PROTECTING RICHMOND TOWN CENTRE

R T Lester (MWH NZ Ltd), I E McComb (Tasman District Council), D R Wilson (MWH NZ Ltd), A M Osborne (MWH NZ Ltd)

ABSTRACT (300 WORDS MAXIMUM)

Richmond town centre 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 episodes.

Tasman District Council have long known of the need to upgrade the stormwater systems, and amidst strong competition for stormwater funding, it has planned to upgrade the stormwater system in the town centre in 2016/17. A severe (1 in 500 year) event in April 2013 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.

In addition to the capacity drivers, there are a number of related matters that Council need to consider, including:

- The main 900mm pipe in the main street (Queen Street) has significant condition issues which cannot be left.
- If the main street is to be trenched to relay large diameter pipes, Council want to use that opportunity to reinstate the main street in a manner that improves the streetscape in alignment with an overall town centre framework.
- The benefit of adopting a resilient stormwater strategy. The strategy accepts that primary drainage systems do not always function perfectly and that overland flow will occur at some time. A resilient stormwater strategy will anticipate this and still manage floods in the catchment.

This paper summarises the immediate situation facing the town centre and the challenges that the project team encountered in developing a resilient strategy.

KEYWORDS

Stormwater strategy, 2-D urban stormwater modelling, resilience, pipe condition, levels of service

PRESENTER PROFILE

Richard is a 3-waters Engineer with MWH NZ Ltd in Nelson. Over his 26 year career he has developed a keen interest in stormwater management and stormwater planning.

1 INTRODUCTION

Richmond is the main town in Tasman District Council with a population of about 14,000. It sits at the bottom of the Richmond Ranges and fronts the Waimea Inlet. Queen Street is the main retail street around which the town centre thrives. Unfortunately in recent times the town centre and Queen Street has been subjected to several severe floods. The most severe was a 1 in 500 year event in April 2013 that caused widespread flooding affecting many Queen Street businesses. Council is still analyzing this event in the context of the this event and other recent extreme events with a view to revising their flood frequency assessments.

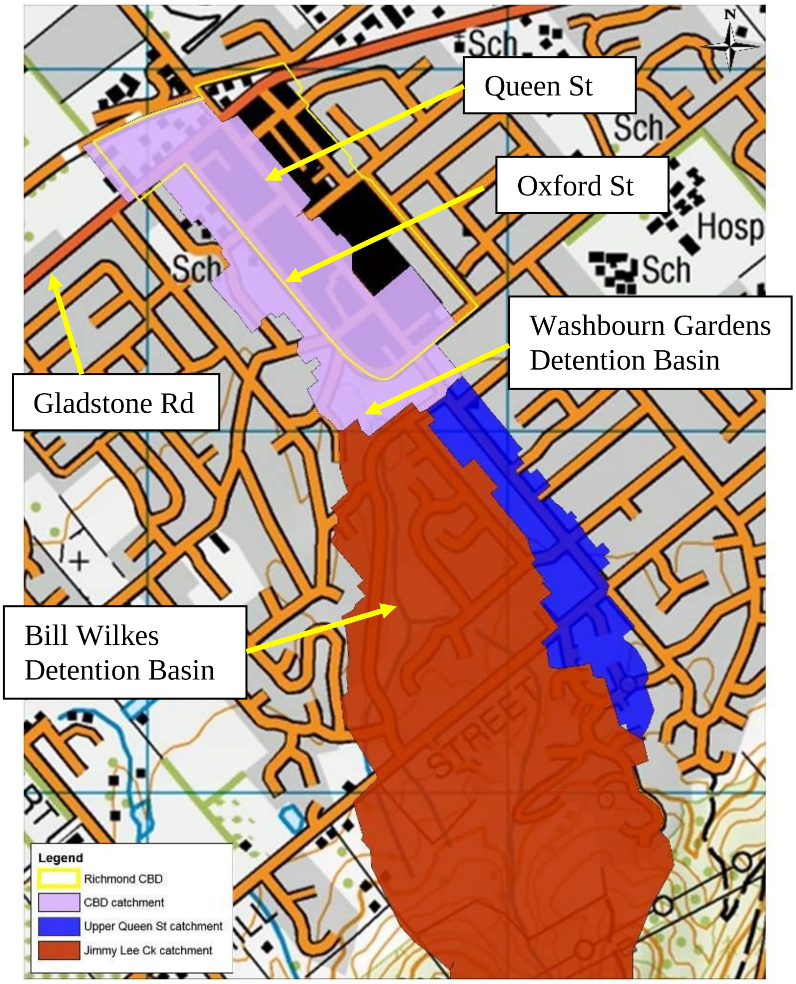
The Tasman District Council are working towards a major upgrade project to resolve the flooding, and since the main street will be significantly impacted by pipeline upgrades, they are taking the opportunity to upgrade the Queen Street carriageway, footpath and streetscape environments. This paper looks at the flooding issues that Richmond faces and how the project team are going about identifying a resilient upgrade strategy.

2 DESCRIPTION OF TOWN CENTRE FLOODING ISSUES

2.1 CATCHMENT DESCRIPTION

Figure 1 shows the three main catchments that feed into the Richmond town centre.

Figure 1: Richmond Town Centre Catchment Plan

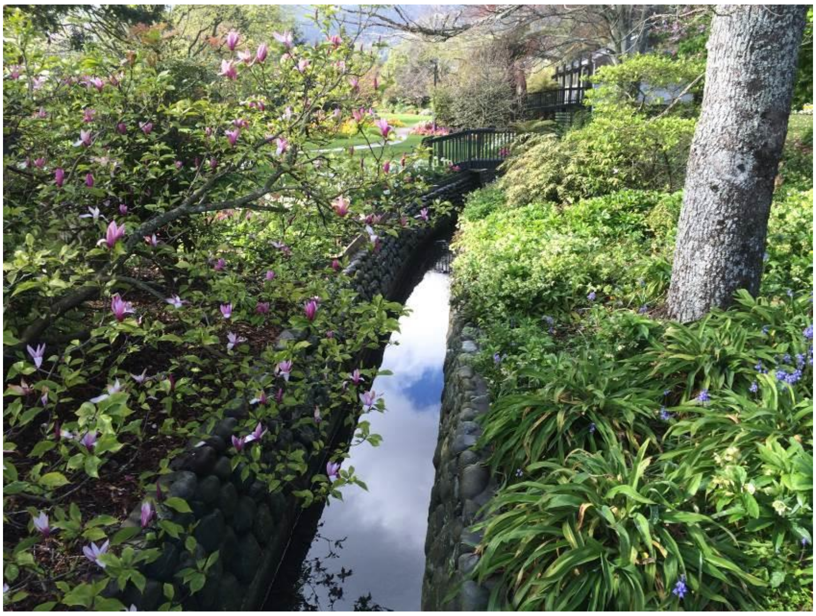


One is a long, thin, mainly urban catchment of 16.2 ha which runs off the hill around upper Queen Street down into the town centre. It is steep with an average gradient of 1 in 13 and is relatively highly developed in terms of impervious area.

The second is called the Jimmy Lee Creek catchment and 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 within it, one at the Bill Wilkes Reserve and one downstream and closer to town at Washbourn Gardens.

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 1950’s. The pipe system carries Jimmy Lee Creek down Oxford Street to Gladstone Road.

Photograph 1: The Channel Downstream of Washbourn Gardens Detention Basin



The town centre itself is 36.1 ha and is highly impervious with a large mall and several carpark 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.

2.2 FLOOD EXPERIENCE

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.

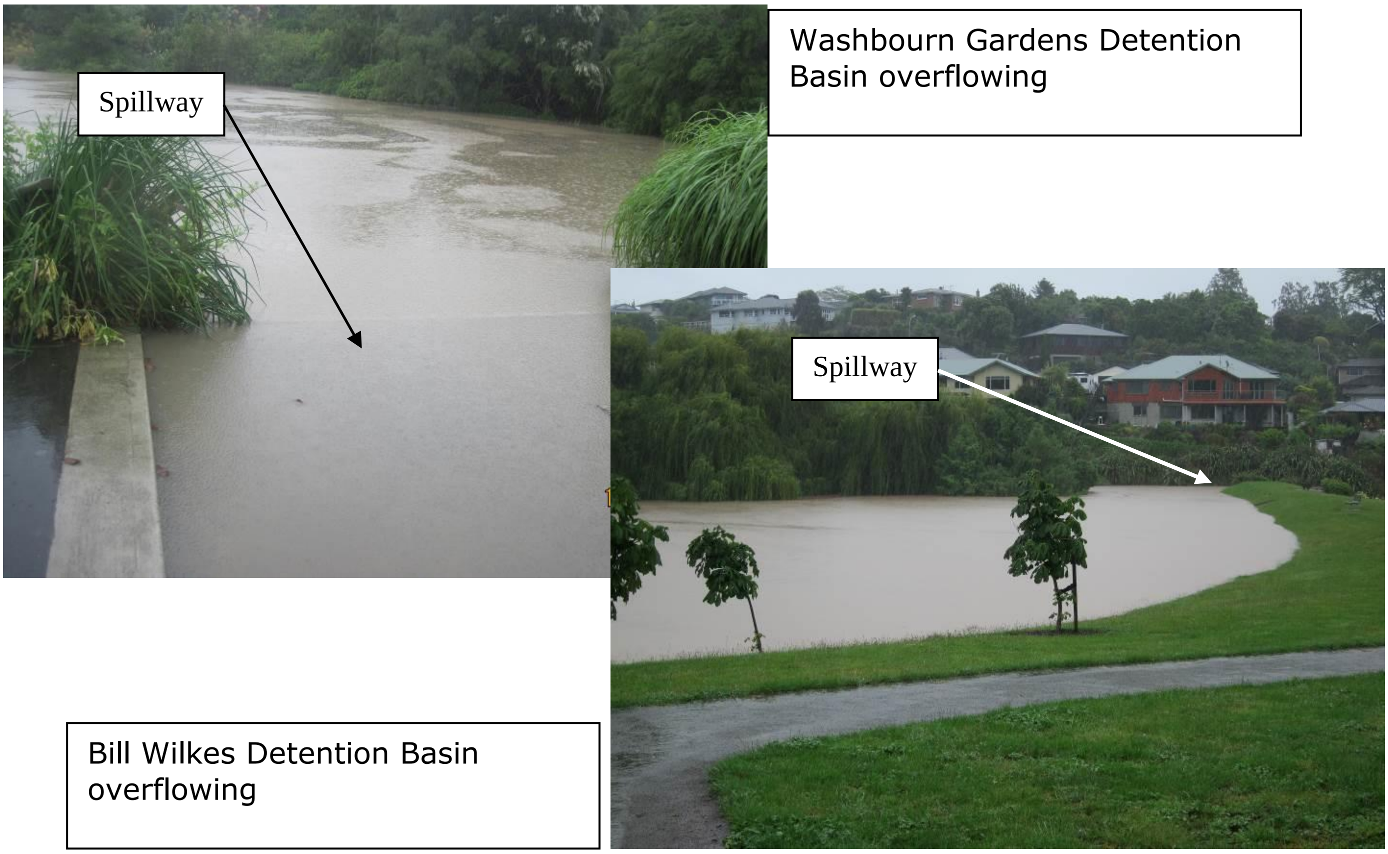
Photograph 2: Overland Flows in the Town Centre

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 carpark, inundating the carpark drainage systems and ponding at the Mall entrance which has not been designed to cope with such flood flows as photograph 3 shows.

Photograph 3: Richmond Mall Carpark off Queen Street

In the Jimmy Lee Creek catchment, the two detention basins fill up and eventually overflow the spillways as shown in photograph 4.

Photograph 4: Detention Dams Overflowing



Once the detention basins overflow, the floodwaters inundate the systems downstream causing flooding in and around Oxford Street as shown in Photograph 5.

Photograph 5: Flooding In Oxford Street

The combined 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 as shown in Photograph 6. 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.

Photograph 6: Ponding at the Bottom Of Queen Street and on Gladstone Road

The main outlet for both catchments is the Beach Road Drain. Photograph 7 shows this timber lined drain that has multiple vehicle crossings that restrict flood flows.

Photograph 7: Beach Road Drain with Bridge Constrictions Fills to Capacity

The lower parts of Beach Road Drain are tidal and even in dry conditions the drain can be at the top of the bank as shown in Photograph 8.

Photograph 8: Beach Road Drain Outlet During a King Tide

3 TARGET LEVEL OF SERVICE

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

- 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 town centre and urban areas without flooding buildings or dwellings

These LOS are consistent with the Council's Engineering Standards and contrast significantly with the 1 in 5 year capacity that most of the existing piped assets provide. As Council cannot afford to significantly advance the reticulation renewal dates, provision of secondary flow paths has been given a higher priority. Council have 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.

4 MODELLING APPROACH

The Richmond piped stormwater network was modelled in 2007 using the InfoWorks platform. As the LOS desired by 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. Council's LiDAR was used to generate the 2D 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 2D surface model. Building outlines were digitized and given high roughness so as to be largely impervious to overland flow. Street kerb and channels were digitized and modelled using higher resolution 2D grids to ensure kerb and channel flow was being adequately represented. Adjustments and some isolated 2D 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. In one such example, photographs showed flood water flowing around a corner, yet the initial 2D model indicated it flowing across the road. The 2D model had to be modified to better represent the real situation.

Various quality assurance checks were undertaken to ensure the base data was sensible. A number of discrepancies were identified that needed to be resolved. Because the focus of the project is the CBD, the discrepancies in this area were focused on. Some of the issues that led to discrepancies included:

- Inaccuracies in converting the LiDAR into a DTM, especially in tree covered areas. In one area, one embankment of a detention basin was planted and the LiDAR conversion represented the planted area as a breach of the embankment.

- Discrepancies between the LiDAR DTM ground surface and manhole lid levels and open channel bank levels.

- High number of interpolated inverts because the 1970's piping of an open channel drain along the road was completed without manholes. There were therefore very few opportunities to get levels.

5 SYSTEM PERFORMANCE

5.1 EXISTING SYSTEM PERFORMANCE

The 1 in 20 and 1 in 100 year inundation maps are shown in Figure 2 and Figure 3 respectively.

Figure 2: 1 in 20 Year Inundation Map – Existing Network

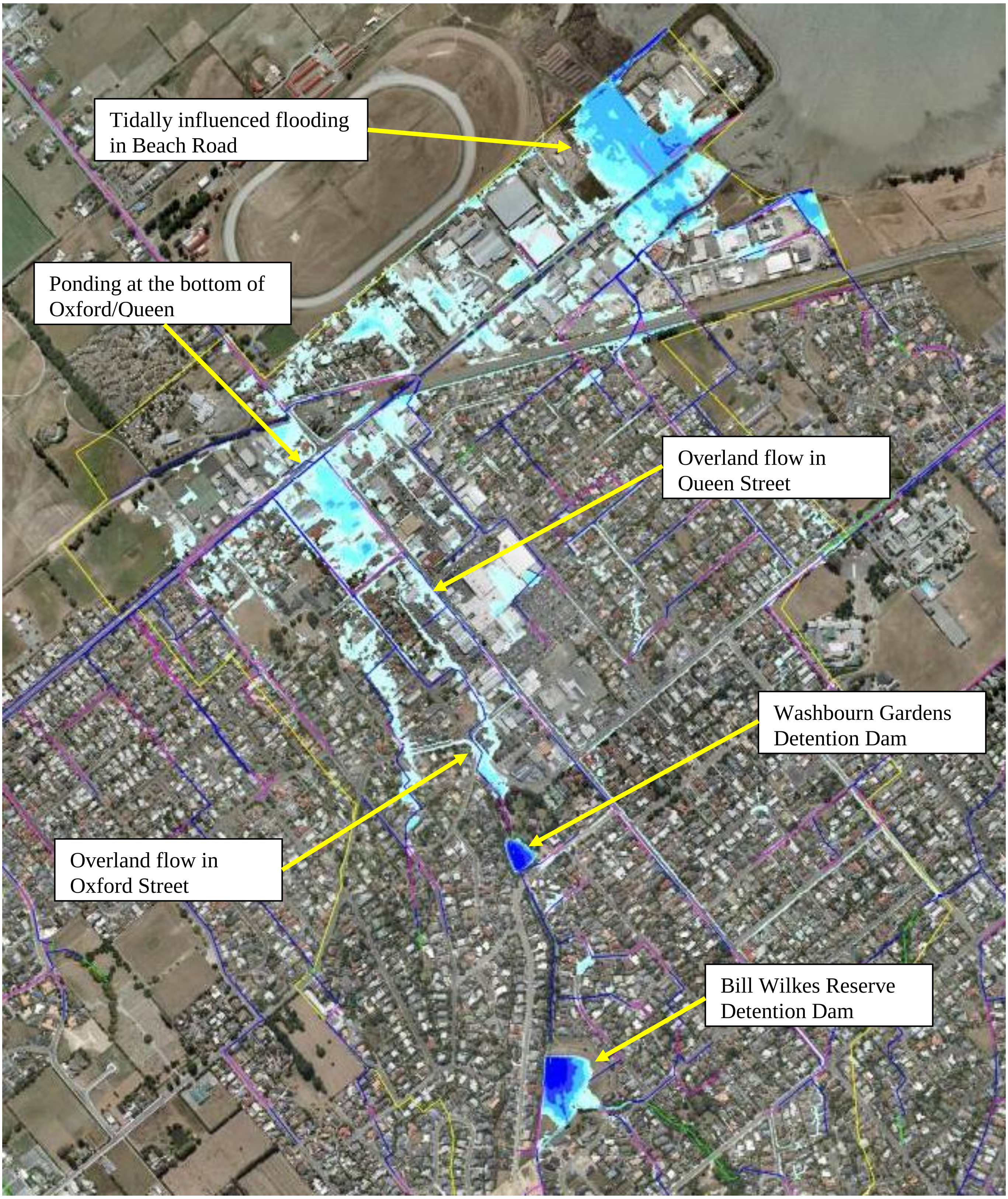
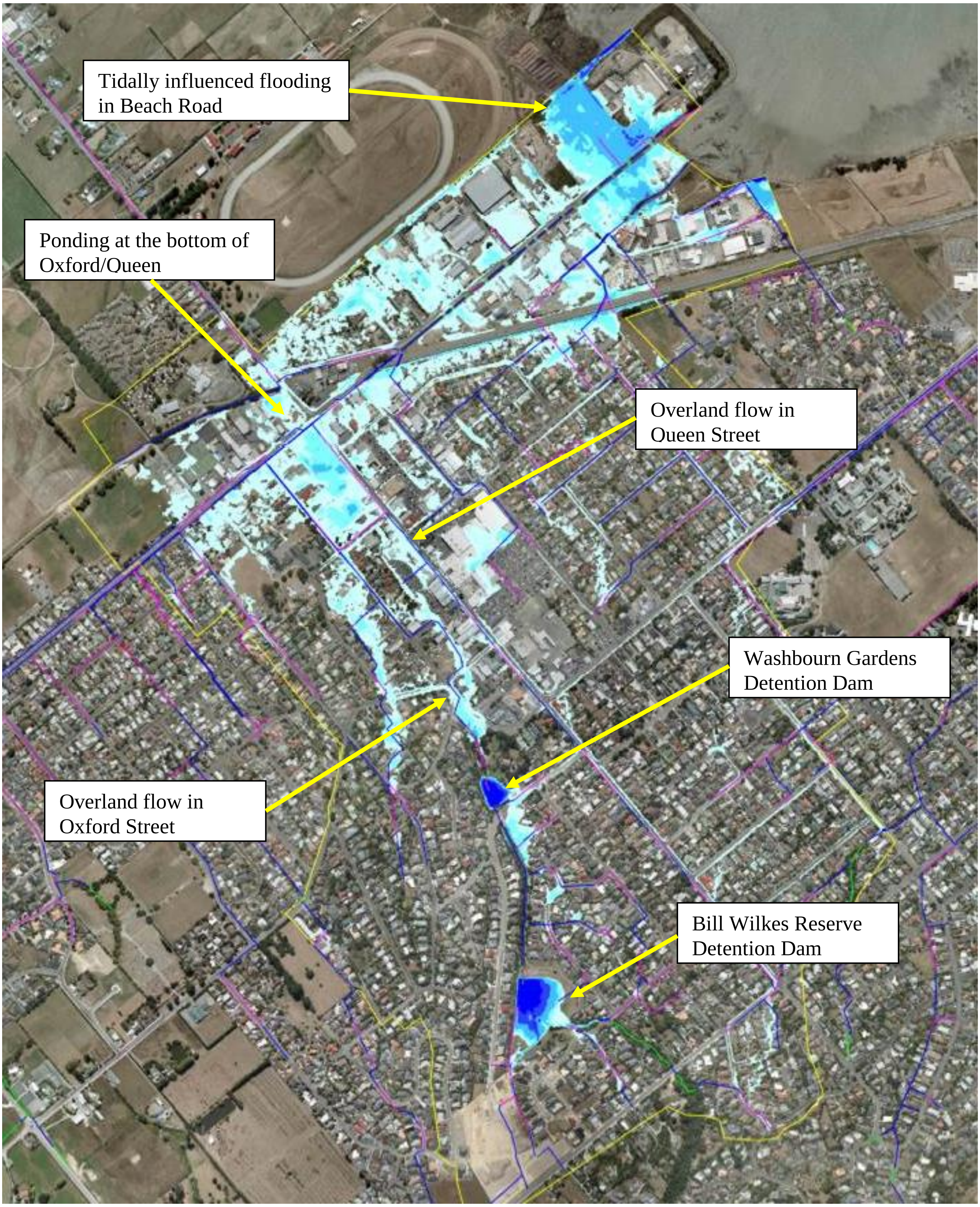


Figure 3: 1 in 100 Year Inundation Map – Existing Network



The overland flows were compared against Council staff knowledge of flood history, flood photographs, Council's database of flooded properties from the April 2013 event and Council's GIS model of the overland flow path developed from LiDAR. The modelled flood performance aligns well with the official records and anecdotal knowledge of flooding.

However, the extent of flood information that Council holds is thought to be no more than 50% of the properties that actually flooded. The reasons for this gap include:

- The flooding occurred very quickly, at dusk, so staff had little time to get around to see the peak results.
- Residents were sometimes reluctant to advise Council of flooding due to concerns regarding flood information going on property files and Land Information Memorandums (LIMs). We understand experience from other Council's in New Zealand show that when flooded, 80% call the fire service compared to 20% who call the Council.

A Council review of this April 2013 flood event was documented in (McComb et al, 2014).

5.2 SYSTEM PERFORMANCE WITH PREVIOUSLY PLANNED UPGRADES

Council had projects in their Long Term Plan (LTP) 2012-22 to address the flooding in and around the town centre. These had been developed through high level strategizing, but were based on a lower level of service than Council has recently adopted as part of the 2015-25 LTP process and were not supported by integrated modelling. They were also staged over a long time to spread the financial burden, however there had not been a detailed assessment of the impact of the staging. The existing projects provided a starting point for the identification of solution options and were included in the model to demonstrate their effectiveness.

5.3 MAIN FLOODING ISSUES

The main flooding issues identified through analysis of the existing system performance were:

- Queen, Gladstone, Oxford area without an adequate outlet: The lower Queen Street, Gladstone Road and Oxford Street area is flat. The primary drainage system has a reasonable capacity but not sufficient to carry extreme events and there is no overland flow path to allow surface water to drain before buildings flood. Gladstone Road itself has a high crown which contributes to the problem and the nearest point of relief, Beach Road Drain is some distance away.
- Lack of Capacity in Queen Street and Oxford Street: The Queen Street and Oxford Street pipe systems are unable to carry the 1 in 20 year flows and the overland flow paths are unable to convey surface flows without flooding buildings through the town centre.

An additional issue that needs to be factored into the upgrade strategy is the condition of the 900 mm diameter stormwater main in Queen Street. The bottom of the concrete pipe has been eroded and is in a very poor condition (refer Photograph 9).

Photograph 9: CCTV Image of Queen Street 900mm Diameter Main

The original construction of the main was irregular, with the pipe being cast in two halves and assembled on-site. It is thought that this method of construction has contributed to the poor condition. It has been concluded that this pipeline either needs to be re-mediated, replaced, or filled up and abandoned. The upgrade strategy needs to include consideration of the pipeline's condition.

6 SOLUTION OPTIONS CONSIDERED

6.1 APPROACH TO SOLUTIONS AND RESILIENCE

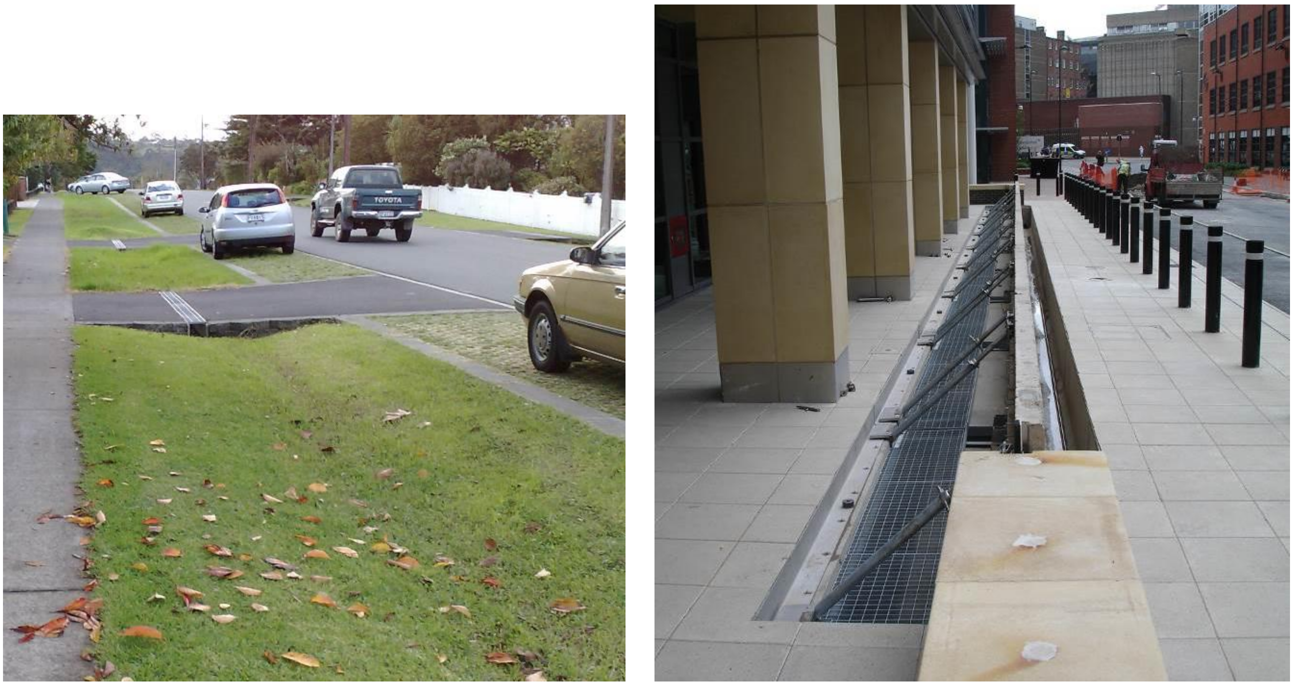
The level of service required is to keep stormwater contained in the primary drainage system in the 1 in 20 year event and out of commercial buildings and dwellings in the 1 in 100 year event. Our approach has been to size the primary drainage system for the 1 in 20 year event through the town centre, and to manage larger storms on the surface using resilient solutions where possible.

The resilience approach is based around accepting that primary drainage systems will overflow at some point, either through higher than design storms, or through obstruction or some other unanticipated event. A resilient system will still function to manage and direct floodwaters in a manner that avoids widespread damage and allows affected properties to return to use quickly with minimal damage.

When the capacity of pipe networks is exceeded, the additional flow will very quickly end up on the surface. For a resilient solution you need to anticipate where the surface flow will travel and manage the full secondary flow path.

Open channels by nature include some resilience because there is some capacity to carry higher flows above design levels. Open channels therefore often form part of a resilient stormwater solution and re-introducing open channels in previously fully piped stormwater systems ("daylighting") is an increasing trend. However there are means of achieving resilience such as flood proofing buildings, sacrificial storage, and controlling the flow on the surface using surface structures to divert the flow along planned paths.

Photograph 10: Examples of Resilience Solutions In Urban Situations



Photos courtesy of Allan Leahy

Photograph 11 shows some local examples of where works have been completed to provide more resilience on one of the main overland flow routes – Oxford Street by building low walls to divert overland flow away from buildings.

Photograph 11: Resilient Solutions Already in Place in Oxford Street

The project team therefore sought to develop a resilient stormwater system to protect the Richmond town centre.

One of the primary proposals that was discussed at the outset was to have an inverted crown in Queen Street to carry overland flow. The existing crown had built up above footpath and sometimes shop floor levels through successive reseals and Council wanted to upgrade the seal and footpaths anyway. This led to the idea of an inverted crown and the combination of the stormwater, streetscaping and roading project. Council intends to narrow traffic lanes, modify the parking potentially moving to angle parking and widen footpaths to make the town centre a slower speed more pedestrian friendly environment.

This idea was tested through a workshopping exercise to determine whether it was suitable. One of the significant issues raised was the public safety aspect with the combination of depth and velocity of overland flow and the impact on pedestrians and cars. Photograph 12 illustrates the hazard fast moving flow can be to people and cars.

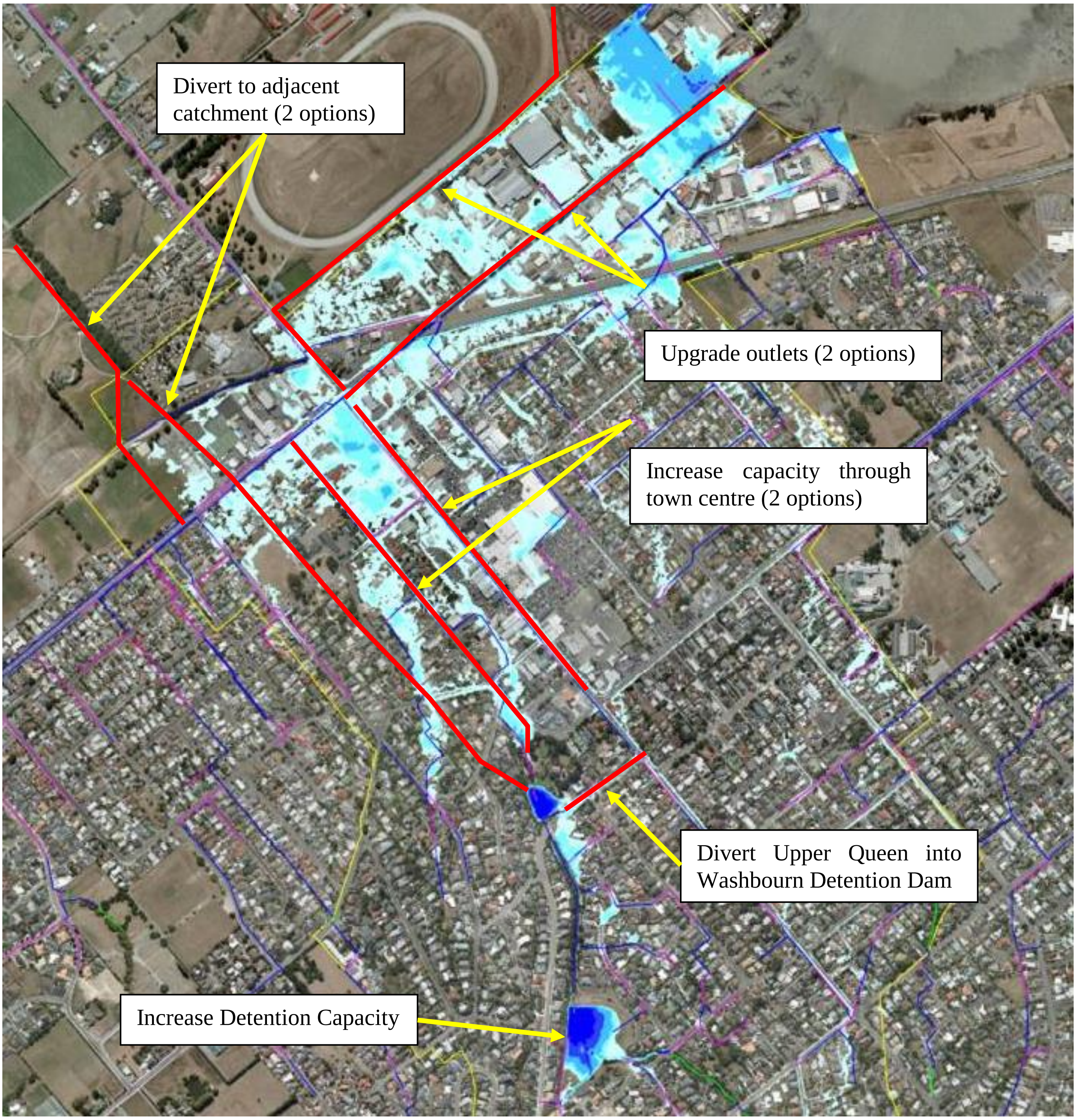
Photograph 12: Photo Illustrating Hazards of Overland Flows

Ultimately Council decided that carrying overland flows through the town centre was not aligned to the town centre landuse or what Council wants to achieve in their main street. The principle was adopted that uphill overland flow would be diverted away from Queen Street. The concept of the inverted crown has been retained and is planned to be incorporated into streetscaping and hence will still form part of a resilient strategy. However, the surface flows will be significantly reduced and the carriageway will only carry the excess runoff from rain that falls directly on the town centre rather than conveying overland from upstream through the town centre thus significantly reducing hazard to pedestrians and vehicles.

6.2 SHORTLISTING

The project team went through a two stage shortlisting process to identify the preferred upgrade strategy. The first stage was a workshop where existing system performance was reviewed and options were brainstormed under the groups of source, pathway, receptor and resilience. The impractical or unfeasible options were discounted and 8 main options were identified for further investigation. The project team is currently assessing these options. Figure 3 schematically shows the options being assessed.

Figure 3: Eight Options Being Assessed



7 THE CHALLENGES OF RETROFITTING RESILIENCE MEASURES INTO A DEVELOPED CATCHMENT

As identified earlier, the preferred approach to managing the 1 in 100 year event to meet the level of service was to use resilience measures to avoid more investment in large infrastructure. The two main opportunities for this are in Queen Street and Oxford Street.

In Queen Street, a significant driver was streetscape and retaining the functionality and form of a central retail precinct. Options to use a deeply inverted crown to carry the overland flow did not align with this driver. Nor did options of interlinking, cascading rain gardens, or planted channels. Once the principle was established that Queen Street was to be avoided as a significant overland flow path, the streetscaping drivers took over. The desire to lower the crown from a road profile perspective has been retained, but slowing the traffic, pedestrian flow and establishing a parking strategy to suit these have become the primary design drivers. However the inverted crown will keep stormwater away from shop fronts and provides an element of resilience.

Oxford Street remained a location where resilience needs to be considered. There seemed to be good opportunity as the previously installed resilience examples are in Oxford Street (refer Photograph 11). However it has proved difficult to provide the resilience. Some of the main issues encountered include the following:

Primary Capacity: the existing primary system needs to be significantly upgraded to meet the 1 in 20 year event level of service. Once the pipe network is in place to deal with the 1 in 20 year event, the system performs reasonably well in the 1 in 100 year event.

Inverted Crown: An inverted crown in Oxford Street would require a complete street re-construction at considerable cost not just for the roadworks, but also to address shallow services.

Surface Channel: Some kind of open channel on a foot path was initially appealing because much of the length of Oxford Street has a reasonable 4.5 m wide footpath and grass verge. However, for significant lengths, the road corridor narrows as the property boundaries inset into the road reserve leaving little opportunity to locate channels.

Also on the south side of the street the ground slopes away from the road where a side catchment joins Oxford Street. This makes it difficult to keep the flow in the road reserve without flooding into the adjacent properties, impeding property access, or damming the overland flow paths joining Oxford Street from the south.

A surface channel of this nature was therefore very difficult to make work.

Carpark Storage: There is a 6,600 m^2 carpark in the block between Oxford and Queen Streets that surface flow naturally gravitates to and that is ideally located to store surface water. Converting this carpark to store runoff with a series of ‘turkey-nest’ dams or cascading dams using raised traffic features was considered, however, the topography was not favourable. The downhill gradient is steep and the horizontal profile of the carpark is ‘humped’. To get any sizable storage would mean totally re-constructing the carpark, excavating the centre of the carpark to some depth and even then not getting sufficient storage to mean pipe upgrades were not required in the streets. It also meant the storage depths in some locations would need to be deep which does not suit a carpark activity.

LIDS: The option of converting large impervious surfaces to soakage or permeable paving was considered but it was assessed that it would not provide sufficient peak flow reduction to enable major primary drainage improvements to be avoided.

Flood Defence: Flood defences such as have already been installed in Oxford Street were considered impractical to apply over a wide residential area. In the Oxford Street area, they were either going to be:

- Permanently in place – which with the topography issues would be a significant visual and physical obstruction
- Manually operated, which, with short catchment times of concentration raises response time and cost issues if operated by Council, and reliability issues if operated by property owners.
- Automated, which was considered impractical and unaffordable.

Providing a resilient solution at an affordable cost is therefore proving a challenging target. To retrospectively engineer a flow path or channel on the surface in an already developed urban area was leading towards expensive civil works. Already to achieve the desired levels of service in the primary network was costing millions of dollars. Then to also try and form surface facilities to control surface flows is yet more expensive.

The approach that we are now exploring with Council is to accept that there are no easy answers, and to look in more detail at the paths the flows will take and to identify where there are opportunities to make gains. This might involve surveying floor levels to check where they are relative to predicted flooding levels, subtle use of footpaths and traffic controls to direct flow. There are some areas where a fully resilient solution is unaffordable and achieving the LOS will rely on the performance of the primary drainage solution.

8 CONCLUSIONS

The Richmond town centre faces significant upgrades to achieve the high level of service that Tasman District Council wants to achieve. To upgrade the primary drainage system to the 1 in 20 year capacity requires significant upgrades in the millions of dollars. The further objective of making the town centre resilient in the face of stormwater flooding will increase the cost.

The primary system upgrades to meet the 1 in 20 year standard can very nearly deal with the 1 in 100 year storm and 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. The flood modelling of Richmond indicates that the overland flow paths have not historically been defined sufficiently to control surface flows without flooding buildings. Options to improve the performance of the overland flows paths have been considered however they are difficult and expensive to ‘engineer’ in an already developed town centre environment.

The options to provide this improved resilience are therefore a challenge. The project team are consequently looking at more subtle means of controlling surface flows where they can be and determining the degree that surface flooding can be accepted in naturally flooding areas.

ACKNOWLEDGEMENTS

Tauranga City Council provided information regarding their inverted road profile experiences.

REFERENCES

McComb et al, 2014 Responding to Acts of God, 2014 Stormwater Conference, Water NZ, Christchurch