

# THE RICHMOND CENTRAL STORMWATER INFRASTRUCTURE UPGRADE

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## **ABSTRACT (300 words maximum)**

Richmond, the largest town in the Tasman District, has a central area that lies at the confluence of two stormwater catchments. While there are detention dams upstream designed to protect the town centre, the stormwater systems do not meet the current desired levels of service and the town centre experiences periodic flooding.

In April 2013 a severe (1 in 500 year) rainfall event caused widespread flooding in the town centre which re-focused the community and the Council on the stormwater deficiencies and reinforced the priority to upgrade the stormwater infrastructure.

The proposed \$13.9 million solution, is a major staged infrastructure project to improve the flood protection while also taking the opportunity to improve the accessibility, safety and functionality of the main street. As part of the initial stage, as well as upgrading the existing stormwater pipes, the crown of the road will be lowered to prevent floodwaters flowing towards business entrances, as happened in 2013. The surface of the street will be reinstated and the community invited to contribute ideas towards the design.

The second stage involves a new 1600mm dia. pipeline to divert stormwater flows away from the Richmond central area out to the estuary via a new widened open channel drain. The new pipeline will collect flows from one of the upstream detention dams and other upstream diverted stormwater pipes.

Subsequent stages in the 10 year programme include further upstream diversions and improved management of overland flow paths.

This paper presents the flooding issues, options considered, the selection of the preferred solution and highlights some the challenges encountered during the design of the first two stages.

## **KEYWORDS**

**Stormwater strategy, resilience, pipe condition, levels of service**

## **PRESENTER PROFILE**

Avik Halder is the Technical Development Leader (Water and Waste) for MWH New Zealand Ltd. Avik has been active in various projects for Tasman District Council as well as several other New Zealand local government clients since moving to New Zealand in 2006. Previously, he has worked in the United Kingdom and Ireland on a variety of utilities infrastructure projects.

# 1 INTRODUCTION

Richmond, the main town in Tasman District, has a population of about 14,000. The town centre is one of the largest commercial and retail hubs in the Nelson/Tasman Region and its role in the region is expected to grow as development around Tasman, and especially Richmond progresses.

Unfortunately, in recent times the town centre including Queen Street (the main street) has been subjected to several severe floods. The most severe was a 1 in 500 year short duration event in April 2013 that caused widespread flooding affecting many businesses.

The Tasman District Council is working towards a major upgrade project to minimise future flooding, and since the main street will be significantly impacted by pipeline upgrades, they are also taking the opportunity to upgrade the Queen Street carriageway, footpath and streetscape environments. This paper presents the flooding issues, options considered, the selection of the preferred solution and highlights some of the challenges encountered during the design of the first two stages of the 10-year upgrade process.

# 2 STORMWATER CATCHMENT

There are the two main catchments that feed into the Richmond central area.

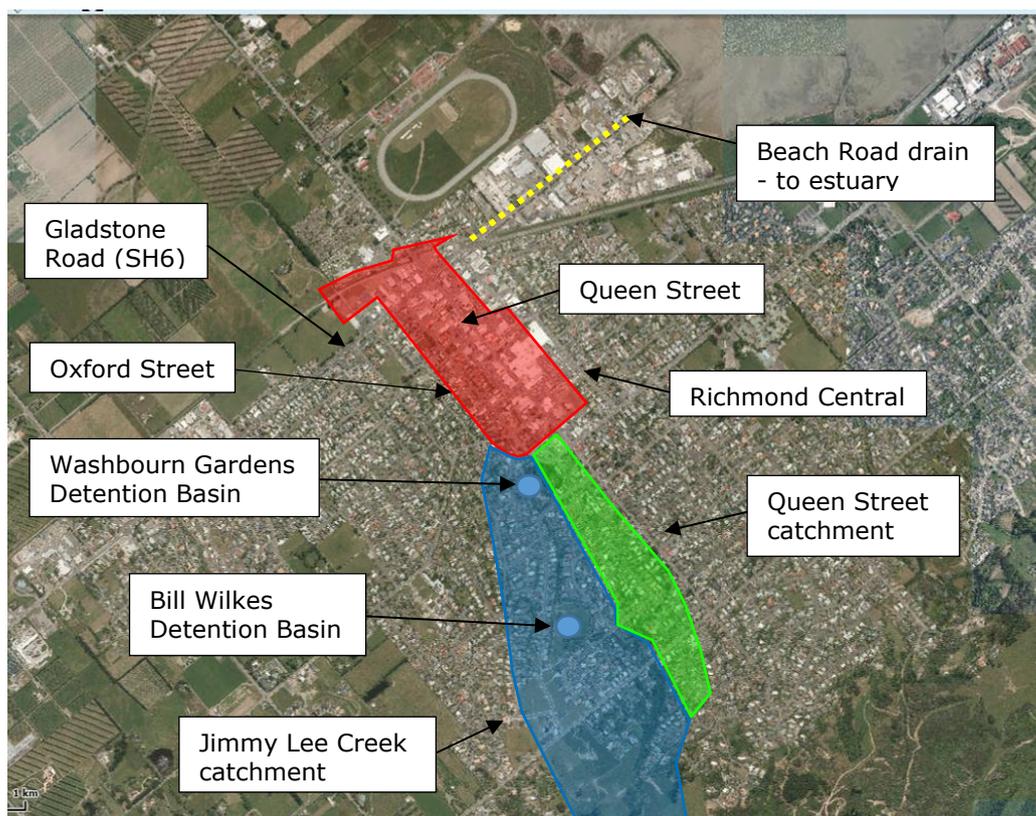


Figure 1: Richmond Catchment Plan

The first is a long, thin, mainly urban catchment of 16.2 ha which runs off the hill around upper Queen Street down into the town centre. It is steep with an average gradient of 1 in 13 and is relatively highly developed in terms of impervious area.

The second, the Jimmy Lee Creek catchment is a larger catchment that extends up onto the steep rural hillside behind Richmond. It is 156 ha, with 102 ha of steep rural hillside and 54 ha of residential development. This catchment has two detention basins, one at

the Bill Wilkes Reserve and one downstream and closer to town at Washbourn Gardens (refer to Figure 1).



*Photographs 1 & 2: Bill Wilkes Detention Basin Outlet (left) Basin full and overflowing at weir (right)*

Downstream of Washbourn Gardens detention basin, Jimmy Lee Creek discharges into a piped stormwater system at the top of Oxford Street. Oxford Street forms the southern side of the ring road around the town centre. Historically Jimmy Lee Creek was a natural creek that ran between Oxford Street and Queen Street. The lower end of Queen Street was only piped in the 1950s. The pipe system carries Jimmy Lee Creek down Oxford Street to Gladstone Road.



*Photographs 3 & 4: Jimmy Lee Creek through Washbourn Gardens*

The town centre itself is 36.1 ha and is highly impervious with a large mall and several car parking areas. Queen Street has a stormwater main running its length, 600 mm diameter at the top end and 900mm diameter at the bottom end towards Gladstone Road.

The lower ends of Oxford and Queen Streets are very flat and they run into Gladstone Road which is also very flat. The stormwater mains in Gladstone Road pick up the flows from Oxford and Queen Streets, turn them 90 degrees and carry them to the Beach Road Drain.

The Beach Road Drain is a timber-lined drain that runs to the Waimea Inlet. It is typically 6m wide and 1.5 m deep and tidally influenced in its lower reaches. It has multiple property access crossings of variable size and construction.



*Photographs 5 & 6: Beach Road Drain during a high tide (left) one of the constricted bridges (right)*

### **3 APRIL 2013 FLOOD EVENT**

On 21 April 2013, 191mm of rainfall was recorded in Richmond (Tasman District Council office gauge) over a period of 24 hours. This event followed 18 months after another large storm of 192mm, although the earlier storm had a significantly lower peak intensity. The 2013 storm had an average hourly intensity of just over 80mm/hr. between 5pm and 6pm and a peak intensity approaching 120mm/hr. The event peak characteristics were estimated by the Tasman District Council to have a probability of occurring in any year of around 0.2% (1 in 500 years).



*Photographs 7 & 8: Overland flows in the town centre (left) Richmond Mall car park off Queen Street (right)*

In Queen Street during extreme events, the primary drainage system capacity is quickly exceeded and flood water is carried on the streets into the town centre. Because the streets have a reasonable gradient (1 in 50 at the top of the town centre), the floodwater can be travelling at a high velocity.

Currently the road crown is high relative to the kerb and channel and shop floor levels so it does not take long before the surface flows flood into shops. It also overflows into the Richmond Mall car park, inundating the car park drainage systems and ponding at the Mall entrance which has not been designed to cope with such flood flows.

The overland flows converge at the bottom of Queen Street and Oxford Street where they join Gladstone Road (which is a state highway). At this point the topography is relatively flat and when the primary drainage system capacity is exceeded, the flood water ponds. The crown of Gladstone Road is higher than the floor levels of the surrounding buildings so it does not take long for the ponding to flood the buildings.



*Photographs 9 & 10: Ponding at the bottom of Queen Street and on Gladstone Road*

#### **4 LEVEL OF SERVICE**

The target levels of service (LOS) for the retrofit project defined by the Tasman District Council were:

- Primary drainage system to contain the 1 in 20 year flows in the town centre
- Primary drainage system to contain the 1 in 10 year flows in urban areas outside the town centre
- Stormwater system able to convey the 1 in 100 year flows in the town centre and urban areas without flooding buildings or dwellings

These LOS contrast significantly with the 1 in 5 year capacity that most of the existing piped assets provide. As the Council cannot afford to significantly advance the reticulation renewal dates, provision of secondary flow paths has been given a higher priority. The Council has also identified that it will not protect land lower than the RL 4.0m contour from tidal effects and the effects of sea level rise.

#### **5 HYDRAULIC MODEL**

The Richmond piped stormwater network was modelled in 2007 using the InfoWorks platform. As the LOS desired by the Council requires an understanding of the surface drainage systems once the primary drainage networks are exceeded, it was agreed that a 2-D surface model needed to be developed and integrated with the pipe network model. To do this the model was converted to an Infoworks ICM model. The Council's LiDAR was used to generate the 2-D digital terrain model (DTM) to simulate the overland flowpaths.

Initial simulations were undertaken to identify key overland flow paths and this information was then used to refine the detail of the 2-D surface model. Building outlines were digitised and given high roughness so as to be largely impervious to overland flow. Street kerb and channels were digitised and modelled using higher resolution 2-D grids to ensure kerb and channel flow was being adequately represented. Adjustments and some isolated 2-D edits were required to mimic detailed surface features not captured in the LiDAR survey that affected significant flow paths. These edits were confirmed by flood photographs, local flood knowledge and by walkover.

## 6 RESILIENT SOLUTIONS

The resilience of a catchment to stormwater flooding covers a range of concepts across a reasonably broad spectrum of subjects, such as:

**Resilient Infrastructure and Management** (understanding and managing existing infrastructure, understanding how and when it will fail (hydraulic, structural, operational, maintenance etc.), managing and mitigating the impact of when it does fail).

**Community Preparedness** (e.g. understanding the limits of infrastructure and planning for exceedance events, flood prediction, flood warning, contingency and response planning, communication and reporting).

**Responsibilities** (e.g. individual and community responsibilities are defined, understood and communicated).

**Adaption** (e.g. awareness of and managing changing conditions over time).

**Interdependencies between stakeholders** (regulators, policy-makers, planning authorities, owners, operators and the public) and the identification and management of risk.

**Financial** – the capability to fund and manage the infrastructure throughout its life and considering the ongoing change.

For the purposes of this study, the aspects or areas of 'resilience' that were considered focused on 'resilient stormwater infrastructure' looking at the source, the pathway and the receptors.

### 6.1 SOURCE, PATHWAY, RECEPTOR APPROACH

The 'Source, Pathway, Receptor, Consequence', is a commonly adopted approach to understanding the link between hazard and risk, and consists of the following elements:

**Source** – the origin of the potential hazard, such as tide, storm surge, heavy rainfall and hinterland runoff.

**Pathway** – open channels, stormwater network (primary drainage network), overland flow paths, (secondary drainage network), flood plains.

**Receptor** – ponding flood areas, property, people, and environment.

**Consequence** – loss of life, damage, cost, environmental impact.

This approach allows a hierarchy against which to consider the flooding issues and develop solutions. For example, if the source can be successfully controlled, then the pathway and receptor are protected. If the pathway can be controlled or managed, then the receptor is protected.

Some examples of source, pathway and receptor controls are shown in the following sections.

### 6.1.1 SOURCE CONTROL



Figure 2: Source control – Catchwater diversion channels

### 6.1.2 PATHWAY CONTROL



Figure 3: Pathway control – Flow path channels in road berms

### 6.1.3 RECEPTOR CONTROL



Figure 4: Receptor control – Dismountable flood boards and glazed flood barrier

## 7 UPGRADE SCENARIOS AND OPTIONS

The project team went through a two stage shortlisting process to identify the preferred strategy. The first stage was a workshop where the existing performance was reviewed and scenarios brainstormed in terms of source, pathway and receptor.

The impractical or unfeasible options were discounted and eight main scenarios were identified for further investigation. At two subsequent workshops scenarios were either progressed, refined or discarded.

The final scenarios could essentially be grouped into three options, the main difference being how the stormwater would be discharged to sea.

- Option 1 - Upgrade the existing Beach Road drain outlet
- Option 2 - Construction of a new outlet beside the racecourse grounds
- Option 3 - New pipeline diverting flows into the Poutama drain outlet

### 7.1 OPTION 1 - UPGRADE THE EXISTING BEACH ROAD DRAIN OUTLET



Figure 5: Option 1- Upgrade the existing Beach Road drain outlet

The existing Beach Road drain can be used but its capacity would need to be enlarged by removing sediment and vegetation as well as the current bridge crossing which constricts the drain. The existing drain is timber lined and in poor condition. There is a risk that any improvement work will further damage the timber.

For this option, upgrading the Beach Road drain alone is not enough, it will need additional capacity between the drain and Queen Street, in order of an additional 1,500mm diameter pipeline.

## 7.2 OPTION 2 - CONSTRUCTION OF A NEW OUTLET BESIDE THE RACECOURSE GROUNDS

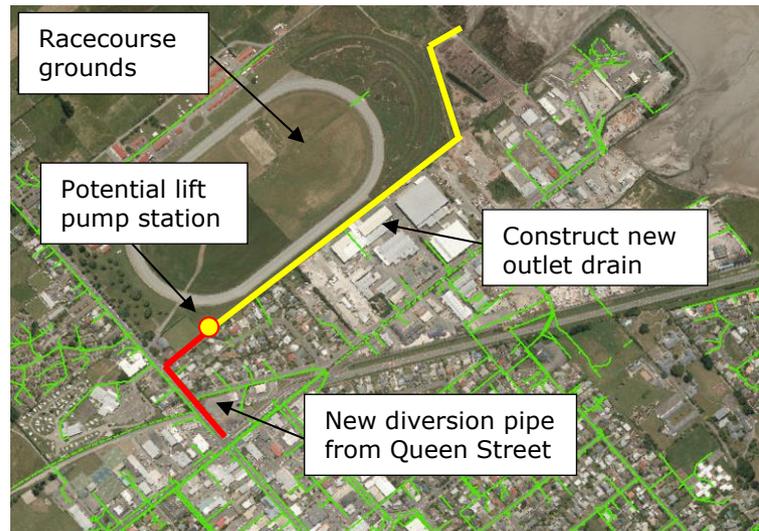


Figure 6: Option 2 - Construction of a new outlet beside the racecourse grounds

Instead of increasing the capacity of the Beach Road drain, a new drain beside the racecourse could be constructed, however this would need large pipes and an open drain to the coast. Due to the topography, gravity discharge of catchment flow from the Gladstone Road/Queen Street intersection would be marginal.

To improve this, a lift pump station at the racecourse ground could be constructed but this would add significant additional cost because of extra pipework to the pump station. This option is the most complicated hydraulically.

## 7.3 OPTION 3 - NEW PIPELINE DIVERTING FLOWS INTO THE POUTAMA DRAIN OUTLET

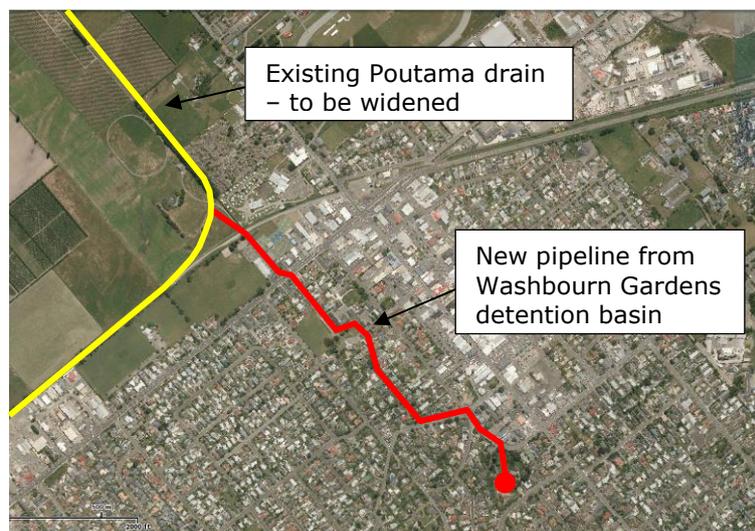


Figure 7: Option 3- New pipeline diverting flows into the Poutama drain outlet

Installing a new pipeline from the Washbourn Gardens detention basin to Poutama Drain effectively cuts off the Jimmy Lee catchment that feeds into the top of Oxford Street. As a result, the existing infrastructure in Oxford Street is sufficient to cope with the remaining stormwater in the town centre.

The pipeline to Poutama Drain would need to be a least 1,600mm in diameter and would be partly pressurised, partly gravity. It will need to be carefully designed to ensure that air can be appropriately managed in the system when the pipeline fills. The Poutama Drain would also need to be enlarged to handle increased flows.

## 7.4 OPTIONS ASSESSMENT

A multi-criteria analysis (MCA) was used to compare the scenarios and options. The main criteria assessed were:

- Economic 30%
- Environmental 20%
- Social 20%
- Solution Resilience 30% (hydraulic robustness, flood resilience, implementation risk and future resilience)

For the purposes of this paper, a simple table indicating some of the positives and negatives of the three outlet options is presented below.

<b>Option 1 - Upgrade the existing Beach Road drain outlet</b>	
Positives	<ul style="list-style-type: none"> <li>• Beach Road drain is the existing outlet to the sea for stormwater discharge in flood events</li> </ul>
Negatives	<ul style="list-style-type: none"> <li>• Limited additional capacity available</li> <li>• Beach Road drain is subject to tidal impact which is predicted to increase with climate change</li> <li>• A major upgrade would be required to increase flow capacity</li> </ul>
<b>Option 2 - Construction of a new outlet beside the racecourse ground</b>	
Positives	<ul style="list-style-type: none"> <li>• Would provide new drainage and outlet to the sea</li> <li>• Required capacity can be constructed to take Q100 flows</li> <li>• Possible future additional outlet</li> </ul>
Negatives	<ul style="list-style-type: none"> <li>• Requires land purchase and associated costs and time</li> </ul>
<b>Option 3 - New pipeline diverting flows into the Poutama drain outlet</b>	
Positives	<ul style="list-style-type: none"> <li>• Provides a new collection system</li> <li>• Delivers flows to an enlarged Poutama Drain</li> <li>• Removes the need for additional pipe work in Oxford Street</li> <li>• Removes the need for a major upgrade to Beach Road Drain</li> <li>• Allows a pickup of flow from local upstream areas</li> </ul>

Negatives	<ul style="list-style-type: none"> <li>• Significant disruption to residents'/road users during construction</li> <li>• Design challenges with construction due to large pipe size</li> </ul>
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Table 1: Assessment of the three outlet options

## 8 PREFERRED SOLUTION

Option 3 was identified as the preferred solution and comprises the upgrade scenario shown below.

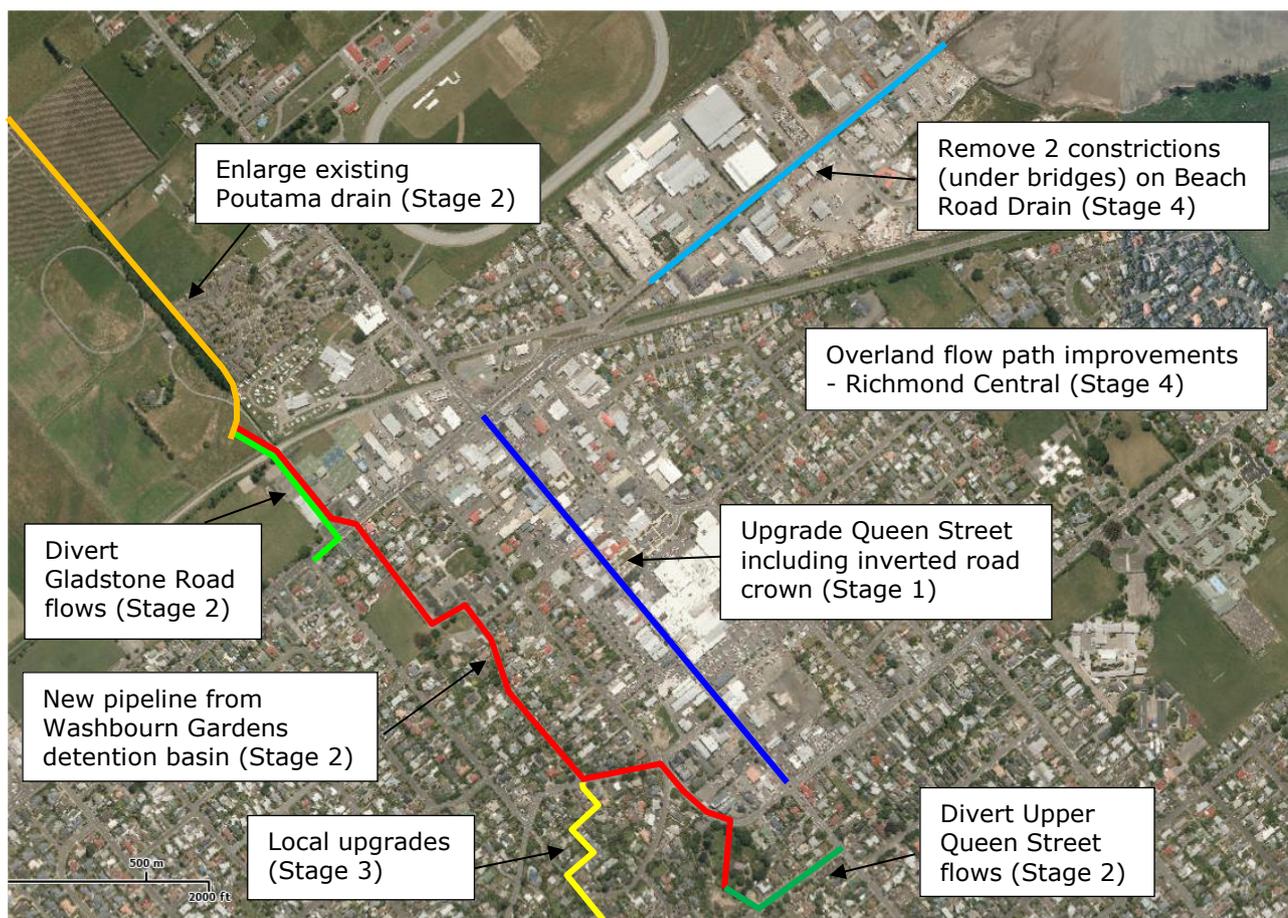


Figure 8: Preferred upgrade scenario and stages

The approach adopted is focused on diverting water away from the town centre and hence is modifying the pathway to protect the receptor.



Figure 9: 100-year flood model of current system (left) after preferred solution (right)

The flood maps demonstrate that the preferred solution achieves the target level of service of the stormwater system being able to convey the 1 in 100 year flows in the town centre and urban areas without flooding buildings or dwellings.

The proposed solution was also checked against the 2013 event and the modelling indicated that a future 1 in 500 year event (after the works were completed) would flood the area less than a current 1 in 100 year event.

The stormwater component of the overall scheme cost is estimated to be \$13.9 million.

It should be noted that the Council identified that it will not protect land lower than the RL 4.0m contour from tidal effects and the effects of sea level rise. This is reflected in the flood map for the preferred solution.

## 9 STAGING OF WORK

Construction of the proposed stages is shown in the table below and in Figure 5.

Stage	Description	Year
Stage 1	Upgrade Queen Street including inverted road crown	2016-17
Stage 2	Upper Queen Street diversion. Gladstone Road diversion. New pipeline from Washbourn Gardens to enlarged Poutama drain.	2017-19
Stage 3	Upgrade Blair Terrace and Washbourn Drive area	2019-22
Stage 4	Remove throttled bridge openings in Beach Road drain and overland flow management across Richmond Central.	2022-25

Table 2: Staging and timing of the upgrade

This staged approach has been proposed to best achieve the upgrade taking into consideration:

- the need to provide improved performance in Queen Street as a priority
- the desire to avoid dis-advantaging (or increase flood risk) to any particular area as the strategy is implemented over the stages
- to bundle projects in appropriate and sensible packages
- to avoid duplication of work interruption in specific areas

The overall design capacity will only be fully realised when the total complement of upgrades is implemented. Until that time, it is acknowledged that in the short term, a lower level of service will be provided in localised areas.

## **10 DESIGN**

Tasman District Council have approved the start of detailed design for both Stage 1 and Stage 2 of the upgrade. Stage 1 is programmed for construction in late 2016 and Stage 2 early 2017.

The following section presents some of the challenges the design team will face for both stages.

### **10.1 STAGE 1 - UPGRADE QUEEN STREET INCLUDING INVERTED ROAD CROWN**

An important part of this stage involves lowering the level of the road carriageway to create a better secondary flow path for stormwater. The crown of Queen Street will be lowered to create a central swale that will direct the flow of water away from buildings.

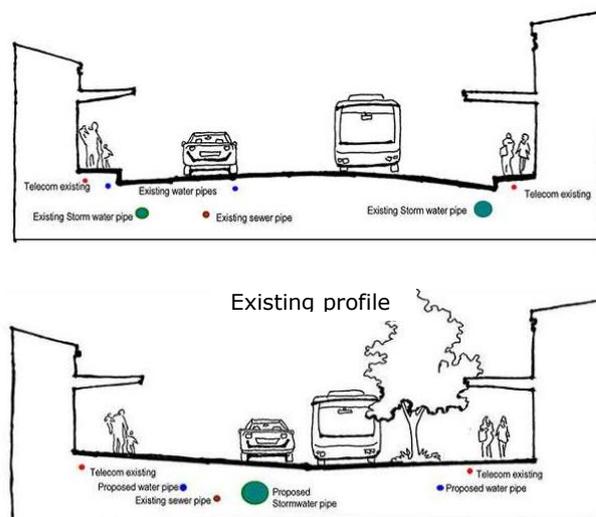
The Council is also taking the opportunity to replace and future-proof aging water and sewer reticulation in order to avoid construction works for other utilities in the near future.

To deliver these outcomes, extensive excavation work is required down the length of Queen Street and the major issue is the disruption to the public and local businesses. The works are proposed to be completed in segments with temporary road surface reinstatement to minimise traffic restrictions

Complete reinstatement of the street will be necessary from shop front to shop front. The re-profiling of the road surface provides the opportunity to improve the accessibility, safety and functionality of the street. The Council is currently engaged in community consultation on the design.



Photograph 11: Queen Street road crown



After re-profiling

Figure 10: Sketch of road re-profiling

## 10.2 STAGE 2 - NEW PIPELINE FROM WASHBOURN GARDENS DETENTION BASIN TO ENLARGED POUTAMA DRAIN

### 10.2.1 PHYSICAL CONSTRUCTION OF A LARGE PIPELINE

The proposed new pipeline from Washbourn Gardens detention basin to the enlarged Poutama drain is expected to be 1600mm dia. This will require a major excavation both in terms of width and depth.

A key challenge will be the inevitable clash with a multitude of existing services. An initial thought is to undertake service diversions ahead of the installation of the stormwater pipeline in order to provide a clear working corridor.

### 10.2.2 JUBILEE PARK, STATE HIGHWAY 6 AND POUTAMA DRAIN

The new 1600mm pipeline as well as a diversion of the existing twin 1200mm pipe will have to cross state highway and run along Jubilee Park, the main sports ground for Richmond and the largest sports and recreation reserve in the District.

The pipelines will then discharge to the existing Poutama drain and out to sea. There will be both vertical and horizontal constraints that will need to be overcome, particularly to tie into the Poutama drain and also provide minimum pipe depth cover across the state highway.

Initial consultation with both Council Parks and Reserves and NZTA staff has indicated a strong preference for a single crossing across Jubilee Park and State Highway 6. Preliminary design indicates this to be achievable but would require a major diversion of approximately 150m of the existing Richmond 750mm trunk sewer.



*Photographs 12 & 13: Jubilee Park and State Highway crossing*

### **10.2.3 WASHBOURN GARDENS**

Washbourn Gardens contains the detention basin from which the new pipeline will receive flow. The gardens are the flagship reserve in the district with frequent community events and plantings of a number of native flora and fauna.

One of the key design challenges will be the intake structure to receive flows for the 1600mm pipeline. This will have complexities from both an operations and maintenance perspective as well as a health and safety perspective not only for maintenance staff but also for the public.

Council Parks and Reserves staff have also indicated that the intake structure will need to incorporate aesthetic features to ensure that it blends in with the gardens. Additionally, there are likely to be restrictions on when construction can occur and stringent reinstatement conditions.



*Photographs 14 & 15: Washbourn Gardens (detention basin spillway – shown right)*

## **11 CONCLUSIONS**

The strategy of the Richmond central stormwater infrastructure upgrade is focused on diverting water away from the town centre and hence modifying the pathway to protect the receptor.

It will comprise significant multi-staged improvement works to achieve the high level of service that the Tasman District Council wants to meet. To upgrade the primary drainage system to the 1 in 20 year capacity involves substantial expenditure. The objective of making the town centre resilient in the face of stormwater flooding also further increases costs.

The primary system upgrades to meet the 1 in 20 year standard can very nearly deal with the 1 in 100 year rainfall event. The amount of surface flooding that results is within levels of service. Is this therefore a resilient system? A resilient system can cater for and recover quickly from greater than design events or obstruction/interruption of the primary drainage solution.

Options to improve the performance of the overland flows paths will be considered as part of the final stage of the upgrade however they will be difficult and expensive to 'engineer' in an already developed town centre environment.

Design is currently underway for the first two stages of the upgrades with Stage 1, the Queen Street upgrade planned to start later this year.

## **ACKNOWLEDGEMENTS**

Figures 2 and 3 images courtesy of Allan Leahy, MWH NZ Ltd.

Figure 4 images courtesy of Floodcontrol International

Figure 10 sketch courtesy of Tasman District Council's website

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