SCIRT Rebuilding Infrastructure

LEARNING LEGACY

Lessons learned from one of New Zealand's most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

Central City Asset Assessment Report

Story: Central City Infrastructure Rebuild

Theme: Programme Management

An outline of the levels of service and condition of the horizontal infrastructure within the central city, providing a broad indication of damage, service levels provided to residents and business owners, and to estimate the cost of repairs following the earthquake events.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz

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Stronger Christchurch
Infrastructure Rebuild Team

Condition Assessment of Horizontal Infrastructure within the Central City

Investigation Report

Status: Second Issue

Date: 11th May 2012

Contents

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Executive Summary

Stronger Christchurch Infrastructure Rebuild Team (SCIRT) has been requested to provide a report to outline the current Levels of Service (LOS) and the condition of the horizontal infrastructure within the area referred to as the Central City. This is in order to provide a broad indication of damage, service levels provided to residents and business owners, and to estimate the cost of repairs following the earthquake events.

Key findings of this report are as follows:

- **Levels Of Service**

  Investigations for this report indicate the existing network supports minimum service levels for the population inhabiting the Central City at this time, with on-going reactive maintenance to maintain this service. However as the population occupying the Central City is less than the pre earthquake population, particularly in the commercial sector, on-going monitoring of service levels supported by reactive and preventative maintenance will be required as the city is re-inhabited.

  SCIRT are currently in the process of developing a Service Plan jointly with the CCC Operational teams to identify assets which have a high, medium or low risk of not providing a service, or may fail within 2 years. This will allow either proactive programming of temporary maintenance holding strategies, (implemented to meet the needs of new or existing developments as they come on-line, or are re-inhabited), or if a major issue is identified, allow accelerated programming of permanent rebuild work. This plan will minimise the risk to the CCC of not being able to provide a basic level of service to support the redevelopment within the central city, and eliminate the need to impose development restrictions due to asset condition prior to infrastructure rebuild. This Plan will be available before June 2012.

  The maintenance and the performance of the assets will need to be formally recorded and monitored during the rebuild process to allow reactive and preventative work to be undertaken.

- **Waste Water & Storm Water Trunk Network**

  The initial wastewater and storm water trunk networks were installed in 1880's in the form of brick barrel sewers. Initial CCTV quality of these pipes was not reliable largely due to emergency response factors and several collapses were repaired immediately after the earthquake events. A programme of improved quality CCTV is currently being undertaken as part of the Brick Barrel Project.

  Of the wastewater brick barrel sewers assessed to date, the sewers on Tuam Street, Madras Street and Kilmore Street are damaged to a greater extent than those on Moorehouse and Fitzgerald. However, all brick barrels have visible earthquake damage.

The storm water brick barrels, where assessed, are also damaged to a great extent. Assessment of these assets will continue and reported on once complete.

For the purposes of this report, it has been assumed that all of the brick barrel pipes in the Central City will require rehabilitation due to the damage, and to provide resilience for future seismic events.

In more recent times the Central City Relief Sewer, Fitzgerald By-Pass Sewer, New Western Interceptor & Southern Relief Sewers have been installed forming the balance of the trunk network within the Central City. These are constructed from reinforced concrete rubber ringed (RCRR) pipework. These pipes have not yet been inspected, however from assessments of similar pipework in other areas, it is expected that they will have sustained only localised earthquake damage. This report will be updated on completion of the CCTV assessments.

- **Waste Water Local Reticulation**

  The Waste Water network includes 66.4km of pipework with 70% of the network (46.7km) constructed more than 100 years ago from earthenware materials.

  25km (38%) of the network has been assessed to date using CCTV surveys and for the purpose of this report, the remaining network has been assessed using the SCIRT MCA Damage Probability tool to allow assumptions of damage levels to be made. Further CCTV surveys will be undertaken to confirm accuracy of the MCA tool.

  In summary, applying the Threshold Levels from the Technical Standards & Guidelines Document, the assessment has found that:

  - 42km of the network (64%) has been identified for full renewal,
  - 8km of the network (12%) has been identified requiring repair only
  - 16km of the network (24%) has been identified for no action

  The full analysis by diameter and pipe material can be found further in the document.

  Consideration will be required for resilience and remaining life issues before a final decision is made regarding the renewal length, particularly for earthenware pipework (approximately 7km of EW pipework is included in the repair / no action lengths).

  It is likely that the replacement lengths will exceed damaged lengths where it is found that upstream pipes have lost grade. Typically, when this occurs, the replacement of downstream pipework is often required to meet self-cleansing velocity Infrastructure Design Standards (IDS). These replacement lengths have not yet been quantified, and hence not included in this report. Concept design will be required to quantify this.

  There are two wastewater pump stations in the Central City. PS2, located in Cambridge Terrace has sustained some earthquake damage but is repairable. However, it is located close to the Avon River and it may be desirable to relocate it to provide resilience against future earthquakes.

The pump station in Bangor Street has sustained higher levels of damage and located in an area that has recently been zoned red. Replacement options will therefore be required during the concept design stage.

- **Stormwater Local Reticulation**

  The storm water network includes 53km of pipework with approximately 75% installed between 1970 and 2000 using reinforced concrete rubber ringed (RCRR) pipe.

  Very little of the network has been assessed using CCTV and therefore for the purposes of this report, the network has been assessed using the MCA tool. A programme of CCTV work will be needed to determine the accuracy of the MCA tool before damage levels can be accurately reported.

In summary, applying the Threshold Levels from the Technical Standards & Guidelines Document, the MCA assessment has predicted that:

- 10.8km of the network (20%) has been estimated for full renewal,
- 6km of the network (11%) has been estimated requiring repair only
- 36.2km of the network (69%) has been estimated for no action

Assessments of this pipe material have found that generally, it has good levels of resilience and therefore only localised earthquake damage is envisaged. Although pipe grades will have been disrupted, this is less of a concern than for the wastewater system due to the surcharging and flushing that occurs in the storm water system during storms.

It is assumed that there is the potential for localised flooding in areas of the Central City due to the ground settlement, and furthermore capacity has been lost within the piped network effectively lowering the expected levels of service during storm events. This could mean that the secondary flow paths (roads and channels) will operate sooner than pre earthquake levels. However this has not yet been confirmed and will require hydraulic model development to verify this.

It is therefore expected that only localised sections of the storm water reticulation network will need to be repaired/replaced due to earthquake structural damage, with further sections of the network replaced due to the lost system capacity.

Only two urgent repairs have been required, one on Manchester St (channel backfilled by demolition contractor) and one on Kilmore St (collapsed main).

- **Potable Water Network**

The Water supply network comprises 73km of mains and 52km of sub mains. Pipe materials vary across the city and include Asbestos Cement, Cast Iron, Ductile Iron, Polyethylene, PVC and other forms of pipe materials

Damage levels for water mains are assessed by the number of breaks repaired following the earthquake events, with renewal decisions made on total number of breaks and the remaining life of the asset as set out in the Technical Standards & Guidelines. It is common practice that during full road reconstruction projects water mains and sub mains are renewed due to the economic benefits of doing this, however for the purposes of this report, this has not been assessed. This decision will need to be made at a later date.

The repairs (including mains, sub mains, individual connections and hydrants) have generally not met the threshold for wholesale water main replacement in the central city. The trunk supply network itself appears to have suffered little obvious damage despite ageing assets. It may be necessary, to determine overall damage and to meet LOS requirements, that leak detection surveys are undertaken. This has not been initiated to date. SCIRT are presenting a paper to the CGG in May with regards to the benefits of leak detection surveys.

In addition, as new developments come on-line and a request for service is made, it has been found that many of the sub mains have been damaged due to the demolition work. It is not currently possible to quantify this damage at the present time.

In summary therefore, applying the Threshold Levels from the Technical Standards & Guidelines Document, the assessment has found that:

- 6.7km of the network (9%) has been identified for full renewal
- All repairs are reactive and undertaken as they are identified

- **Roading**

The roading network includes 65km of pavements, Kerb & Channel, footpath and surface drainage assets. The predominant surface layers are Asphaltic Concrete, Open Graded Porous Asphalt, Block Paving and Chipseal surfacing.

Unlike the underground assets, the damage has not been related to material type but closely follows the damage caused by liquefaction, lateral spread and cracking of surfaces due to the horizontal and vertical forces during the earthquake event.

Following each of the major seismic events, a condition survey was undertaken detailing all earthquake related damage to categorise roading assets as suffering Minimal, Minor, Moderate, Major or Severe earthquake related damage.

In summary of this condition assessment, the earthquake damage can be stated as:

- 14km pavement un-assessed within the cordon zone
- 5km of pavement suffering severe damage
- 3km of pavement suffering major damage
- 2.5km of K&C suffering severe and major damage
- 15km of footpath suffering severe and major damage

This indicates initial EQ damage only. However, demolition work will have had an impact on the current condition with on-going damage expected during the demolition programme.

Further damage is also expected from redevelopment works and deterioration of the roading assets due to water intrusion into the pavement layers (due to EQ damage and construction activity). A full resurvey and comparison with the damage data will be required to consider this.

Renewal and total cost of repair will not only be dictated by the earthquake damage, but will also be dependent on the proposals in the Central City Plan such as Eco Streets, Slow-core roads and traffic flow changes. The district energy scheme, tramway and light rail proposals will also affect the cost of the roading rebuild / repair.

The significant trenching works required to repair and renew the underground infrastructure will also have notable effect on the roading assets and the resultant pavement renewal works.

As the Central City area is a high quality amenity area, the damage thresholds for renewal and repair work that is acceptable in suburbs may not be acceptable in the Central City.

- **Bridges**

  There are 17 bridge structures within the central city area including 15 road bridges, and 2 footbridges.

  A preliminary condition assessment has been undertaken which identified 10 structures to have only minor to moderate earthquake related damage, and 7 structures with high damage levels. The main defects, identified include the settlement of bridge approaches, movement and rotation of wingwalls and abutments, concrete spalling and structural cracking. All bridges are currently within the SCIRT design process.

- **Cost Estimate**

  The original cost estimate undertaken by WT Partnership has not been modified as part of this report.

  However, it will be possible, under a separate exercise to compare the original estimated damage levels with the information contained within this document to outline the differences.

  It will be necessary for a further review of the cost estimate as more assessment of asset condition is made, and concept designs progress for optimal design of network assets.

1. Introduction

Christchurch City Council (CCC) has requested the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) provide a report with regard to current Level of Service (LOS) compliance and the asset condition for horizontal infrastructure within the area referred to as the Central City (Study Area, refer Figure 1, inclusive of the 4 avenues – Deans Avenue, Bealey Avenue, Fitzgerald Avenue and Moorhouse Avenue).

A copy of the original Client Brief for this report is presented in Appendix 7.1.

Figure 1 Central City Study Area

1.1. Stakeholders

The following key stakeholders are relevant to this Study:

- Bruce Henderson, CCC Asset Management Team Leader
- CCC Asset Owners
- SCIRT Asset Owner Representatives

- John Moore, SCIRT Asset Assessment Leader

In addition, the report will be made available to the CCC Central City Team, representatives from CERA, NZTA and those parties who will be impacted by the programme. This will be distributed by Will Doughty on behalf of the Client Interface Team.

2. Network Description

2.1. Wastewater (WW) Catchments and Network Features

Figure 2 Central City Wastewater Catchments and Key Infrastructure Components

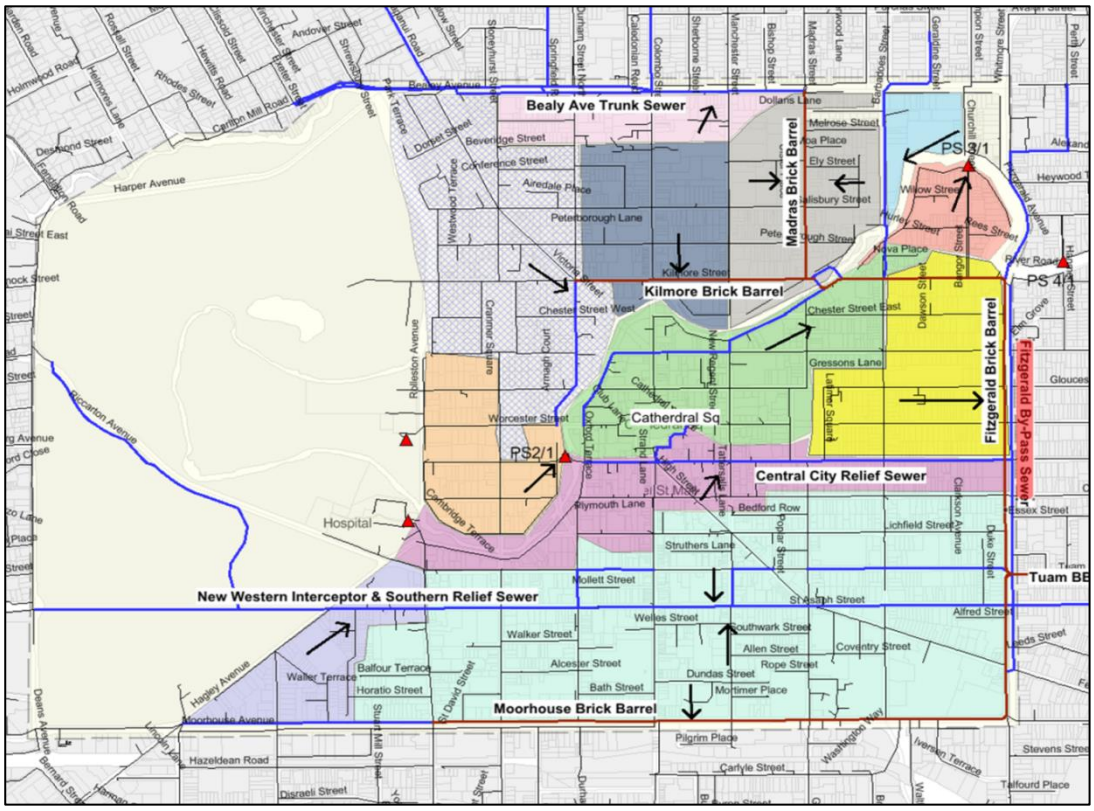


Figure 2 presents the wastewater catchments and key infrastructure components in the Central City area. In general the WW system collects and conveys wastewater loads generally in a west to east direction from the surrounding catchments.

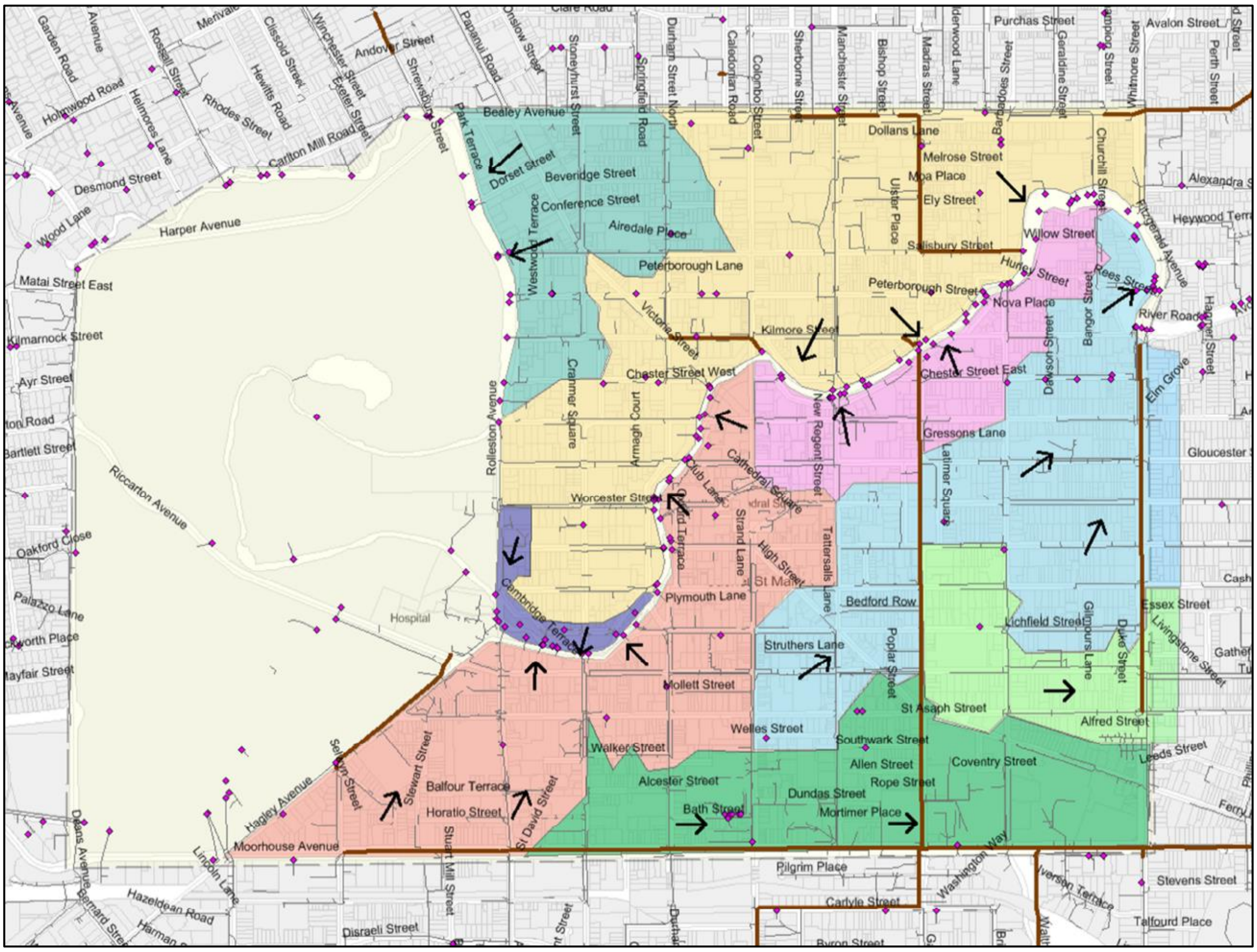
Particular features of the wastewater system include:

- The Central City area confined through trunk sewers located on Bealey Avenue to the north, Moorhouse Avenue brick barrel to the south, Fendalton Duplication to the west, and the Fitzgerald St brick barrel to the east.

- Five discrete sub-catchments to the north of the Avon River. Pump station PS02 lifts and discharge flows from the local sub-catchment to the Hereford St Central City Relief trunk sewer.
- Six discrete sub-catchments to the south of the Avon River. Pump station PS03 lifts and discharges flows to the Kilmore St East brick barrel trunk sewer.
- There are also the Central City Relief trunk sewer along Hereford St, and the Southern Relief and Western Interceptor trunk sewers along St Asaph Street.
- A significant amount of the network was constructed more than 100 years ago with the trunk sewers built in the form of Brick Barrels, and the local reticulation system from Earthenware materials.
- The Council has developed a hydraulic model of the wastewater system which is available for use by the SCIRT Design Teams.

2.2. Storm Water (SW) Catchments and Network Features

Figure 3 – Storm water Infrastructure & Key Components



The SW network collects surface water through a network of kerb and channel infrastructure, under-channel pipes, sewers and trunk mains (some of which are >100 year old brick barrels).

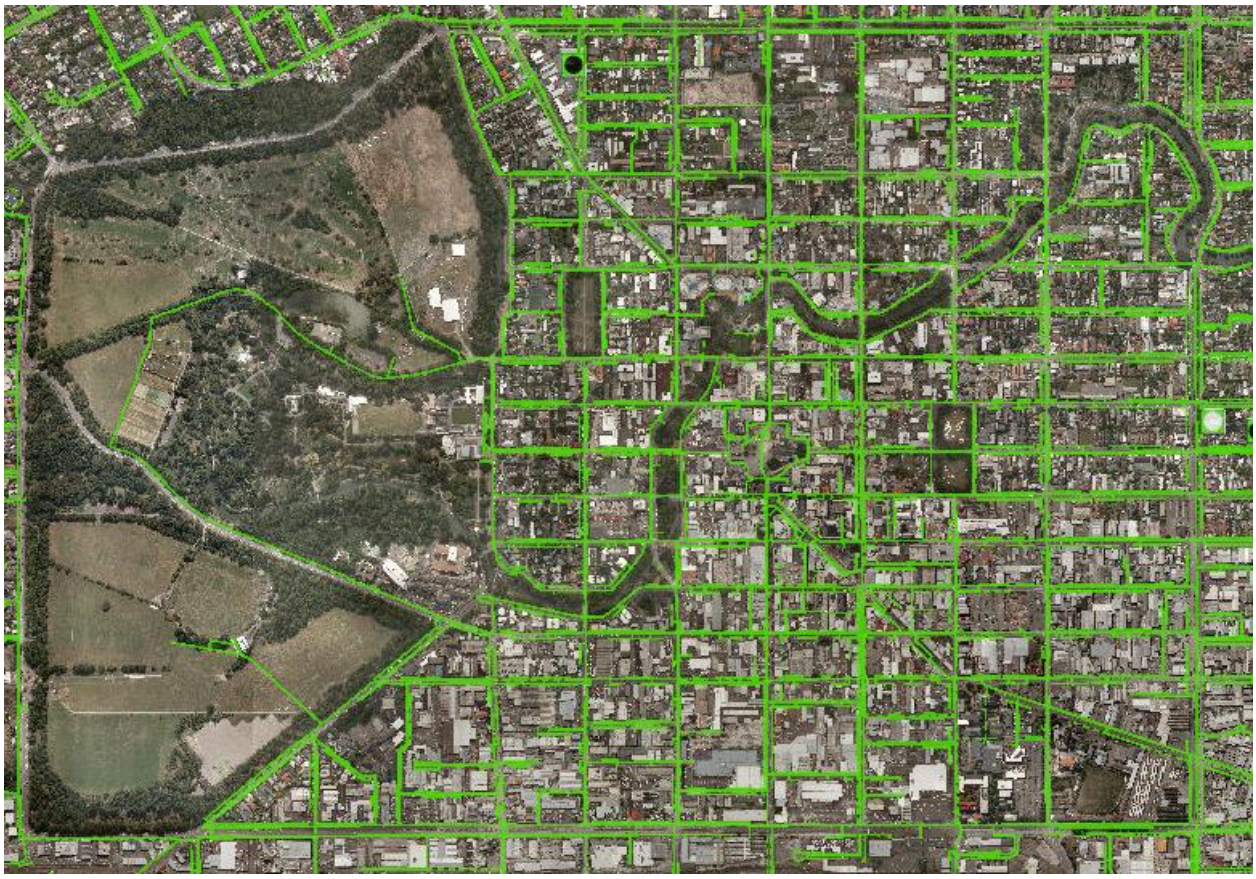
Approximately 2/3 of the central area discharges to the Avon River. The south-eastern portion discharges eastward to the Heathcote River and City Outfall Drain. The Moorhouse Ave brick barrel is an important link with the Heathcote River and other trunk mains. There are important interconnections to neighbouring catchments in the west and south that provide useful redundancy and additional capacity. These linkages, and the size of trunk mains, are believed to be reasons for the system's good past performance. Particular features of the Stormwater system include:

- With the exception of the Brick Barrels, the majority of the piped infrastructure was constructed between 1970 and 2000 from reinforced concrete, rubber ringed pipework (RCRRP)
- There were no recorded flooding areas due to undersized SW pipework prior to the earthquake events.
- There is currently no SW pipework catchment model for the Central City as this time. It is envisaged that the CCC with SCIRT's assistance will develop this model to assess any

effects of the lateral spread (reducing the River Avon's capacity) and ground settlement (potential loss of capacity or localised flooding issues) to assist the rebuild process.

2.3. Water Supply (WS) Zones and Network Features

Figure 4 – Water Supply Infrastructure & Key Components



The WS network comprises 7 pressure zones of which the Central area is the largest. A water supply well and pumping station is located Montreal Street near Bealey Avenue and the trunk main to the Central City is a 650 mm diameter main supplied from Colombo Street.

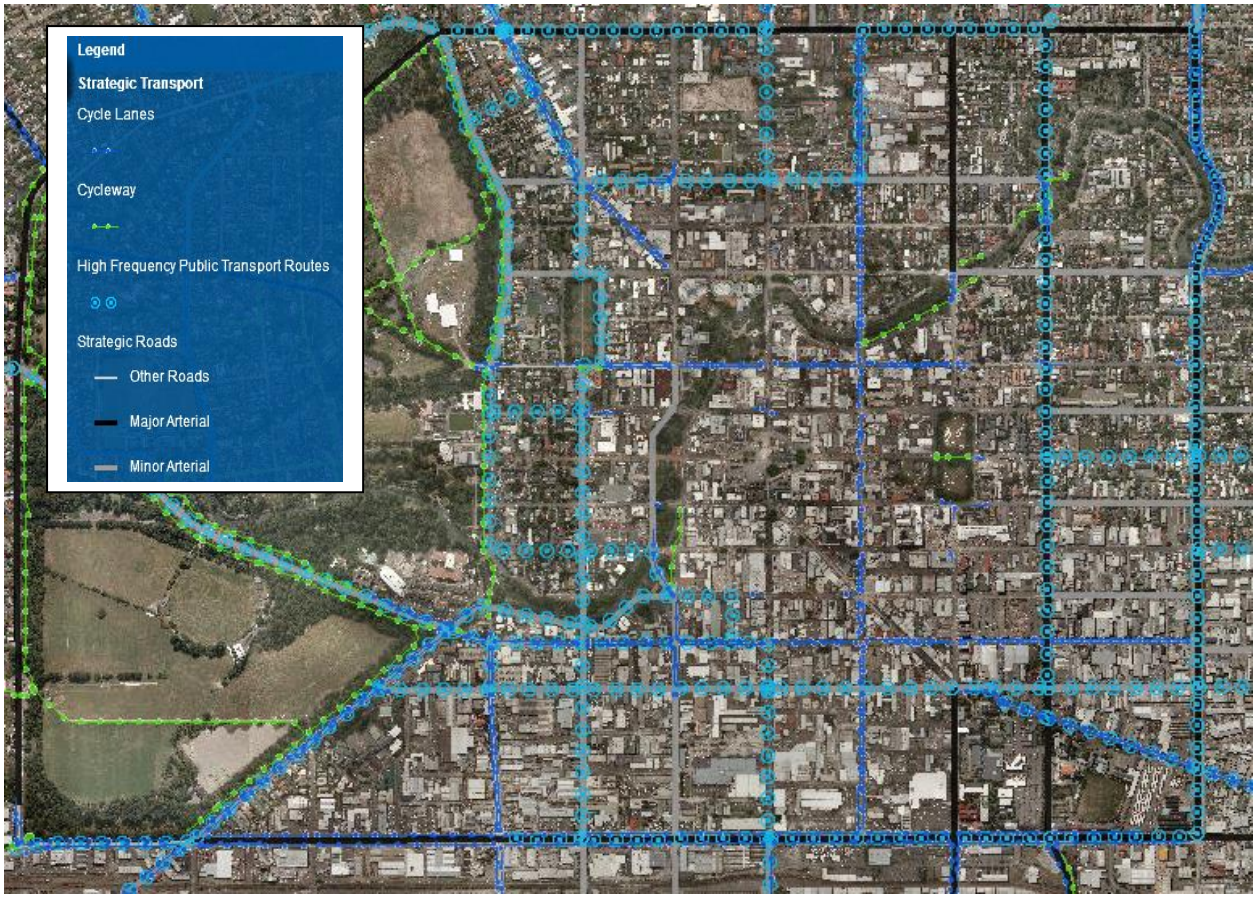
Particular features of the Water Supply system include:

- The mains within the Central City are largely of asbestos cement (AC) and ductile iron (DI) construction.
- Pre earthquake water demand was in the order of 60 ML/d, on average throughout the year.
- The Council has developed a hydraulic model of the potable water system

- Christchurch City Council is undertaking a project to rezone the City into smaller management zones. Levels of service for fire flows and normal operating pressure will be reviewed as part of this project. Some of the objectives of this project are to:
  - Improve emergency response capability
  - Improve resilience and protect vulnerable assets
  - Defer the need for additional water sources through leakage reduction and demand management
  - It is likely that water pressure in the Central City will be reduced

2.4. Road Network

Figure 5 – Roading Infrastructure & Key Components



The current road network is a combination of arterial, collector and local roads. The outer ring route along the avenues, as well as routes through and across the central city, provide for rapid movement of vehicles and public passenger transport. The importance of some routes will change

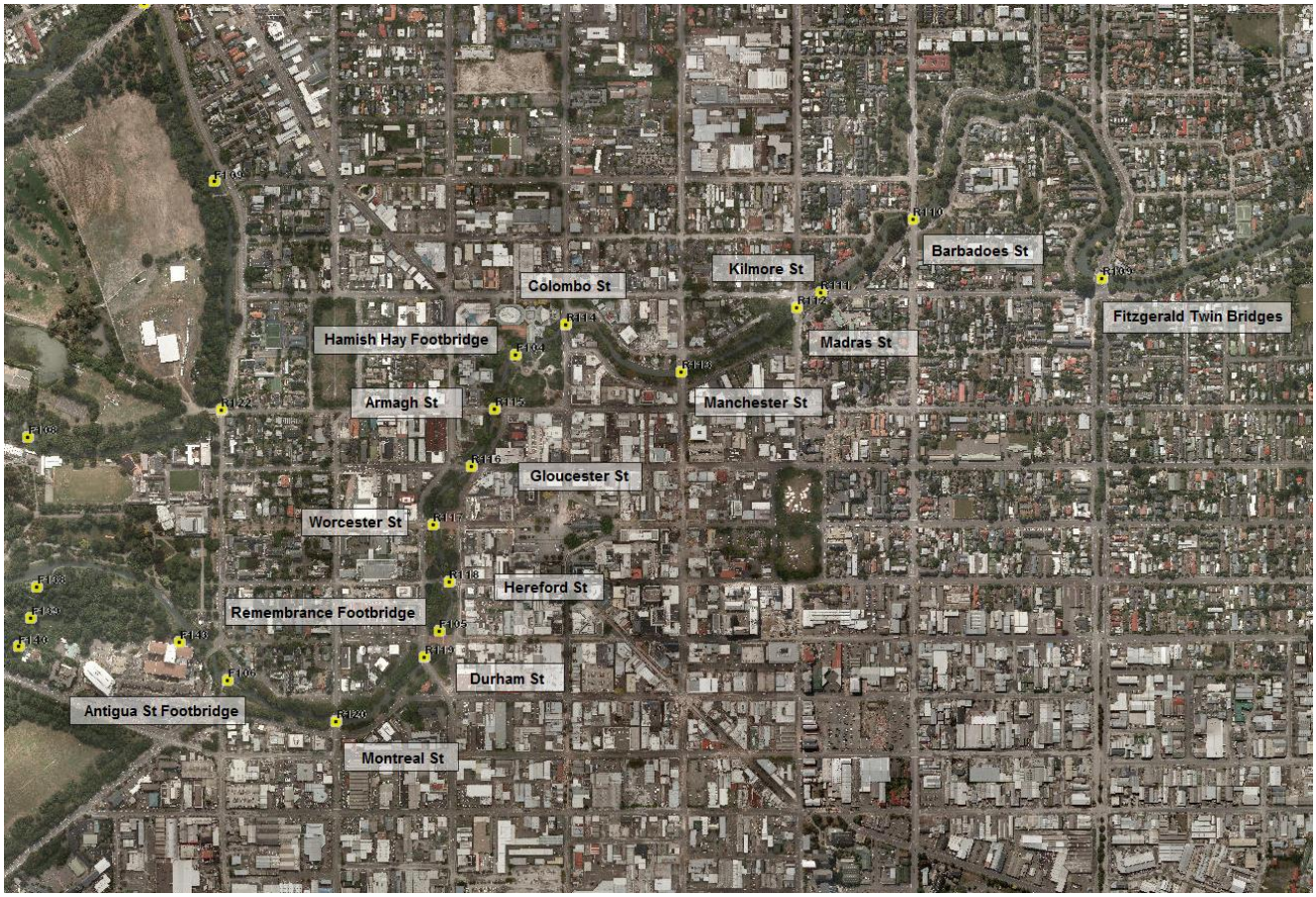
as a result of the Central City Plan recommendations as well as red zoning of land in the north-east of the central city.

Particular features of the roading system include:

- The road infrastructure includes carriageways, kerbs and channels (and road storm-water pipes), footpaths/pedestrian malls, cycle-ways, streetlights, tram infrastructure, traffic signals, signs and markings, and road landscaping and trees.
- Traffic signals, streetlights and tram infrastructure are excluded from the SCIRT scope of work.
- The network hierarchy is expected to change as a result of the Central City Plan adoption by central government. This is likely to influence future public passenger transport routes and will require modelling to identify future destinations and capacity issues and needs.
- The road network is currently functioning adequately in terms of traffic flows. Levels of service for all transport users are likely to worsen as more of the city is made available to traffic and other factors including the rebuild of buildings and underground assets disrupt traffic flows.

2.5. Bridges, Culverts and Retaining Walls

Figure 6 – Road & Footbridges Key Components



The Transport and Greenspace bridges are key components of the vehicular, cycle and pedestrian networks.

Particular features of the bridges include:

- There are two Greenspace assets currently in scope for SCIRT. These are the Hamish Hay footbridge and the Remembrance Arch structures.
- There are several transport bridges with a heritage component - the Armagh Street bridges, Gloucester Street, Colombo Street, Worcester Street, and Hereford Street traffic bridges, and the Cashel Street (Remembrance) and Antigua Street footbridges.
- Changes to the road hierarchy may impact on the rebuild needs and timing of several central city bridges. All are expected to remain. Central city traffic modelling will influence bridge needs.

- A key factor for the rebuild of bridges will be Council decisions as to whether to rebuild to 100% of new building standard (as adopted by Council for Council facilities) and how this impacts on the future use of heritage structures in particular.

3. Levels of Service (LOS)

3.1. Statement of Current LOS Compliance

Investigations for this report indicate the existing network supports basic service for the population inhabiting the Central City at this time. On-going reactive maintenance supports this service with repairs undertaken to support the Cordon Reduction programme as necessary.

There is concern with regard to the overall risk of failure of the Brick Barrel sewers, a collapse of which would cause major disruption to service. SCIRT are currently accelerating the investigations and rehabilitation of these sewers. The Kilmore Street Brick Barrel also only provides a limited service and therefore the north western area of the city has potential risk of not meeting requirements. Major temporary repairs are currently being undertaken to this asset.

It must be noted that as the current population is less than the pre earthquake population, particularly in the commercial sector.

3.2. Level of Service (LOS) Investigations and Current Intelligence

A number of investigations have been made across the earthquake events by CCC engaging City Care under the network Operation and Maintenance (O&M) contract. Operations have been coordinated through designated Area Managers, initiated from CCC and through the public Request For Service (RFS) system.

Operations have typically included:

- Removal of liquefaction silts resulting from elevated inflow and infiltration (I&I) as a result of broken pipes and manholes. This work is necessary to restore service and hydraulic capacity. Such operations have typically included CCTV. As a result of these investigations emergency repairs have been made[1].

The following areas have been focussed upon:

- Wastewater (WW) brick barrel structures. The original trunk mains dating from 18th Century are typically of brick barrel construction. These mains are critical to the viability of the network as a whole and therefore are high priority in terms of condition assessment and rehabilitation (as necessary). A number of condition assessments have been made and most recently a report by AECOM provides a guide to criticality and damage. The report contains caveats regarding the suitability of some of the CCTV work, and this will need to be re-assessed after follow up CCTV has been completed.
- Wastewater (WW) earthenware reticulation network. City Care has on-going maintenance programmes in place for reactive maintenance to the wastewater system to maintain service levels.
- Wastewater within the Cordon Zone. In addition, CCC are making CCTV requests to specifically inspect outstanding elements of the network within the area as part of the cordon reduction programme. Three emergency repairs have been made in specific areas

[1] As at 9 Feb 2012, 1,551 mains repairs and 1,162 public lateral repairs (source CCL) across the City.

to the network where necessary to restore LOS to the wastewater network. It is understood from CCC WW Cordon Reduction Coordinator (Dan Swords) that there are no specific or known areas of the network where LOS is a genuine risk on the basis of operational cleaning and flushing activities. The LOS compliance cannot be assured until the CCTV assessment is complete.

- Stormwater (SW) Network (all assets). In December 2011 Hydrotech Drainage Ltd were commissioned to undertake all remaining CCTV for SW assets within the Central City. 9km has been completed to date and SCIRT are currently waiting for the assessments to be undertaken. A programme of silt removal will be needed to provide minimum LOS to return capacity from the damage caused by the liquefaction. LOS compliance during storm events is likely to be affected due to the ground settlement and loss of capacity in the system. This is unquantifiable until a hydraulic model is developed to assess this. Until this time, it may be assumed that there is a higher probability of surface flooding during storm events within the central city, particularly where large ground settlements have occurred.
- Roading assets. Repairs have been undertaken to roads to level humps and hollows and to fill cracks caused by the liquefaction, ground settlement and lateral spread around rivers. On-going repairs will be needed to keep the pavement waterproof and prevent accelerated deterioration in trafficked areas. Demolition activities are also having a notable affect on the condition of the roading assets. Road closures due to the cordon area is having major impact on traffic flow around the city. Minimum LOS can be maintained however during the infrastructure programme.
- Bridges. Bridge approaches were badly affected due to lateral spread around rivers along with structural damage to abutments, decks, wing walls and other supporting structures. Several bridges remain closed and will require major refurbishment to allow them to reopen. This will obviously have effect on traffic flows around the city as the area is developed and re inhabited. Repairs have been made to the bridge approaches to maintain LOS for traffic flow.
- Construction works will also have a noted impact on levels of service and will need to be managed to minimise this impact as both the vertical and horizontal infrastructure programmes progress.

3.3 LOS Provision during the Rebuild Programme

SCIRT are currently working with the various CCC Operational teams along with their Maintenance Contractors to produce Service Plans. These will indicate the risks associated with each asset type at a network level. This will identify assets which, through the most up to date information available, will have a high, medium or low risk of not meeting basic service requirements, or are at risk of collapse within 2 years. This assessment will then be used to allow programming of the most economical maintenance intervention strategy based on the rebuild programme, development proposals and current / future service levels.

When a new development is therefore proposed, or an area re-inhabited, the rebuild programme will be reviewed and the maintenance intervention strategy implemented as necessary to provide minimum levels of service.

This will minimise the risk of loss of service before the infrastructure is renewed/repaired, and backed up by reactive maintenance as required. The aim is therefore to change the programming of this work from reactive to preventative where possible.

This will allow the infrastructure and city rebuild works to proceed in parallel without loss of service or the application of constraints due to the damaged infrastructure.

4. Synopsis of Current Asset Assessment and Damage Indicators

SCIRT adopts six principal asset assessment tools:

1. Land survey; topographical, cadastral and LIDAR
2. Pipe Assessment; CCTV, profile metering and pole camera (SW & WW)
3. Leak detection surveys, damage repair records (WS)
4. Structural assessments (Bridges & Retaining Walls)
5. Road Assessments; RAMM Condition Assessments, Pavement testing
6. Multi Criteria Analysis (MCA) tool. This desk top analysis tool creates an output MCA score that predicts the condition of pipes which have not been surveyed by other means. Inputs include survey completed to date, and other key criteria such as liquefaction index, material type and road surface damage.

Data from the assessments is transposed to three database systems:

- InfoNet. This is a licensed software which in time CCC may use as an integrated hydraulic modelling and asset management package. The inputs to InfoNet can be converted to Clean Flow which is the proprietary software presently used by CCC.
- RAMM Database. Road asset management tool licenced to the CCC and NZTA for all road and structure assets.
- SCIRT Geographical Information System (GIS).

All damage levels are assessed using these tools and defined for renewal/repair options based on the CCC Infrastructure Rebuild Technical Standards & Guidelines document (IRTSG) threshold levels.

5. Current Asset Condition

5.1. Wastewater & Storm Water Trunk Network

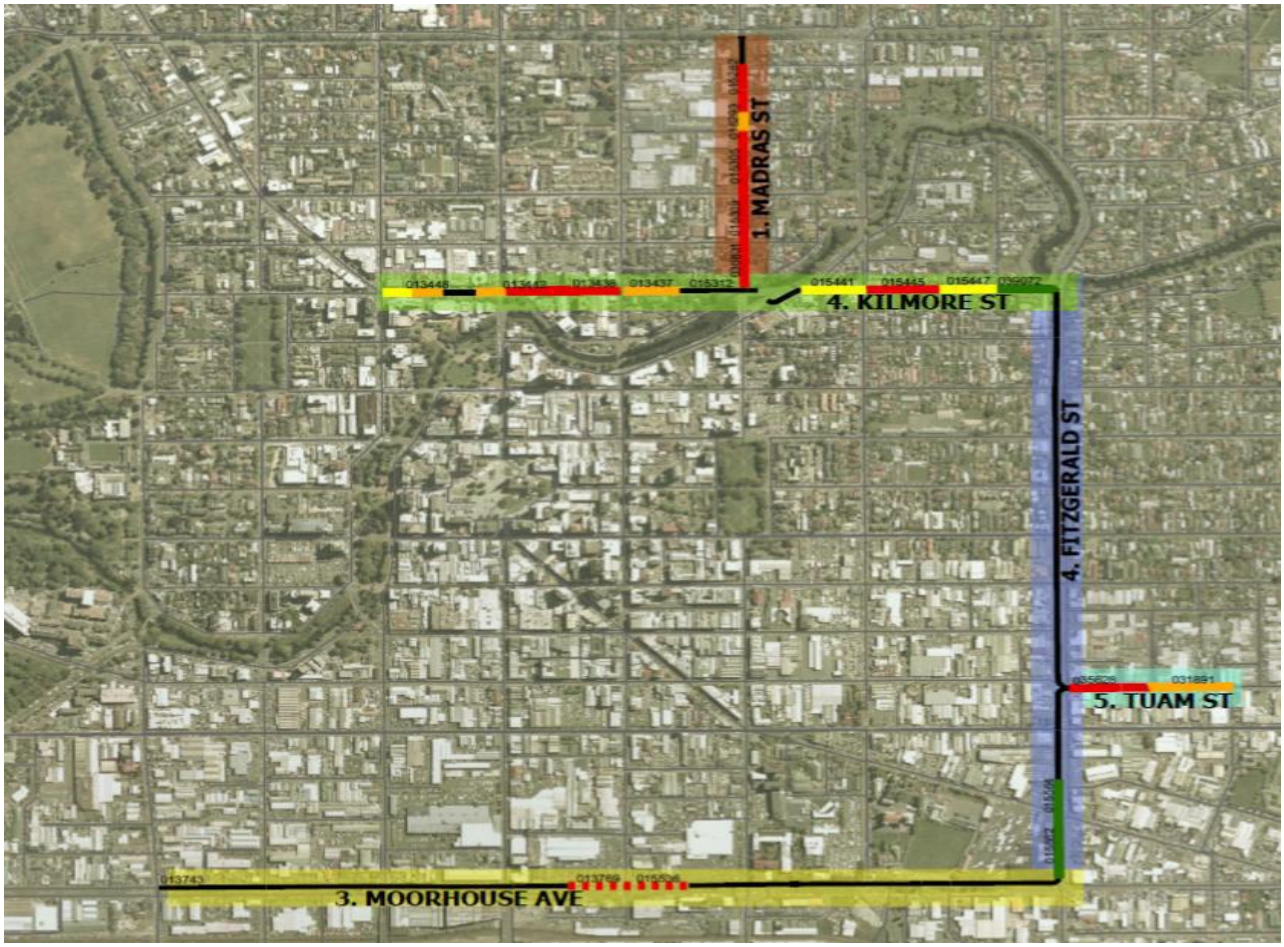
Generally, the majority of the damage to the trunk network has been on the brick barrel sewers. The Central City Relief Sewer, Fitzgerald By-Pass Sewer, new Western Interceptor & Southern Relief Sewers have been constructed from reinforced concrete rubber ringed (RCRR) pipe. These pipes have not yet been inspected, however from assessments of similar pipework in other areas, it is expected that they will have sustained only localised earthquake damage.

5.1.1. Wastewater Brick Barrels

The report prepared by AECOM consultants (available from the SCIRT team) has assessed the wastewater brick barrel sewers. This report was commissioned by City Care in mid-2011.

Figure 3 below indicates the damage assessed for the Madras St, Kilmore St and Tuam St sewers with red indicating sewers in critical condition and orange those with a risk of failure within 2 years.

Figure 3 Central City Wastewater Brick Barrel Sewers Damage Synopsis (at Nov 2011)



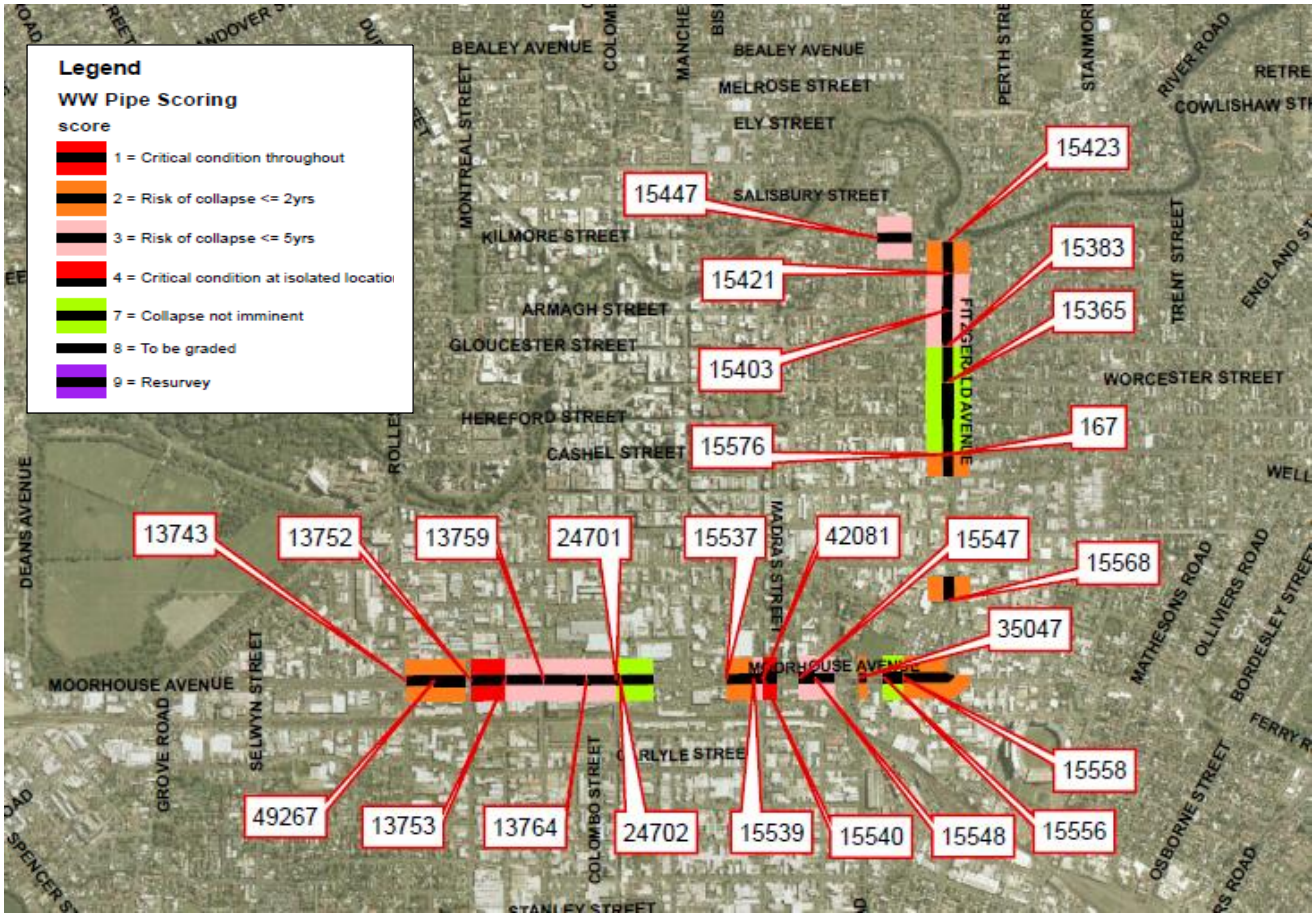
The following key points are made in this report:

- 40% of the brick barrel sewers (red legend) CCTV surveyed have suffered obvious and visible structural failures and a further 40% show signs of earthquake damage which will probably cause structural failures or loss of service within 2 years, unless remedial action is taken,
- Lack of serviceability is significant due to infiltration of liquefaction silts
- Aggressive cleaning of brick barrel sewers through contracting activity[2] has been seen to exacerbate damage through removing grout in brick crowns for example, weakening structural integrity

Since November 2011, further CCTV survey and resultant assessments can be seen below in Figure 4 for the Fitzgerald and Moorehouse brick barrels.

Figure 4 Central City Wastewater Brick Barrel Sewers Damage Synopsis (at May 2012)

[2] For example, cleaning and jetting in preparation for CCTV survey



This assessment of these sewers has found that although nearly all Brick Barrels have visible signs of earthquake damage, their potential risk of failure is less than the Tuam, Kilmore and Madras sewers, and are hence damaged to a lesser extent.

The wastewater brick barrel structures are being prioritised in view of the criticality these structures provide in sustaining the trunk network operation. Lining of the brick barrel sewers using Cured in Place Pipe (CIPP) has been identified as the preferred method of rehabilitation.

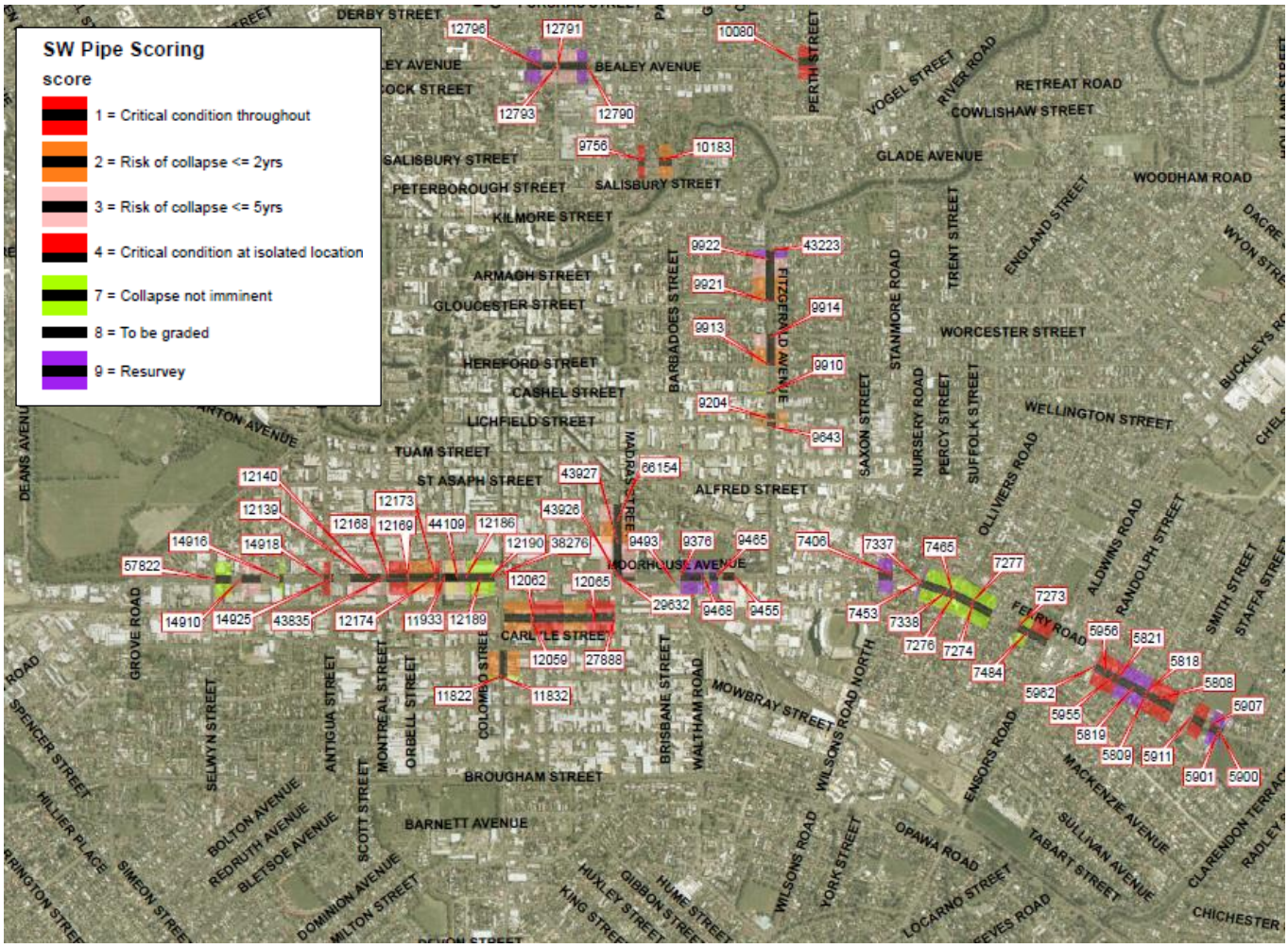
This report will be updated on completion of the CCTV assessments.

5.1.2. Storm Water Brick Barrels

Survey of the SW brick barrel pipework has shown that the pipework is in similar or worse condition than the WW brick barrels. Surveys and assessments of these sewers has not yet been completed to date, however a summary of the condition can be seen below in Figure 5.

SCIRT are currently finalising the design of the rehabilitation work required with specialist contractors appointed.

Figure 5 Central City Stormwater Brick Barrel Sewers Damage Synopsis (at May 2012)



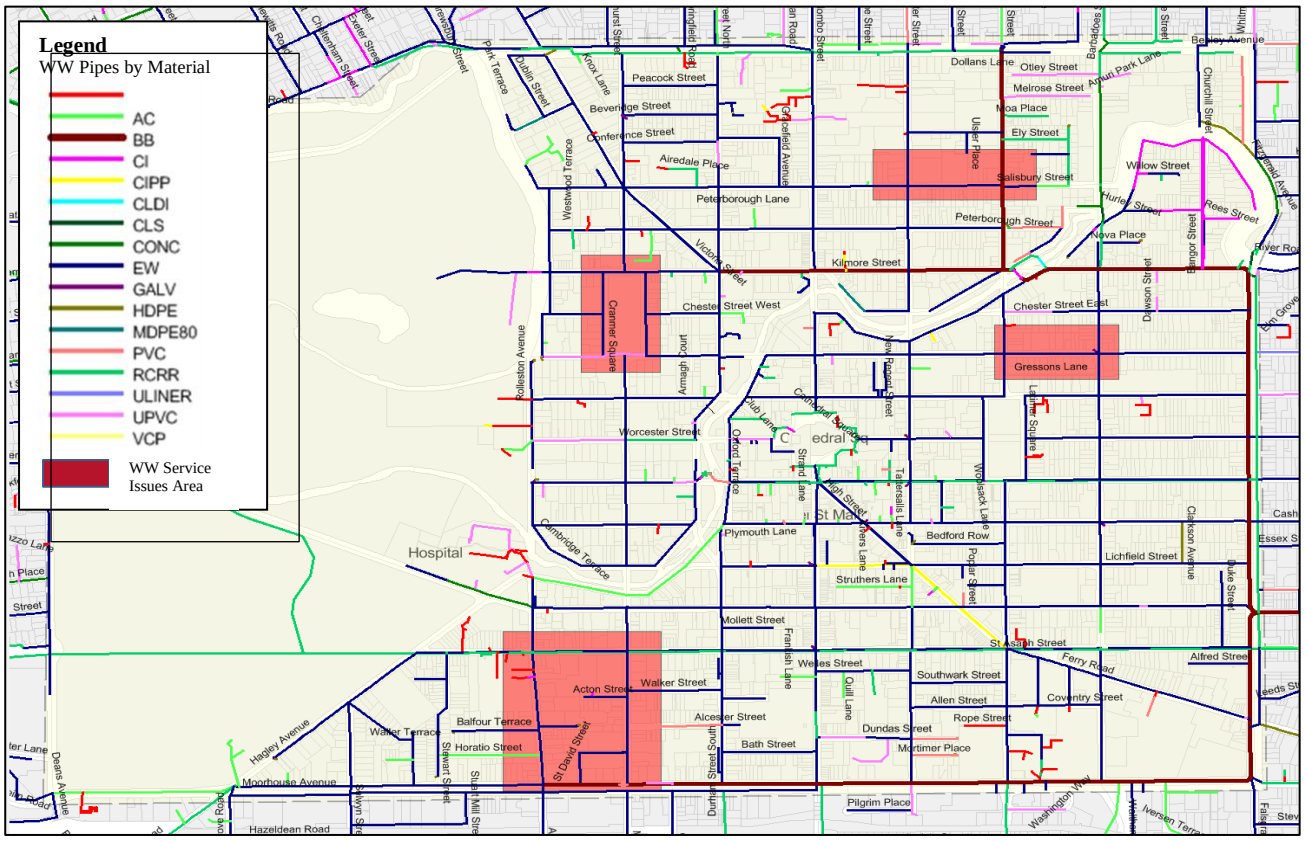
Similar to, and to a greater extent than the wastewater network, the lack of serviceability is significant due to infiltration of liquefaction silts. The aggressive cleaning of brick barrel sewers has been seen to exacerbate damage, weakening structural integrity.

The storm water brick barrel structures are being prioritised in view of the criticality these structures provide in sustaining the trunk network operation. Lining of the brick barrel sewers using Cured in Place Pipe (CIPP) has been identified as the preferred method of rehabilitation.

5.2. Wastewater Reticulation Network Assets

The damage levels experienced within the central city area are generally due to the pipe material. The map below shows the reticulation system by material types with dark blue representing earthenware (EW) materials, red representing the brick barrels (BB) and green for newer pipework, constructed from reinforced concrete, rubber ringed pipework (RCRR).

Figure 6 Wastewater Reticulation Network by Material Type



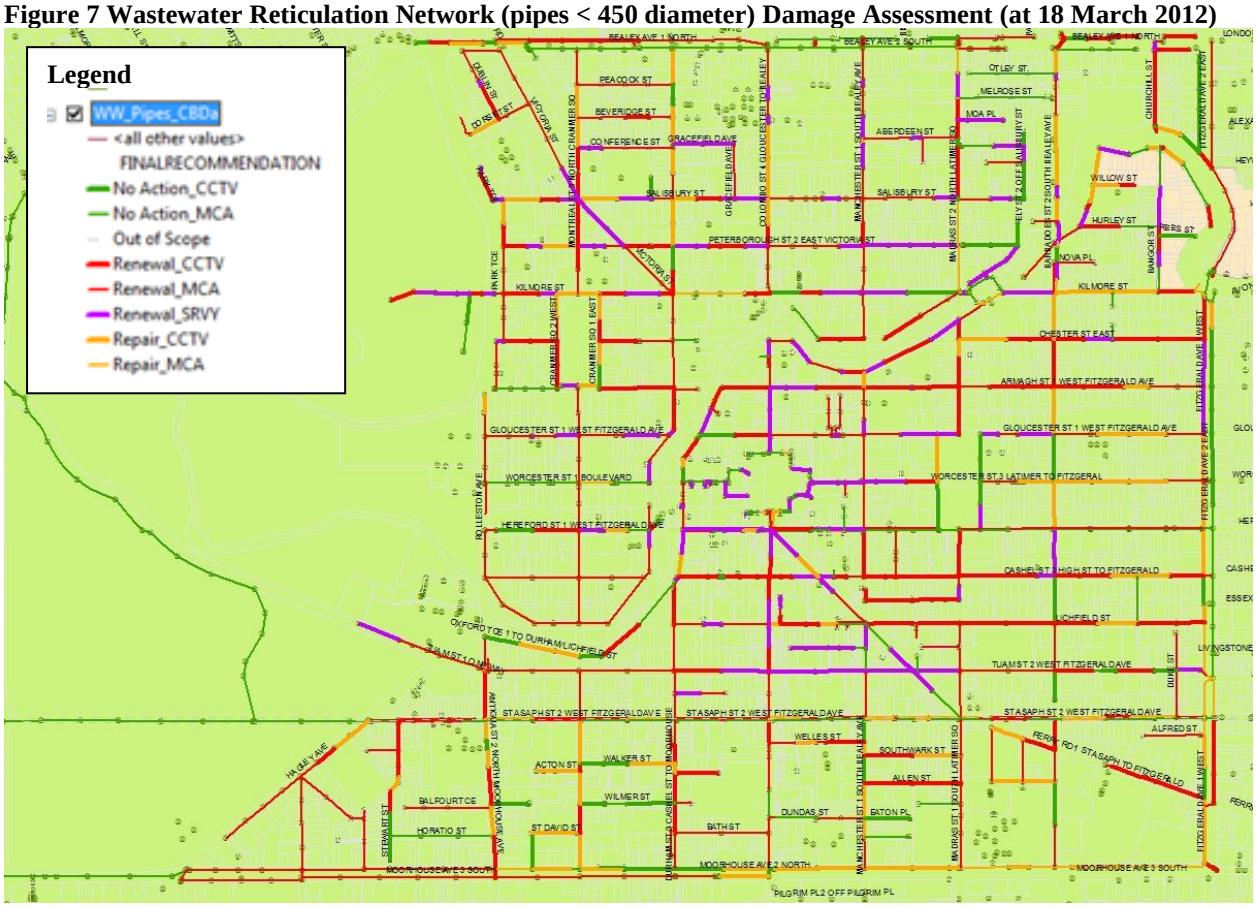
The CCTV log sheets have been assessed by SCIRT and are mapped below in Figure 7.

Key observations include:

- 37% of the Central City has undergone CCTV survey. These figures exclude emergency response CCTV which generally does not meet the New Zealand Pipe Inspection Manual (NZPIM) standards. Further CCTV is required in the cordoned area in accordance with the cordon reduction programme.
- Damage to the pipes has generally taken the form of fractures, displaced joints, loss of grade and collapse. Differential settlement between the manholes and connecting pipework has also been observed.

- A number of manholes have been inspected to confirm positive flow in the correct direction. No incidents of backflow or surcharge have been reported. These investigations are, however, in the context of lower flows in the Central City.
- The two pump stations (PS2 and PS3) were damaged in the February 22 2011 earthquake and are likely to need major refurbishment or complete replacement.
- Other notable damaged assets are the siphon under the Avon River at Hagley Park which is badly damaged and not functioning correctly.
- The remaining 63% of the network has been assessed using the Damage Probability MCA tool to estimate the remaining volume of renewal, repair or no action lengths. The accuracy of the MCA tool has been found to be 92% for identifying the need for renewal/repair, and 72% accurate identifying the corrective action based on the Threshold Levels for renewal or repair. The results of which can be seen below.
- Combining the CCTV, Grade damage information and the MCA analysis results therefore gives a holistic view of predicted damage levels to the reticulation system and can be seen below in Figure 6.

Figure 7 Wastewater Reticulation Network (pipes < 450 diameter) Damage Assessment (at 18 March 2012)



A holistic analysis can therefore be undertaken to assess the renewal, repair and no action lengths within the central city. This analysis can be seen in the tables 1, 2a and 2b below.

Table 1 Damage by Material Type

	Length	Renewal CCTV	Renewal Grade	Renewal MCA	Renewal Total	Repair CCTV	Repair MCA	Repair Total	No Action CCTV	No Action MCA	No Action Total
Total	66.4	12.7	7.5	21.9	42.1	7.3	0.3	7.6	4.3	12.6	16.9
AC	2.2	0.1	0.4	-	0.5	0.2	-	0.2	0.3	1.3	1.6
Concrete	0.9	0.1	0.1	0.6	0.8	0.2	-	0.2	-	-	-
EW	46.7	11.9	5.9	21.3	39.1	5.8	-	5.8	1.8	-	1.8
PVC	3	-	0.1	-	0.1	0.2	-	0.2	0.9	1.8	2.7
RCRR	11.1	0.3	0.6	-	0.9	0.4	0.3	0.7	1.1	8.3	9.4
Other	2.5	0.3	0.4	-	0.7	0.5	-	0.5	0.2	1.2	1.4

Table 2a Damage by Material Type and Dia

	Total		AC		Concrete		EW		PVC		RCRR		Other	
	Length (km)	Renewal (km)	Renewal Length	Renewal %	Renewal Length	Renewal %	Renewal Length	Renewal %	Renewal Length	Renewal %	Renewal Length	Renewal %	Renewal Length	Renewal %
150	9	5.2	<0.1	6.6%	0.1	100.0%	4.2	99.3%	<0.1	2.9%	0.4	39.7%	0.5	25.9%
200	1.4	0.3	0.2	68.4%					<0.1	4.4%			0.1	96.5%
225	39	29.5	0.2	15.1%	0.3	100.0%	28.8	80.3%	<0.1	6.8%	0.1	11.6%	0.1	26.4%
300	4	3.4			0.2	100.0%	3.1	90.8%			0.1	37.3%		
>300	13.1	3.5			0.2	42.4%	3	95.1%			0.3	3.4%	<0.1	11.2%

Table 2b Number of Repairs

	AC	CONC	EW	PVC	RCRR
150	0	0	0	0	0
200	0	0	0	1	0
225	0	0	70	1	0
300	0	0	0	0	3
>300	0	9	1	0	11

The data in Table 1 shows the lengths of pipework determined for renewal, repair or no action based on Threshold levels defined in the Technical Standards & Guideline documents. These lengths have been determined through CCTV data, level data (to determine loss of grade) and the MCA tool to complete the analysis. The following is a summary of this data:

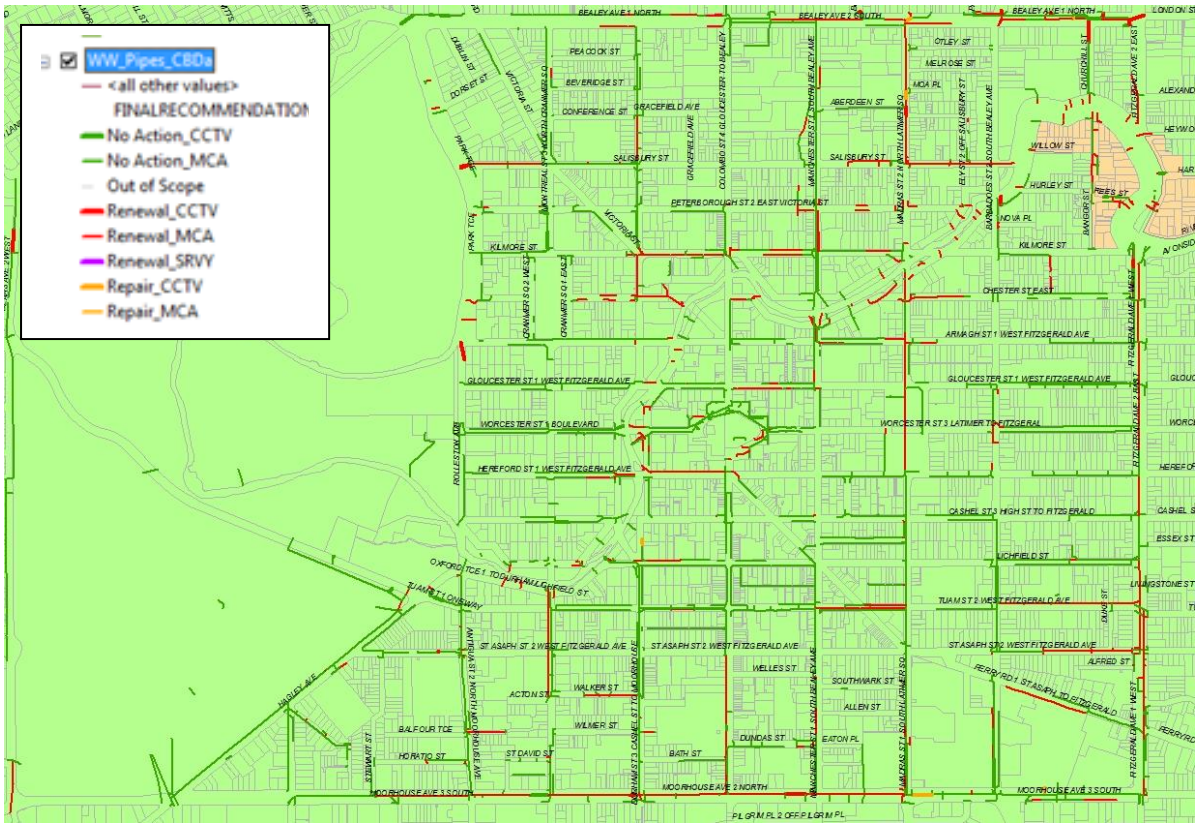
- From the total network length of 66.4km, 42.1km (63%) of pipework requires replacement, 7.6km (11%) requires repair and 16.9km (26%) requires no action.
- There is 46.7km of EW pipework, 39.1km (84%) of which requires replacement. 5.8km of EW pipework requires repair leaving an estimated 1.8km of undamaged EW pipe. Further CCTV would be required to confirm this.
- Of the 7.6km of EW pipe requiring repair or no action, the expected life of an EW pipe is 150 years. The oldest sewer of this material type is 130 years therefore none fall within 15years of their expected life for renewal. However this pipework offers very low levels of resilience which should be considered before renewal lengths are finalised.
- From the 0.9km of non-reinforced concrete pipework, 0.8km requires replacement with the remaining being repaired.
- Sectionised replacement of other pipe materials will be required on an asset by asset basis however this does not account for the catchment requirements to achieve the required IDS grades for self-cleansing velocity where grade damage has occurred. This will be determined at Concept design stage for optimum sewer network design. Due to the settlement and the flat grades within the central area, it may be found that a large portion of the 24.5km of pipework remaining for repair/no action could have to be replaced for optimal, resilient design standards. A cost estimate range will need to be used until this is determined.
- Reinforced Concrete Pipework has performed well during the EQ events. From the 11.1km of pipework, only 0.6km (5%) requires replacement primarily due to grade related issues rather than structural damage.

Table 2a details the damage levels by material and diameter to allow cost estimate production. Table 2b has also been produced from CCTV data and MCA analysis to estimate the numbers of repairs required for cost estimate production.

5.3. Storm Water Network

Minimal CCTV has been undertaken to date therefore all asset damage data has been assessed using the MCA tool. Levels of accuracy will then be confirmed through programmed CCTV surveys. It can be noted though that 75% of the network was constructed between 1970 and 2000 using RCRR pipework. The performance of which on the network has been satisfactory showing good resilience. Therefore much lower levels of repair and replacement are expected on the network, summarised below

Figure 8 Stormwater Reticulation Network Damage Assessment (at 18 March 2012)



The following key observations are made:

- No flooding has been reported following rainfall experienced since the earthquake events.
- Localised surface ponding has been observed due to kerb & channel damage (slumping) caused by the ground settlement and liquefaction. Some of this damage may require addressing prior to the pavement renewal /rebuild work to resolve LOS issues to assist the redevelopment of the city, particularly in commercial areas.

- A high degree of internal cracking has been observed however the majority of pipes are serviceable. The analysis of pole camera[3] data will assist SCIRT in developing a rapid indication of major pipe defects.
- Hydraulic damage, i.e. loss of capacity due to ground settlement cannot be quantified at this stage. A hydraulic catchment model will be required to assess this damage and SCIRT are currently liaising with the CCC regarding this work.

[3] Pole camera is a rapid means of determining gross pipe defects and the subsequent need for CCTV. The camera focus accuracy is up to 15 m in pipe length. SCIRT are currently developing QA/QC procedures against assessing pole camera CCTV footage

The tables below outline the MCA assessment for damage by material and diameter.

Table 3 Damage by Material Type

	Length	Renewal CCTV	Renewal MCA	Renewal Total	Repair CCTV	Repair MCA	Repair Total	No Action CCTV	No Action MCA	No Action Total
Total	53	0.2	10.4	10.8	0.1		0.1	0.5	41.7	42.2
AC	8.1		1.6	1.6	< 0.1		< 0.1	0.1	6.4	6.5
Concrete	5.1	< 0.1	4.6	4.6				0.1	0.4	0.5
EW	3.4	< 0.1	2.5	2.6				< 0.1	0.8	0.8
PVC	1.7			0				< 0.1	1.7	1.7
RCRR	35	0.2	1.7	2	< 0.1		< 0.1	0.3	32.4	32.7
Other	0			0					< 0.1	0

Table 4 Damage by Material Type and Diameter

	Total		AC		Concrete		EW		RCRR	
	Length	Renewal	Renewal Length	Renewal %	Renewal Length	Renewal %	Renewal Length	Renewal %	Renewal Length	Renewal %
< 300	21.8	4.8	0.7	18.4%	1.1	92.3%	2.3	92.5%	0.7	4.7%
300	10.4	2.4	0.6	19.4%	1.6	91.1%	0.2	30.6%	0.1	1.1%
375	6.8	1.1	0.2	24.3%	0.6	91.4%	0	0.0%	0.2	4.8%
450	3.2	0.6	0	0.3%	0.6	91.0%	0		0	0.0%
525	2.2	0.4	0.2	58.7%	0.3	100.0%	0		0	0.0%
600	1.3	0.3	0		0.3	84.6%	0		0.1	8.8%
750	1.6	0.1	0	0.0%	0.1		0		0	0.0%
900	0.5	0.2	0		0		0		0.2	51.4%
1050	0.8	0	0	0.0%	0		0		0	0.0%
> 1050	0.6	0.6	0		0		0		0.6	95.4%

The data in Table 3 shows the lengths of pipework determined for renewal, repair or no action based on Threshold levels defined in the Technical Standards & Guideline documents. These lengths have been determined through the limited CCTV data and the MCA tool to complete the analysis. The following is a summary of this data:

- From the total network length of 53km, 10.8km (20%) of pipework requires replacement, 0.1km (<1%) requires repair and 42.2km (80%) requires no action. However, due to the low sample length of actual assessments, and through observed damage during reactive maintenance, it can be assumed that a much larger % of localised repairs will be required. Based on the WW statistics, a figure of 6% to 11% should be used (3km – 6km of pipework).

- Of the 10.8km of renewal, the majority of this is for the EW, Concrete and AC pipework, similar to that of the WW network (confirmed through higher %'s of actual survey data). This should give some confidence for cost estimation.

- Replacement of other pipe materials will be required on an asset by asset basis however this does not account for the catchment requirements to achieve the required IDS grades, however this is less important for SW networks due to first flush during storm events. This will be determined at Concept design stage for optimum sewer network design.

- It has been assumed, as with the WW network, Reinforced Concrete Pipework has performed well during the EQ events. From the 35km of pipework, it is estimated that only 2km (6%) requires replacement.

Table 4 details the damage levels by material and diameter to allow cost estimate production. There is not enough information at this stage to estimate the number of repairs required therefore for cost estimation, a contingency should be included.

5.4. Water Supply Network Assets

Figure 9 Water Supply Network Asset Repairs (based upon City Care CAM data, at 8 March 2012)

Figure 9 has been developed from City Care CAM data with the number of breaks recorded on individual mains and sub mains. The CAM data used to populate Figure 7 is currently being validated as inaccuracies were identified during the initial emergency response period.

The water supply network comprises 7 pressure zones with the largest serving the Central City. Pre earthquake water demand is in the order 60 ML/d, on average throughout the year.

The mains within the Central City are mostly of asbestos cement (AC) and ductile iron (DI) construction and in general have shown a good level of resilience, despite the ageing nature of the assets.

Water supply asset assessment has been limited however a number of repairs and reconnections have been made in the Central City. A number of fire hydrant connections have been damaged by contractors undertaking demolition work. The trunk supply network appears to have suffered little obvious damage despite ageing assets however a long term strategy encompassing leak detection and possible rezoning is underway between CCC and SCIRT.

Analysis of the above break data against the threshold levels for renewal can be seen overleaf.

Table 5 - Length to Be Replaced

Diameter	AC	CI	DI	Other	PE	PVC	Grand Total
20				382	92		474
25				184	776	0	960
32				0	6	0	6
38				0			0
40				100	1,160	0	1,261
50				205	965	0	1,171
63					233		233
Sub Main Total				**872**	**3,233**	**0**	**4,105**
75	448	21		9	0		479
80				0			0
100	251	1,454	0	105	0	549	2,360
125			0		0		0
150	208	969	0	892		1	2,071
200	435	44	218	0	0	94	789
250		0		0			0
300	184		0	806		0	990
350				0			0
375	0	0	0	0			0
450				0			0
600				0			0
Mains Total	**1,527**	**2,488**	**218**	**1,812**	**0**	**644**	**6,689**

Table 6 - Total Length

Diameter	AC	CI	DI	Other	PE	PVC	Grand Total
20				1,166	1,004		2,170
25				1,072	4,584	65	5,721
32				187	344	56	587
38				153			153
40				1,739	22,295	32	24,066
50				3,103	12,679	28	15,811
63					3,058		3,058
Sub Main Total				**7,420**	**43,965**	**181**	**51,566**

75	450	447		33	5		935
80				5			5
100	510	8,810	212	326	6	2,687	12,550
125			7		10		17
150	6,764	6,173	2,873	1,214		4,907	21,932
200	11,335	3,113	7,769	725	1	1,834	24,777
250		2		45			47
300	4,480		1,394	3,175		214	9,263
350				49			49
375	686	89	69	1,279			2,123
450				609			609
600				647			647
Mains Total	**24,224**	**18,634**	**12,325**	**8,107**	**21**	**9,642**	**72,952**

Table 7 - Percentage Replacement

Diameter	AC	CI	DI	Other	PE	PVC	Grand Total
20				32.8%	9.2%		21.9%
25				17.2%	16.9%		16.8%
32					1.7%		1.0%
38							
40				5.8%	5.2%		5.2%
50				6.6%	7.6%		7.4%
63					7.6%		7.6%
75	99.7%	4.8%		28.2%			51.2%
80							
100	49.3%	16.5%	0.2%	32.2%		20.4%	18.8%
125							
150	3.1%	15.7%		73.5%		0.0%	9.4%
200	3.8%	1.4%	2.8%			5.1%	3.2%
250							
300	4.1%			25.4%			10.7%
350							
375							
450							
600							
Grand Total	**6.3%**	**13.4%**	**1.8%**	**22.4%**		**6.7%**	**9.2%**

From this analysis, the following observations can be made:

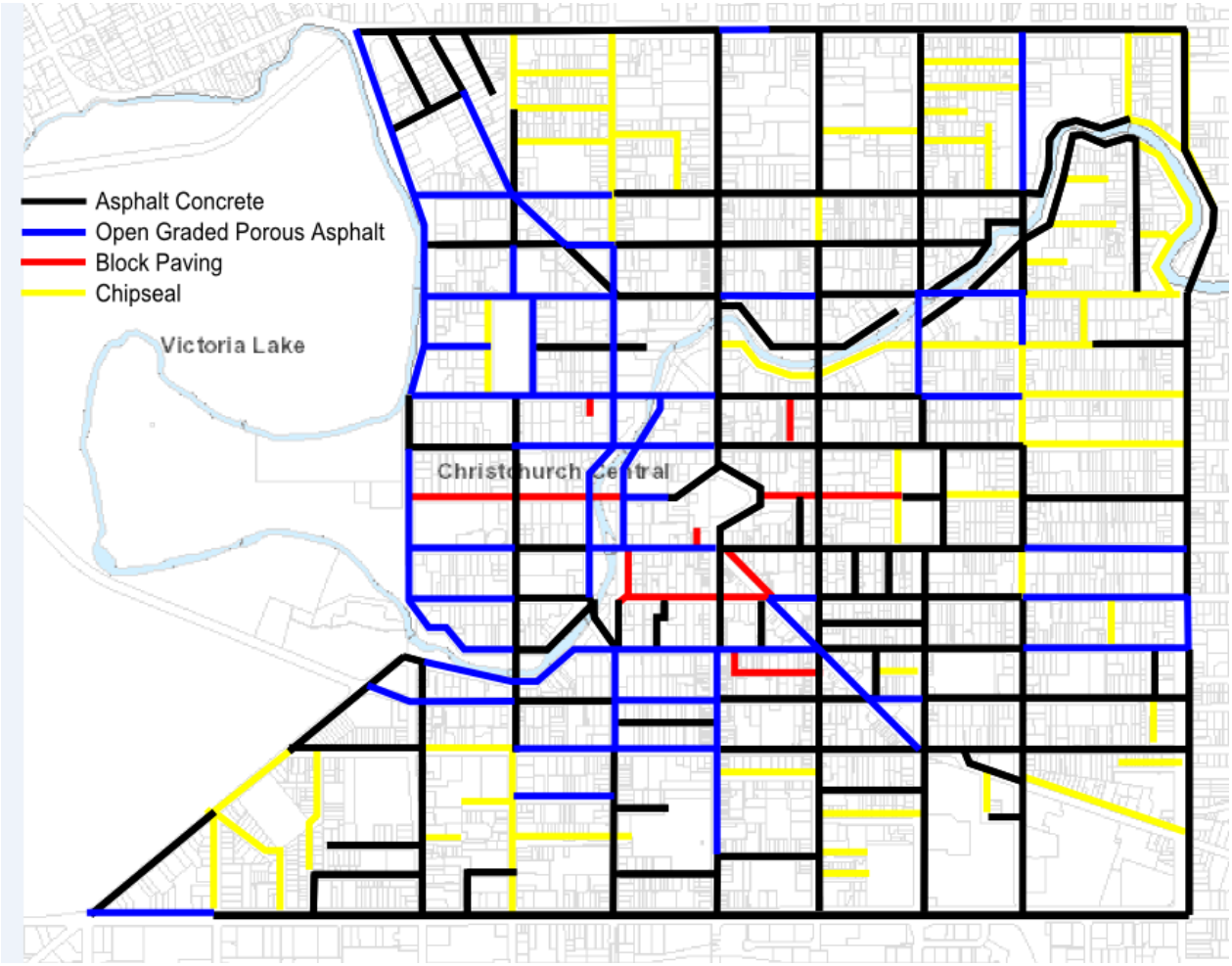
- From the total 73km of mains within the central city, only 6.7km (9%) requires replacement due directly to earthquake damage.
- Very few trends for damage by material type are evident other than small diameter AC mains, however there are only short sections of this type of material in the central city.

- Lead joints in CI pipework is also a common failure type to this pipe material
- 4km of sub mains have been identified for repair to date. This is expected to increase due to damage from demolition activities.
- Leakage detection will be required before final lengths of damage are confirmed for replacement. Network leakage is significantly higher since the EQ events than pre EQ events. This damage is currently unquantifiable without these surveys undertaken.

5.5. Roading

Unlike the WW and SW infrastructure, damage levels to roads, footpaths and cycleways has not been related to the material type of the asset. Rather, damage levels are more related to liquefaction, ground settlement and lateral spread across the central city. However, surface treatment type information is important for cost estimation for repairs. As shown in Figure 10 below, the majority of the central city is made up of Asphalt surfaces with pockets of Chipseal in isolated areas or individual seal lengths.

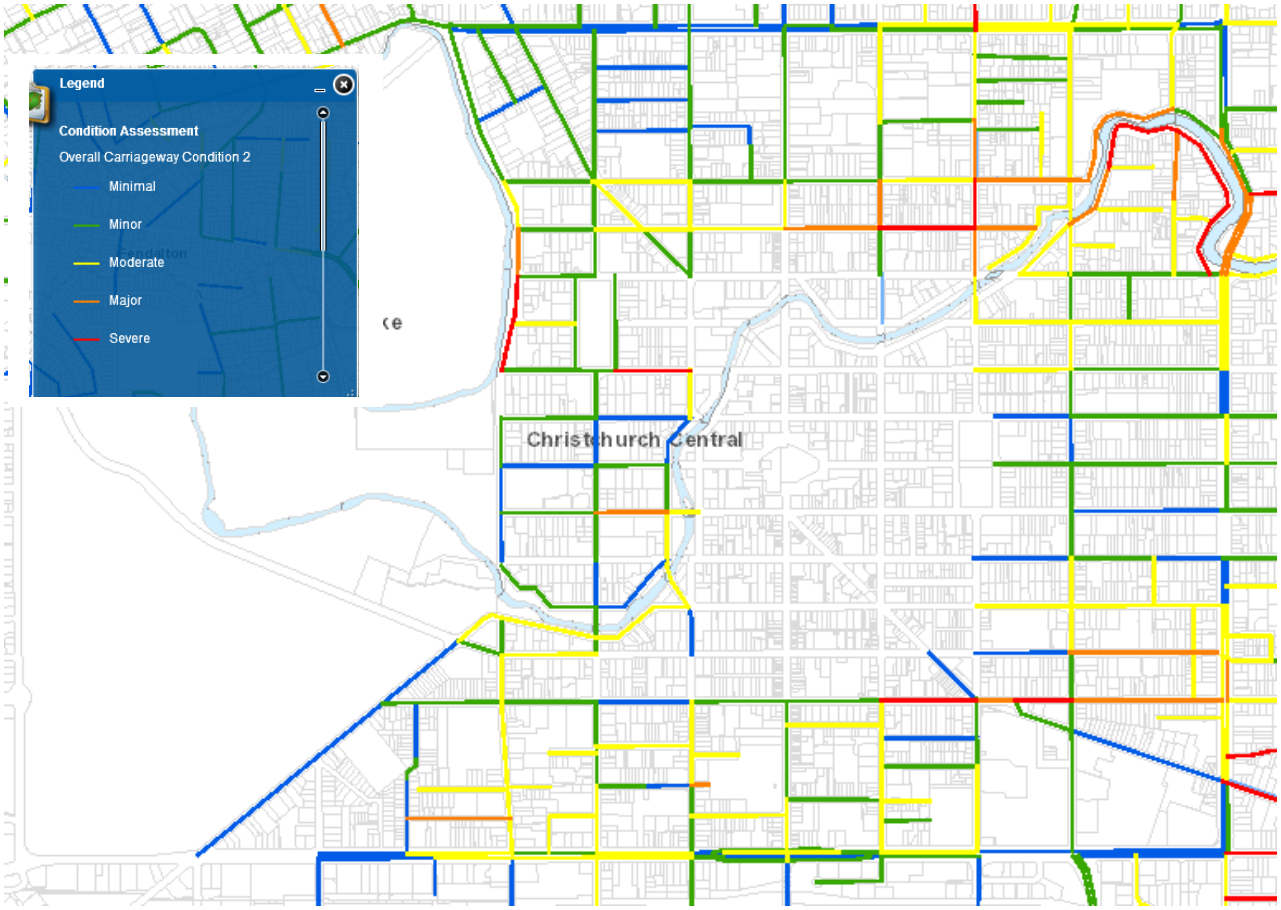
Figure 10 Road Surface Treatment Type



A visual inspection was undertaken following the February earthquake with updates made to liquefaction areas post June and December events to record physical damage to road, pavement and K&C assets. Each damage point was recorded in RAMM and given a damage score. A

cumulative score was then taken for each intersection to intersection length of road and ranged into an overall Condition Rating from 1 to 5 (1 being Minimal damage, 5 being Severe). The results of which can be seen in Figure 11 overleaf for the pavement assets.

Figure 11 Road RAMM Condition Rating - Carriageways



The following key observations are made:

- Major and severe damage levels generally follow liquefaction areas and the river course. Liquefaction intrusion into the sub base layers are expected where this is the case. As with other areas, liquefaction has travelled horizontally between layers, often contained by the top surface layer causing humps and hollows in the road.
- Cracking and differential settlement also caused damage to the pavement layers, particularly around the river and bridge approaches due to lateral spread.

- Surface ponding is widespread in the city due to the settlement of pavement layers and kerb and channels which have lost grade. This prohibits the free flow of surface water to road sumps.
- Trench fill above utility services settled with fill material migrating into the surrounding ground when the liquefaction occurred, causing surface dips over these utilities.
- Footpath damage occurred particularly at the building boundaries and many tripping hazards now exist.
- Damage levels within the cordoned zone needs assessment. Make safe work is currently being undertaken by the CCC Operational teams to coincide with the cordon reduction programme.

Analysis of the RAMM condition surveys can be seen in the tables below.

Table 7: Carriageway Damage Rating

			Carriageway									
			Damage Rating									
			0	1	2	3	4	5	#N/A			
Carriageway Construction		Two Coat Seal	451	952	4039	1343	115	478	371		7,749	m
		Single Coat Seal	0	790	500	1304	159	0	589		3,342	m
		Asphaltic concrete	1294	6235	9261	6159	2486	3108	8431		36,974	m
		Interlocking concrete blocks	0	405	0	0	0	0	1451		1,856	m
		Open Graded Porous Asphalt	666	3165	2747	2711	0	1286	3836		14,411	m
		Slurry Seal	0	224	340	220	0	121	47		952	m
											65,284	m
			2,411	11,771	16,887	11,737	2,760	4,993	14,725	65,284		

Table 8: Kerb & Channel Damage Rating

			K&C									
			Damage Rating									
			0	1	2	3	4	5	#N/A			
Carriageway Construction		Two Coat Seal	451	3785	2228	472	130	312	371		7,749	m
		Single Coat Seal	0	1730	758	265	0	0	589		3,342	m
		Asphaltic concrete	1294	13606	7054	5010	580	999	8431		36,974	m
		Interlocking concrete blocks	0	236	169	0	0	0	1451		1,856	m
		Open Graded Porous Asphalt	666	4987	3000	1485	0	437	3836		14,411	m
		Slurry Seal	0	586	90	229	0	0	47		952	m
											65,284	m
			2,411	24,930	13,299	7,461	710	1,748	14,725	65,284		

Table 9: Footpath Damage Rating

			Footpath									
			Damage Rating									
			0	1	2	3	4	5	#N/A			
Carriageway Construction		Two Coat Seal	451	1577	2236	1950	194	970	371		7,749	m
		Single Coat Seal	0	606	473	477	529	668	589		3,342	m
		Asphaltic concrete	1294	6749	5423	5356	1076	8645	8431		36,974	m
		Interlocking concrete blocks	0	0	236	169	0	0	1451		1,856	m
		Open Graded Porous Asphalt	666	1563	2473	2931	867	2075	3836		14,411	m
		Slurry Seal	0	586	90	0	0	229	47		952	m
											65,284	m
			2,411	11,081	10,931	10,883	2,666	12,587	14,725	65,284		

Table 10: Combined (Carriageway, K&C & Footpath) Damage Rating

			Overall									
			Damage Rating									
			0	1	2	3	4	5	#N/A			
Carriageway Construction		Two Coat Seal	451	944	3879	1626	36	442	371		7,749	m
		Single Coat Seal	0	658	791	1304	0	0	589		3,342	m
		Asphaltic concrete	1294	6229	7932	8522	3591	975	8431		36,974	m
		Interlocking concrete blocks	0	236	169	0	0	0	1451		1,856	m
		Open Graded Porous Asphalt	666	2114	3620	3617	121	437	3836		14,411	m
		Slurry Seal	0	474	202	108	121	0	47		952	m
											65,284	m
			2,411	10,655	16,593	15,177	3,869	1,854	14,725	65,284		

From this analysis, the following observations can be made:

- Formal asset condition assessments have not been completed for a large sector of the central city due to on-going cordon restrictions and danger to assessment personnel. A desktop assessment for the cordoned area has been made from aerial photographs and initial assessments for inclusion in the damage tables.
- Damage to roads is widespread across the central city with riverside roads suffering some lateral spread and liquefaction damage, and specific areas – probably geologically aligned with former stream and river paths – damaged by liquefaction and subsidence.
- 5.2km of the 51 km visually surveyed (10%) has been identified as 'Major or Severe" damage levels. These roads are likely to need major repair or renewal options. The remaining moderately – minor damaged roads will require repair only. However, it is expected that asset lives for most infrastructure components have been reduced markedly. Pavement strength testing and remaining life assessment will be required to confirm this and finalise the full renewal programme.
- Kerbs and channels and the under-channel piped system form a major component of the city storm-water drainage infrastructure and have suffered moderate to major damage. The pipes have not been assessed for a large sector of the central city. Although only 2.5km has been identified as initial earthquake damage to major or severe extents, the demolition programme has had, and continues to have a major impact on both kerb and channel and footpath asset condition.
- Pavement, Kerb and channel and footpath renewals will not only be dependent on EQ damage levels. The predominant factor is more likely to be the proposals within the Central City Plan with relation to the slow core streets, eco streets and other traffic flow modification works. The full cost of the roading rebuild works cannot therefore be quantified at this time. Cost estimation therefore can only consider earthquake damage, and improvement works will need to be considered in the Central City Plan.
- In addition, for cost estimation, due to the significant trenching reinstatement required outside of the significant or major damaged roads, full width carriageway surfacing may also be required in the form of Thin Asphaltic Surfacing (TAS) treatments for aesthetics and smoothness of ride. A decision will be required later on the extent of this work however as the central city is a high amenity area, standards for renewal and repair works may be different than those within suburban areas. This should also be taken into account.

5.6. Bridges, Retaining Walls & Embankements

Figure 12 Structures Damage Record (at 12 Feb 2012)

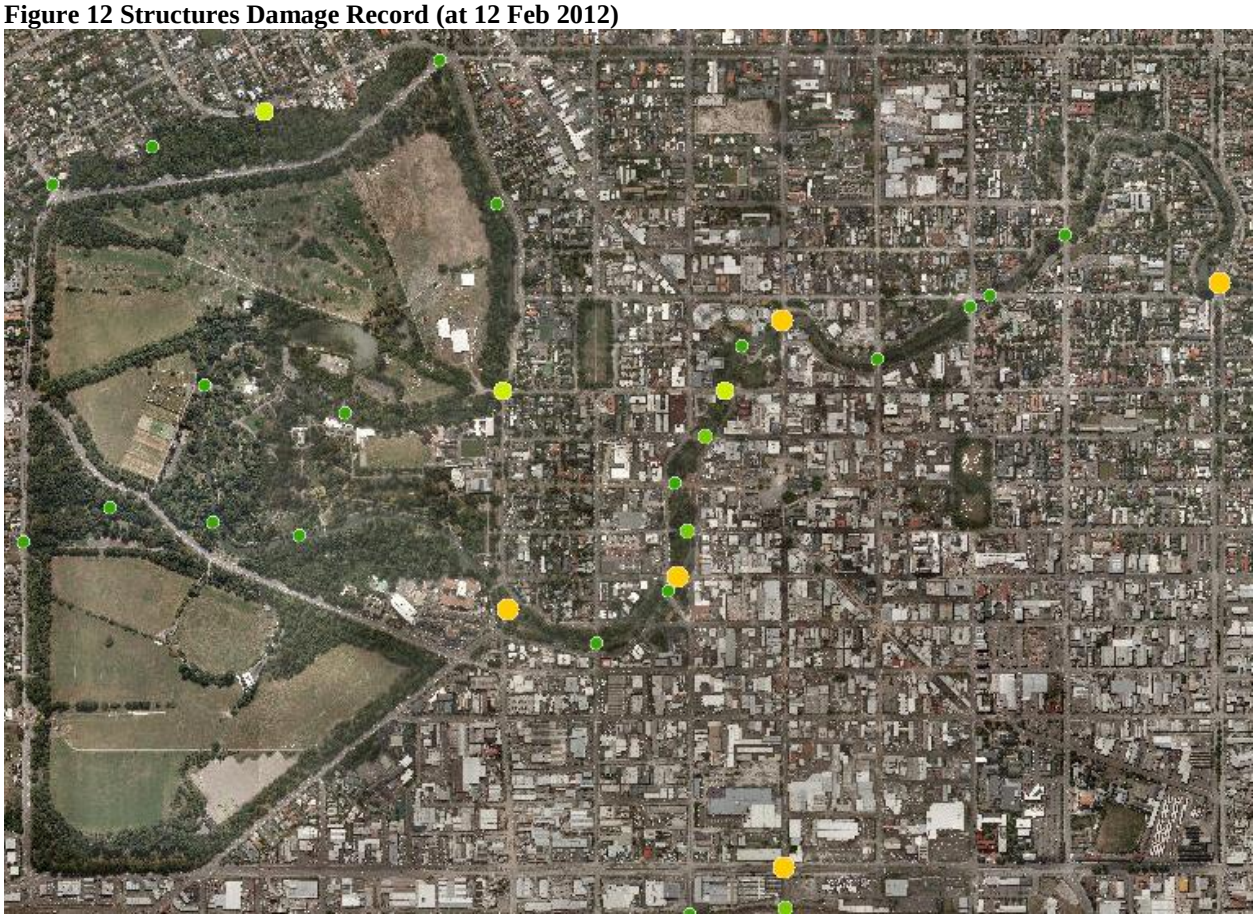


Figure 12 shows the location and damage levels to the bridge structures. Green represents low levels of damage requiring minor repair works with yellow representing moderate to major refurbishment. Currently, only Antigua St footbridge and Fitzgerald Ave twin bridges are being reviewed with regard to replacement rather than repair.

There are 17 bridge structures within the Central City area[4] (refer Table 2). All apart from Moorhouse Avenue Bridge are situated along the River Avon.

A preliminary condition assessment of the bridges has been undertaken which identified most of the structures have only sustained minor to moderate earthquake damage. The main defects include settlement of bridge approaches, movement of wingwalls/abutments, concrete spalling and structural cracking.

Some bridges however have sustained more significant damage including:

- R109 Fitzgerald Avenue Bridges,
- R114 Colombo Street Bridge,
- F104 Hamish Hay Footbridge,
- R115 Armagh Street Bridge,
- F105 Bridge of Remembrance,

[4] Excluding greenspace assets i.e. on / within Hagley Park. For example, R164 culvert under Deans Avenue

- F106 Antigua Street Footbridge and
- R702 Moorhouse Avenue Bridge

Speed restrictions have been implemented on three of the bridges due to the extent of the earthquake damage (Colombo Street Bridge, Armagh Street Bridge and Moorhouse Avenue Bridge).

Two bridges have been closed (F105 Bridge of Remembrance and F106 Antigua Street Bridge) and one partially closed (R115 Armagh Street Bridge) due to the severity of the earthquake damage. Where required temporary remedial works have been undertaken for example Moorhouse Avenue Bridge where steel girders have been installed to support the bridge piers and deck.

Table 11 Central City Bridge Status

Bridge ID	Bridge Name (from Council Database)	Street/Location	Asset Type	Operational Status	Condition	Other Comments
R109	Fitzgerald Ave (2)	Fitzgerald Avenue	Road Bridge	East Open to Class 1 vehicles only West closed	Significantly damaged	
R115	Armagh St	Armagh Street	Road Bridge	Closed	Significantly damaged	HPT & CCC listed Heritage
R114	Colombo St	Colombo Street	Road Bridge	Closed	Significantly damaged	HPT & CCC listed Heritage
R702	Moorhouse Ave O/B	Moorhouse Avenue	Road Bridge	Open	Significantly damaged	
F105	Remembrance	Cashel Street	Footbridge	Closed	Significantly damaged	HPT & CCC listed Heritage
R119	Durham St	Durham Street	Road Bridge	Open to Class 1 vehicles	Minor damage Structurally sound	
R110	Barbadoes Street	Barbadoes Street	Road Bridge	Open to Class 1 vehicles	Minor damage Structurally sound	
R118	Hereford St	Hereford Street	Road Bridge	Open to Class 1 vehicles 30 kmk/hr	Structural damage but serviceable	
R112	Madras Street	Madras Street	Road Bridge	Open to Class 1 vehicles	Minor damage structurally sound	
R111	Kilmore St	Kilmore Street	Road Bridge	Open to Class 1 vehicles	Structurally sound. Approaches require re-levelling to open bridge to normal traffic.	
R113	Manchester St	Manchester Street	Road Bridge	Open to Class 1 vehicles	Minor damage structurally sound	
R120	Montreal St	Montreal Street	Road Bridge	Open to Class 1 vehicles	Minor damage structurally sound	
R116	Gloucester St	Gloucester Street	Road Bridge	Open to Class 1 vehicles	Minor damage structurally sound	HPT & CCC listed Heritage

F104	**Hamish Hay**	Chester Street West	**Footbridge**	**Open for pedestrian use**	**Structural damage but serviceable. Bridge currently cordoned off. Foot traffic could be restored to bridge.**	HPT & CCC listed Heritage
R117	**Worcester St**	Worcester Street	**Road Bridge**	**Open to tram**	**Minor damage Structurally sound**	HPT & CCC listed Heritage
F106	**Antigua**	Oxford Terrace	**Footbridge**	**Closed**	**Significantly damaged**	CCC listed Heritage
R123	**Carlton Mill**	Harper Avenue	**Road Bridge**	**Open**	**Structurally sound.**	
R122	**Armagh St (HAG)**	Rolleston Avenue	**Road Bridge**	**Open**	**Minor damage structurally sound**	
R164	**Culvert under Deans Ave**	Deans Ave	**Culvert**	Open	**Minor damage structurally sound**	

Retaining Walls & Embankments

The river banks along the Avon through the CBD have undergone varying amounts of earthquake related damage. Earthquake related features include liquefaction, fissures, vertical slumping, laterally spreading, cracking to road surfacing and kerbs etc. The area worse affected within the CBD is between Manchester and Colombo Street Bridges along Oxford and Cambridge Terrace

This work has not been included in the estimate and will depend on the 30m exclusion zone proposed around the river.

Notes

Appendix A

Study Briefing (18 November 2011)

18th November 2010

Condition Assessment of Infrastructure within Four Avenues of City

Background.

Since the February 2011 earthquake a number of individual condition surveys have occurred to individual aspects of the Councils infrastructure within the four Avenues. Much of this effort, but not all, has been limited to addressing immediate operational concerns. However there has not been an overall condition assessment of the ability of the wastewater network, nor the land drainage network, nor the roading network to ascertain their ability to resume full service, or to the amount of work required to restore them to the condition they were in prior to the Christchurch earthquakes.

Intention:

The intention of this work request is that at completion both CCC and SCIRT will have a sound indication of the condition of the Councils key infrastructure within the Central Business District as well as its ability to provide core service to that district. In addition a clear indication of the work and cost required to restore these assets to a condition equivalent to that that existed prior to the Christchurch earthquakes will have been established. This request is limited to Wastewater, Land drainage networks plus Transport Bridges and other key structures that require intrusive and/ or expert assessment.

Water supply condition will initially be assessed separately by the use of leak and repair information. Similarly Carriageway, kerb and channel, footpath etc will be assessed utilised appropriate trained people utilising visual inspection in the future when the building deconstruction effort is further advanced and these assets are experiencing less machine damage.

Scope:

Infrastructure involved is:

Wastewater pipe work and pump stations and other "in line "assets. This includes risk due to the inability to convey water away, and /or discharges of flows flowing from trunk mains conveying flows through the area.

Land Drainage pipe work, pumping stations and other "in line" assets. This includes risk of flooding by way of the inability to convey water away, and /or over flowing or in flowing from the Avon River, or other trunks conveying flows through the area.

Transport Bridges especially including vehicle traffic carrying, but also pedestrian.

Location:

The above infrastructure located within the area commonly referred to as the main four Avenues, Specifically including Fitzgerald Ave, Moorhouse Avenue, Bealey Avenue, Park Tce / Rolleston Ave, and Hagley Ave.

Task:

Research and assemble condition assessment information presently existing. Sources include:

- City Care Ltd CCTV records and analysis.
- Manhole level survey work and pipe alignment / grade surveys
- City Care Ltd maintenance contract staff and records (Land Drainage & Wastewater contracts).
- GHD Report - prepared to summarise situation as WW Area managers effort disbanded as emergency operations at CWTP wound down
- Aecom draft report on Brick barrels (Chris Mance has it) - looks like a fair bit of investigation has taken place and is recorded in this doc.
- CCC Land Drainage and Wastewater Operations staff and records
- Informal Knowledge known to contractors / consultants utilised during period (e.g. Jim McMahon SKM, Adam Wheeldon Opus plus others.
- Bridge condition assessment Reports prepared for immediate Operation assessments. Amongst others Stuart Smith (SCIRT) is likely to have information.

Undertake further condition assessment to establish a sound understanding of the condition of the network and their assets, and the work required to restore service and condition.

Utilise The Draft Central City Plan Rebuild programme to understand the nature and programme to rebuild the central city.

Work with the wastewater Maintenance Contractor (City Care Ltd) to understand the nature and scope of "heavy immediate" repair work that City Care (as maintenance Contractor) will be requesting / handing over to SCIRT to undertake.

Prepare work Plans including options and recommendations, and estimates to undertake necessary restoration.

Access to undertake condition assessments within the Cordoned area.

This will need to arranged with CERA (Note Mike Giloolly is attempting to identify the appropriate CERA contact person)

Work outside cordoned area – traffic disruption etc

Work arrangements should be discussed and co-ordinated with CCC Transport & Greenspace Unit as per doc TRIM reference 11/275015 which is referred to in the CCC Infrastructure Recovery Technical Standards and Guidelines. Lawrence Timpson (027 228 1841) should be the initial contact person.

Outputs:

Within 4 months. A report/s outlining the present (at time of reporting) ability for the wastewater and land drainage infrastructure to function normally. And the non maintenance Contract work required to restore these services to a functioning state to allow occupation to each part of the area with minimal temporary equipment such as overland pumping, use of sucker trucks etc. The assumption is that the maintenance Contract will undertake the initial street by street\ (building by building) assessment to establish the availability of local service and undertake the initial repair work to re-establish these services as per their ongoing contract arrangements. When the repair work is beyond these contract arrangements a request will be forwarded for SCIRT to undertake the task.

Within 6 months, a Second report detailing the damage to the assets and the options and recommendations, and estimates to repair / renew to return the assets to a permanent functioning condition at least similar to that that existing prior to the earthquakes.

Within a 6 to 12 month period, a third report suggesting/ recommending a strategy for the repair, renewal or replacement of the Infrastructure in a orderly manner that fits with the central city redevelopment plan, and builds in seismic resilience as well as achieving the desirable goal of not having to undertake any further significant infrastructure renewal works for a 30 years. This report should also consider the Water supply network.