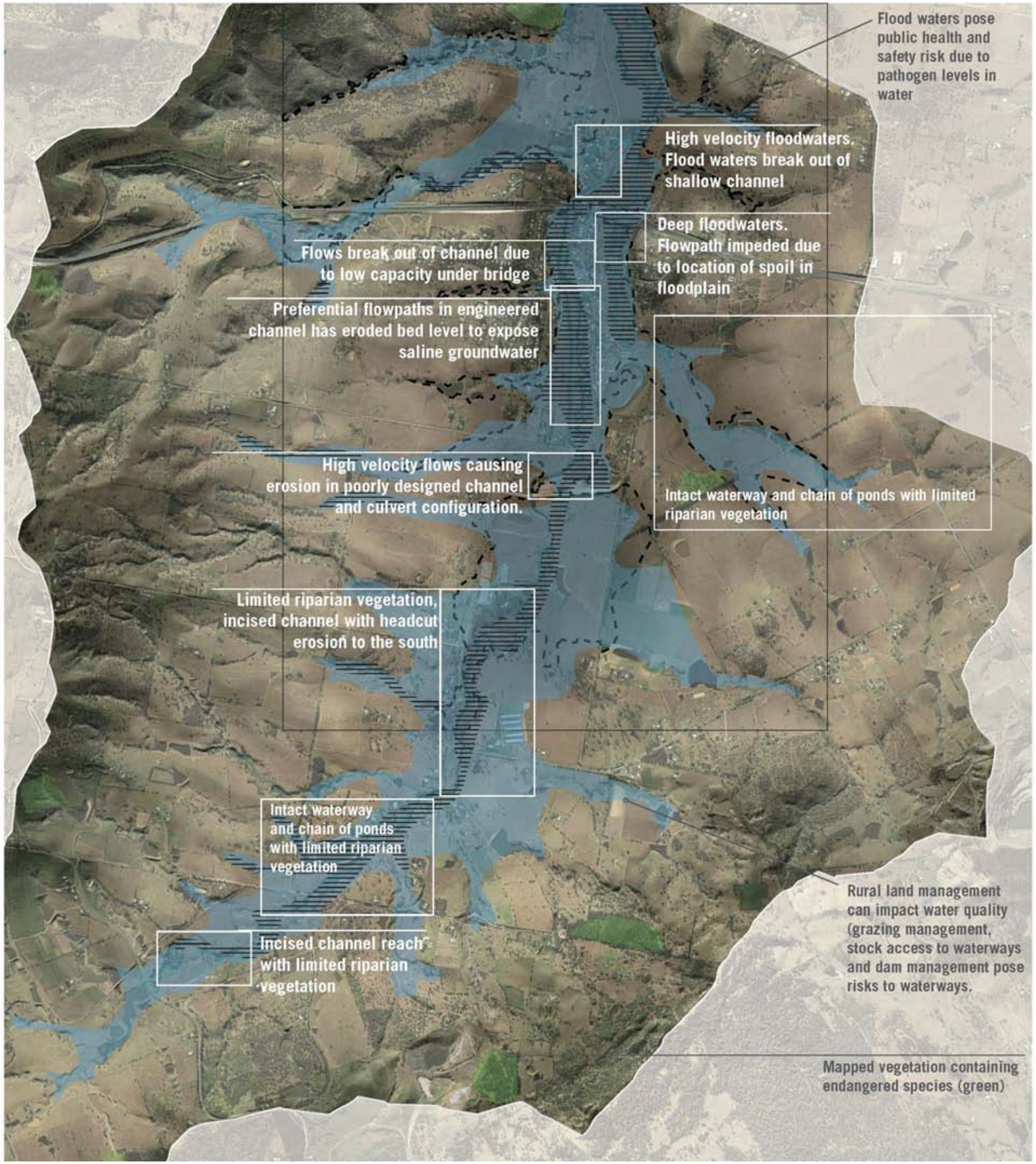


Figure 17 – Summary of Upper Black Snake Creek catchment constraints

PRIORITY ACTION PLAN

Issue	Action*	Risks Addressed	Cost	Timeframe	Residual Risk	Priority	Implementation Pathway
Flooding	Develop Marburg community flood plan	Loss of Life	Low	Immediate	Low	High	To be undertaken as part of broader Ipswich City Council Community Resilience Program
	Replace inadequate culverts and infrastructure	Breakout flooding through township	High	Ongoing	Low	Medium	To be part of Ipswich City Council capital works program subject to further more detailed investigations
	Remove existing blockages to flood flow on eastern tributary	Local flooding impacts	Low	Immediate	Low	High	DTMR to be contacted to remove blockages
	Undertake revegetation of eastern and western tributary to slow flood flows	Local flooding impacts	Medium	Ongoing	Medium	High	To be undertaken as part of a program of re-vegetation delivered through an investor-landholder-facilitator partnership
	Re-alignment of upstream channel and culverts at Rosewood-Marburg Road to reduce the frequency of flooding and address existing erosion	Infrastructure effectiveness	Medium	Short term	Low	Medium-High	To be part of Ipswich City Council capital works program (note: if this action is delayed, short term erosion remediation works are required to arrest current active erosion)
	Develop planning mechanism to ensure existing development rights in flood prone areas are not used	Inappropriate development	Low	Short term	Low	High	Transferable development rights within catchment to be part of review of Ipswich City Council Planning Scheme
	Flood relief channel on western tributary	Local flooding impacts	High	Long term	Low	Low	Implemented under a co-investment model or fully privately funded

*refer Section 5 Preliminary Action Plans for description of action

PRIORITY ACTION PLAN

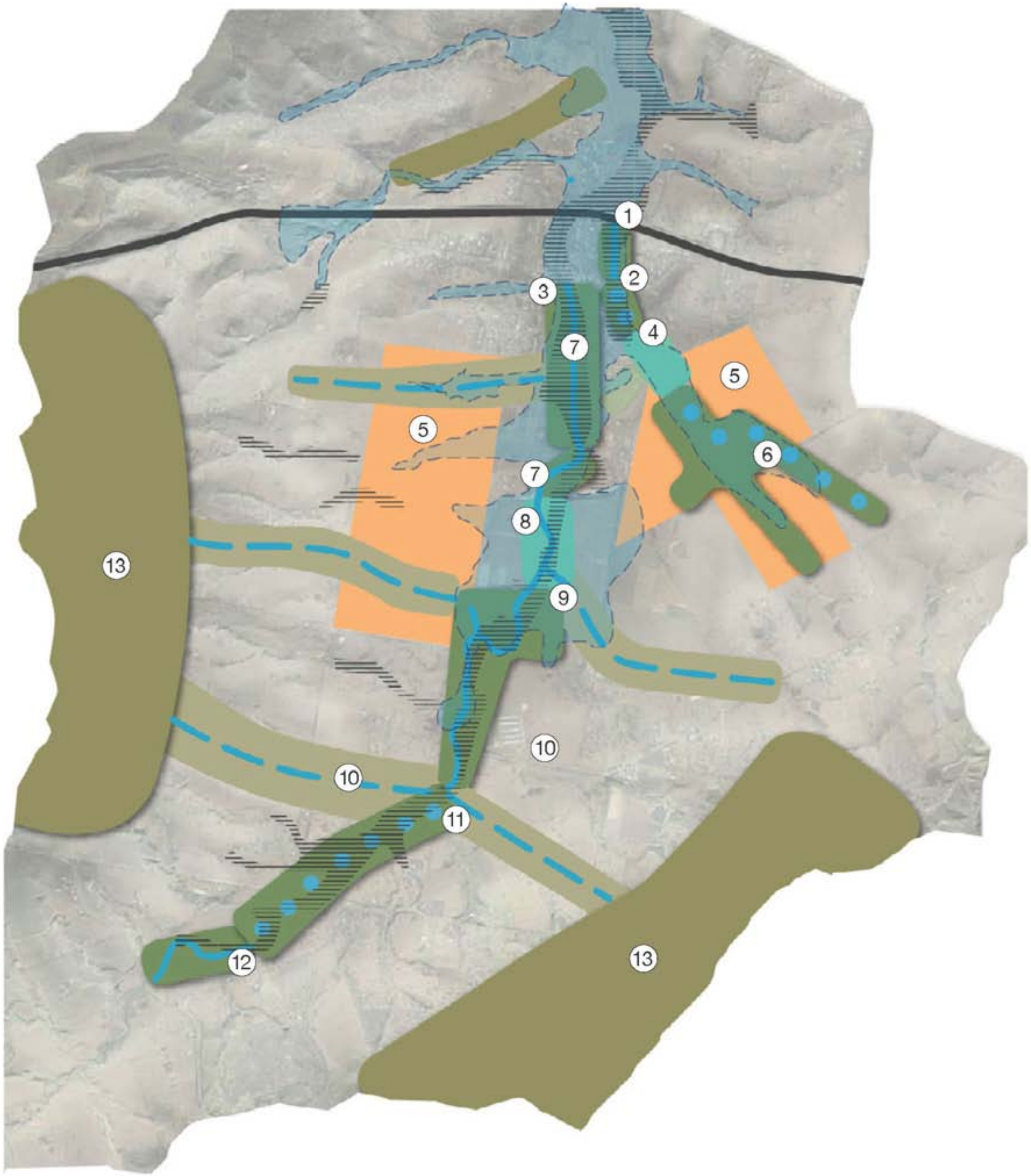
Issue	Action*	Risk Addressed	Cost	Timeframe	Residual Risk	Priority	Implementation Pathway
Salinity	Artificial lowering of shallow groundwater table and re-use of brine	High saline groundwater table	High	Ongoing	Medium	Medium	Further investigation of schemes elsewhere and development of business case
	Restore deep rooted trees	High saline groundwater table	High	Ongoing	Low	High	Development of partnership funding applications to Local, State and Federal funders. Prioritisation of offset receiving sites. Implementation through an investor-landholder-facilitator partnership.
	Undertake geomorphic restoration of creek channel	Interception of saline groundwater	Medium	Ongoing	Low	Medium	Development of partnership funding applications to Local, State and Federal funders. Implementation through an investor-landholder-facilitator partnership.
	Develop landholder guidebook for salinity and water quality management	Lack of landholder knowledge of appropriate action	Low	Immediate	Low	High	Development of landholder guide based on current guidelines.
	Develop community landscape asset vision	Lack of common appreciation of shared direction	Low	Immediate	Medium	Medium	Developed as part of the updated Marburg Community Plan.
	Implement community capacity building program	Lack of community capacity	Low	Short term	Low	High	Development of partnership funding applications to Local, State and Federal funders to support existing active and enthusiastic community groups develop and deliver training.
	Encourage landholder planting and preservation of vegetation on private lands	Lack of deep rooted vegetation	Low	Ongoing	Medium	High	This can be done making use of existing Council resources through the Free Tree Scheme and Bushland Conservation Scheme.

*refer Section 5 Preliminary Action Plans for description of action

PRIORITY ACTION PLAN

Issue	Action*	Risks Addressed	Cost	Timeframe	Residual Risk	Priority	Implementation Pathway
Water Quality	Undertake landscape restoration	Declining water quality	High	Ongoing	Medium	Medium	Development of partnership funding applications to Local, State and Federal funders. Prioritisation of offset receiving sites. Implementation through an investor-landholder-facilitator partnership.
	Restore / re-create floodplain wetlands	Declining water quality	Medium/ High	Ongoing	Low	High	Development of partnership funding applications to Local, State and Federal funders. Prioritisation of offset receiving sites. Implementation through an investor-landholder-facilitator partnership.
	Implement protective riparian fencing and restoration program	Pathogen and nutrient pollution	High	Ongoing	Low	High	Development of partnership funding applications to Local, State and Federal funders. Prioritisation of offset receiving sites. Implementation through an investor-landholder-facilitator partnership.
	Develop septic system management education program	Human health and pathogen and nutrient pollution	Low	Short term	Low	High	To be developed by Ipswich City Council based on existing septic education programs / guidelines.
	Monitor water quality to strengthen understanding of water quality issues (e.g. source of pollutants)	Understanding of water quality trends	Medium	Ongoing	Low	High	Water quality monitoring is already being undertaken by the community and Seqwater. There needs to be some coordination and communication of monitoring outcomes to identify trends and data gaps.
	Strategic planning to inform future sewerage management infrastructure	Water quality	Medium	Medium term	Low	Medium	Queensland Urban Utilities strategic planning

*refer Section 5 Preliminary Action Plans for description of action



Legend

1	Removal of spoil and creation of stable natural channel to convey flows
2	Riparian revegetation on existing chain of ponds system (salinity affected)
3	Natural channel design (chain of ponds) to retain flood conveyance but address bed erosion combined with planting of deep rooted trees in floodplain / riparian zone
4	Regional floodplain water quality wetland system
5	Potential rural living
6	Riparian revegetation on existing chain of ponds system and protecting remnant vegetation
7	Address erosion through channel works
8	Revegetate riparian zone with deep rooted trees (salt tolerant)
9	Address channel erosion and revegetate riparian zone with deep rooted trees (salt tolerant)
10	Revegatation of mid slope valleys connecting vegetation along main channel to upper slopes (this can occur along all midslope valleys)
11	Riparian revegetation on existing chain of ponds system
12	Address channel erosion with natural channel design and riparian revegetaion (salt tolerant)
13	Revegetatation of pre-development vegetation
	Flooding
	Salinity

Figure 18 - Proposed locations of actions across the Upper Black Snake Creek catchment

DELIVERING THE PLAN

The investor-landholder-facilitator partnership will be critical in the delivery of many of the proposed actions within the Upper Black Snake Creek catchment. Figure 19 outlines how these roles can operate and work together to deliver successful project outcomes.

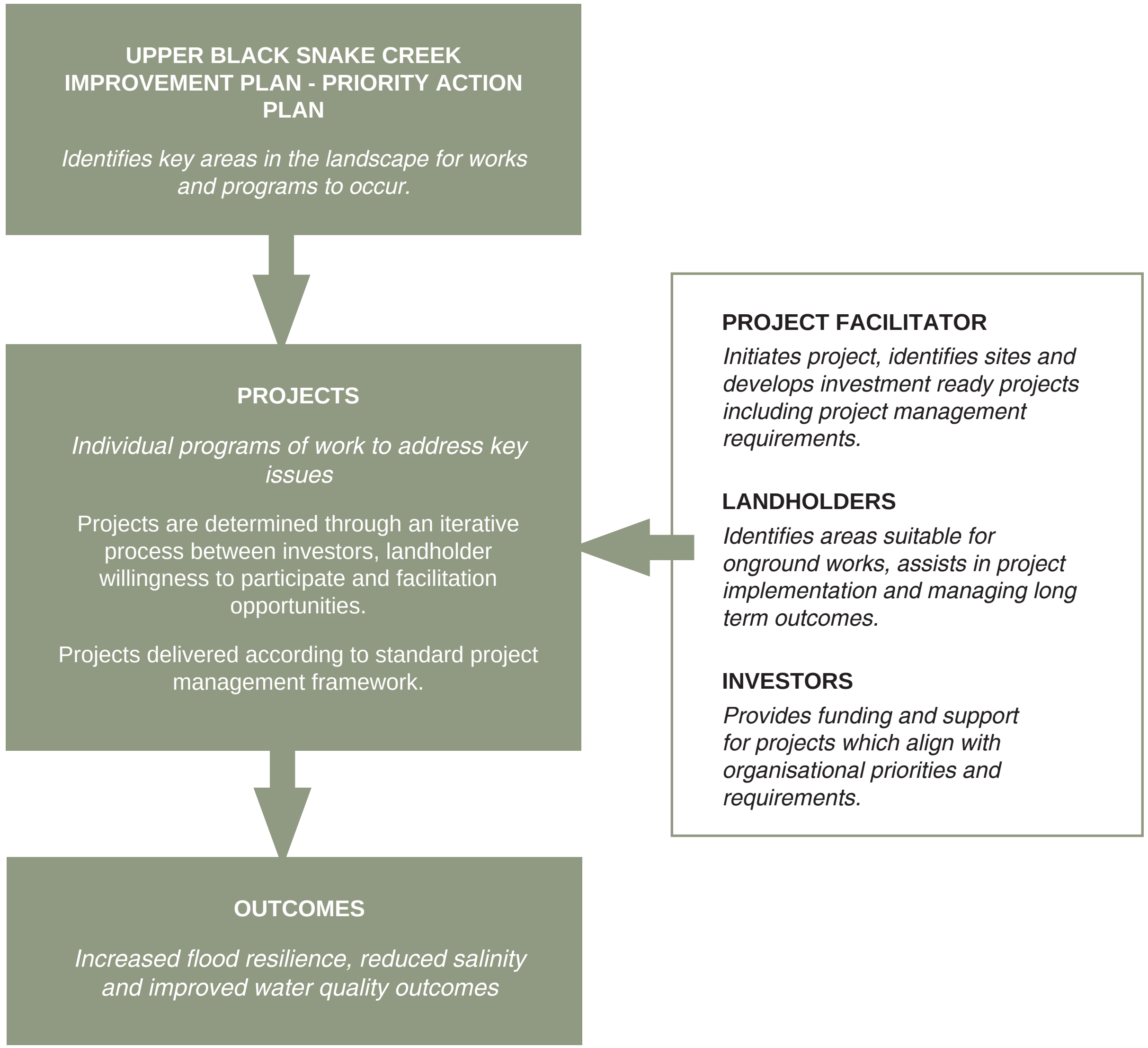


Figure 19 – Investor-landholder-facilitator partnership

TARGET FUTURE CONDITION

The following figures provide a graphical depiction of the target catchment condition following the application of the priority action plan.

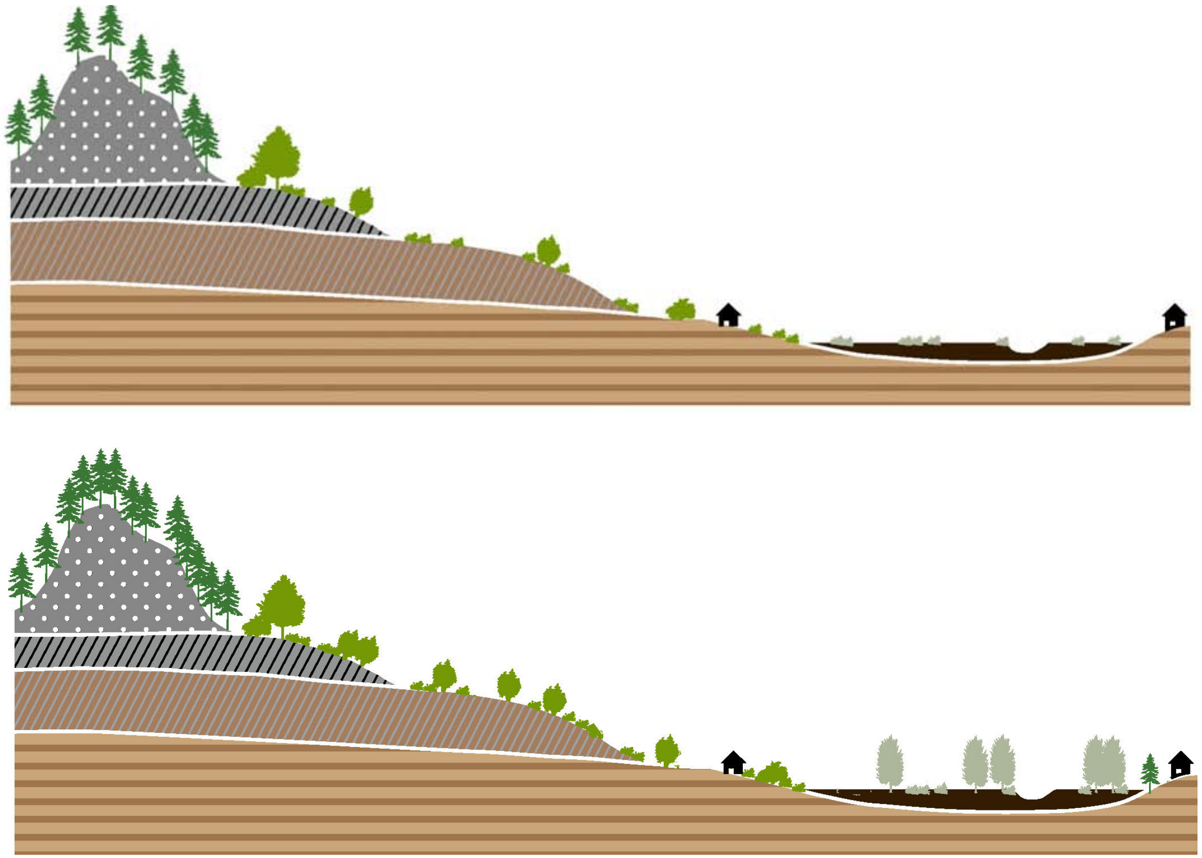


Figure 20 – Cross section of Black Snake Creek showing current condition (top) vs target future condition (bottom)

Figure 21 – Aerial plan of Black Snake Creek showing current condition (left) vs target future condition (right)

REFERENCES

Brierley, G.J. and Fryirs, K.A. (2005) Geomorphology and River Management: Applications of the River Styles Framework

Brooks, A. P., Brierley, G. J. and Millar, R.G. (2003) The long term control of vegetation and woody debris on channel and floodplain evolution: Insights from a paired catchment in southeastern Australia. Geomorphology 51, 7-29

Ellis, M.D. & Bigwood, R.C. (2006) Landscape and Salinity Assessment of the Black Snake Creek Catchment South East Queensland, Department of Natural Resources and Water, Brisbane, Queensland

Parsons Brinkerhoff (2012) Marburg Detention Basin Acceptable Flood Capacity Assessment

RPS (2011) Black Snake Creek Waterway Health and Water Quality Assessment - Stage 1 Report

SEQ Catchments Ltd (2008) Black Snake Creek Project – Natural Resource Assets & Sustainable Land Use in the Black Snake Creek Catchment

Watkinson (2013) Brisbane River Groundwater

Appendices

APPENDIX A - FLOOD STUDY REPORT

APPENDIX B - STAKEHOLDER ENGAGEMENT REPORT AND WORKSHOP MINUTES

APPENDIX C - CATCHMENT CONDITION ASSESSMENT REPORT