

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 Implementation Plan

**Story:** Central City Infrastructure Rebuild

**Theme:** Programme Management

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A document outlining the methodology for rebuilding horizontal infrastructure in the central city, covering wastewater - local reticulation and trunk; wastewater pump stations, storm water local reticulation and trunk, potable water, roads, bridges.

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](http://www.scirtlearninglegacy.org.nz)



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# Central City Horizontal Infrastructure Rebuild Implementation Plan

## First Issue

### Quality Control Sign Off

Issue	Revision	By	Review	Approve	Date
Draft Central City Plan	Draft 4.1	P McFarlane	R Topham	R Topham	11 May 2012
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## Contents

Executive Summary .....	3
Purpose & Scope .....	3
Key Aspects of Implementation Plan .....	3
1. Introduction .....	6
1.1. Scope and Purpose .....	6
1.2. Catchment/Area .....	6
1.3. Assets .....	7
2. Earthquake Damage .....	7
2.1. Land Damage .....	7
2.2. Asset Description & Condition .....	7
3. Implications of the Central City Plan and other Initiatives on Design of the Rebuild	8
4. Consenting and Planning Requirements .....	11
4.1. Items to be Clarified by the Client Organisations .....	11
5. Proposed Rebuild Strategy .....	11
6. The Rebuild of Specific Services .....	12
6.1. Stage 1 - Works to provide basic service whilst the rebuild is being completed.	12
6.2. Stage 2 - Trunk Wastewater and Storm water Pipes .....	13
6.3. Stage 3 - Wastewater Reticulation .....	13
6.4. Stage 4 – Rebuild the Storm water, Water Supply and Roads in-line with the Central City Plan .....	13
6.4.1. Storm Water .....	13
6.4.2. Potable Water Reticulation .....	15
6.4.3. Utilities & Connections to New Developments .....	15
6.4.4. Roading .....	15
6.5. Bridges .....	16
7. Cost Estimate .....	17
8. Proposed Sub-Projects .....	18
8.1. Rebuild Activities Currently Underway .....	18
8.1.1. Works to provide service whilst the rebuild is being completed .....	18
8.1.2. Rebuild/rehabilitate wastewater and storm water trunk pipes to secure the network.	19
8.1.3. Rebuild the wastewater network and localised repairs to stormwater and water supply networks. Repairing roads where necessary, but in most cases not rebuilding them.	19
8.2. Rebuild Activities Currently Planned .....	20
8.2.1. Rebuild storm water, potable water and roads, on a street by street basis. These works will be phased in with the re-population of the City. ....	20
8.2.2. Works to gain a better understanding of the condition and performance of the existing network .....	21
Appendix A - Consenting and Planning Requirements .....	
Appendix B - Items to be Clarified by the Client Organisations .....	
Appendix C – Sub-Projects .....	
Appendix D: Central City Infrastructure Renewal: Client Statement .....	
Appendix E: Central City Condition Report .....	
Appendix F: Central City Utilities Coordination & Shared Corridors Project Execution Plan	
Appendix G: Central City Storm Water Modelling Proposal .....	
Appendix H: Risks to Basic Service Levels	

## Executive Summary

### Purpose & Scope

This Implementation Plan outlines SCIRT's methodology for rebuilding horizontal infrastructure in the Central City.

The Implementation Plan will be periodically updated to identify, manage and support any requirements arising from the wider recovery process coordinated by the Central City Development Unit (CCDU). As such, it may be necessary to combine this plan with other rebuild programmes, for example utility services, to provide an integrated approach to the rebuild of the horizontal infrastructure, or coordinate this work with the vertical infrastructure programme.

It is intended, that the next update of this plan will be undertaken once the Blueprints have been issued by the CCDU, to ensure that the needs of these proposals are accounted for within the staged approach outlined below.

The Implementation Plan covers the following assets:

- Wastewater - local reticulation and trunk, including brick barrels
- Wastewater pump stations
- Storm water - local reticulation and trunk, including brick barrels
- Potable water
- Roads
- Bridges

The damage levels sustained in the earthquake events is described in the "Condition Assessment of Horizontal Infrastructure within the Central City – Investigation Report" (Condition Report) released by SCIRT in May 2012, a copy of which is appended to this Plan.

This initial Implementation Plan has been based on the draft Central City Plan, the attached Draft 'Central City Infrastructure Renewal: Client Statement', the Condition Report and SCIRT's understanding of the issues that need to be addressed.

### Key Aspects of Implementation Plan

There are several key aspects to consider for the delivery of the horizontal infrastructure rebuild work:

- The post-earthquake fragility of certain elements of the infrastructure (refer to the Condition Report)
- The need to maintain basic service levels for wastewater, water supply, land drainage and transportation requirements for the repopulation/redevelopment of the central city without imposing restrictions
- Risk and consequence of failure of one or more of these assets
- Timing of the work to facilitate the delivery of the Central City Plan and other recovery plans
- Unknown requirements for levels of service needed based on the development proposals
- The ability to respond to programming work to support key initiatives implemented by the CCDU as the rebuild progresses.

Considering these issues, a four stage approach to the rebuild of the Central City is proposed as follows:

1. Coordination and planning with the CCC Operational teams to provide basic service levels whilst the rebuild is being completed.
2. Rebuild/rehabilitate wastewater and storm water trunk pipes to secure the network.
3. Rebuild the wastewater network and localised repairs to storm water and water supply networks. Repairing roads where necessary, but in most cases not rebuilding them.
4. Rebuild storm water, potable water and roads, on a street by street basis. These works will be phased in with the Implementation of the Central City Plan and other recovery plans

This approach endeavours to:

- Provide service until the infrastructure has been rebuilt/repared in the most efficient and economic manner
- Complete, as soon as possible, the deeper services and those services where the design is fairly well fixed and is not significantly influenced by the Central City Plan.
- Schedule next, those services which are in reasonable condition and have uncertainty about their design.
- Allow flexibility in programming the streetscape works and road reconstruction to facilitate the vertical infrastructure rebuild.

To facilitate this work, SCIRT requires key information or decisions to be made from the Client Organisations through this staged process. At the time of writing this report (June 2012) the following information is required:

Item	Issue
Programme	<ul style="list-style-type: none"> <li>Identify the initial priority areas to be rebuilt to support the wider rebuild activities or transitional projects.</li> </ul>
Recovery Activities	<ul style="list-style-type: none"> <li>Confirm the location of construction traffic routes for demolition and rebuild of the vertical infrastructure.</li> <li>Confirm the demolition programme</li> </ul>
Utilities/Infrastructure	<ul style="list-style-type: none"> <li>Confirm the need for common utility corridors and interaction with current utility owner works programmes.</li> <li>Confirm potential layout requirements of the district energy scheme, light rail network and any extension proposals for the tram line.</li> <li>Confirm whether any ground strengthening works are proposed</li> <li>Confirm whether there are any other services/infrastructure that needs to be allowed for</li> <li>Confirm the proposals for the 30m exclusion zone around the Avon River for realignment of infrastructure</li> </ul>

Wastewater	<ul style="list-style-type: none"><li>• Confirm that the current population modelling/land use mapping with applied population densities should be used for calculation of flows within the Central City, or the average sewerage flows (ASF) defined in Pages 6-9 of IDS should be used.</li><li>• Confirm whether the sections of the 130 year old earthenware pipework, which does not meet threshold levels for full renewal, should be replaced to provide future resilience within the system.</li><li>• Confirm the availability of land within the Central City for possible pump station locations if alternative systems are used. (This may limit the number of options SCIRT considers if land is unavailable).</li></ul>
Storm water	<ul style="list-style-type: none"><li>• Confirm the level of service to be provided in the Central City for storm events to allow development of the hydraulic model.</li></ul>
Potable Water	<ul style="list-style-type: none"><li>• Confirm the level of service for fire flows and normal operating pressure.</li><li>• Confirm the pressure to be provided at the zone boundary.</li></ul>
Bridges	<ul style="list-style-type: none"><li>• Confirm preference for order of rebuild to support wider recovery initiatives.</li><li>• Confirm any requirements for heritage interpretation</li><li>• Confirm the proposals for the Moorehouse Overbridge and Fitzgerald Ave Twin bridges (through the Greater Christchurch Transportation Statement)</li></ul>



## 1. Introduction

### 1.1. Scope and Purpose

This document defines projects for the rebuild of horizontal infrastructure in the Central City area. The document describes the assets in this area and the information currently known about their condition. Council requirements, interfaces and constraints that may impact on the rebuild are identified. The various rebuild options are considered at a high level but will be developed further during the concept and detailed design phases.

This Implementation Plan is based on the draft Central City Plan and SCIRT's understanding of the issues that need to be addressed. The Client organisations are developing a Central City Infrastructure Implementation Statement (Draft attached) which will provide further guidance to SCIRT. Issues arising from the Implementation Statement have been incorporated into this Implementation Plan, and further periodic changes will be made at key milestones in the development of the recovery plans.

### 1.2. Catchment/Area

The project area is shown in Figure 1. It is nominally bounded, and includes the "Four Avenues", being Bealey Ave, Fitzgerald Ave, Moorhouse Ave and Deans Avenues.

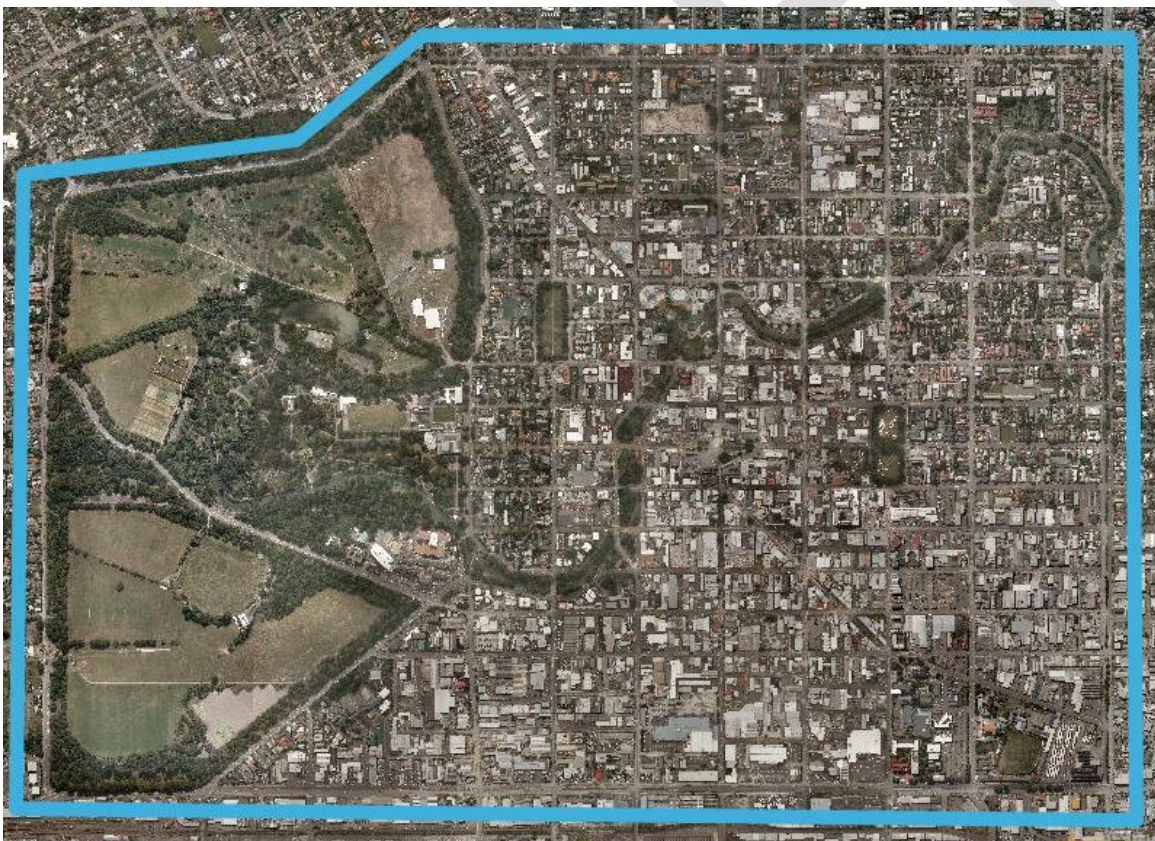


Figure 1 - Central City Area



### 1.3. Assets

The Implementation Plan covers the following assets:

- Wastewater - local reticulation and trunk, including brick barrels
- Wastewater pump stations (2 no.)
- Stormwater - local reticulation and trunk, including brick barrels
- Potable water
- Roads
- Bridges

Exclusions from the plan and outside the current SCIRT scope of works include:

- Tram lines
- Street lights
- Traffic loops and signals
- Greenspace assets, trees and soft landscaping
- Streetscape work (hard landscaping)
- Utility Owners assets

## 2. Earthquake Damage

### 2.1. Land Damage

The LIDAR survey indicates that large parts of the Central City experienced ground settlements in the range of 50mm to 300mm. Larger settlements occurred adjacent to the Avon River and along the central portion of Kilmore St. Further, the LIDAR survey has indicated that some areas have risen. It is expected therefore that this has resulted in significant differential settlement.

Liquefaction was observed after the February Earthquake adjacent to the Avon River, in an area up to 200m north of Moorhouse Ave, on Kilmore St and the area adjacent to the Christchurch Casino. These are also the areas where the largest settlements have occurred.

### 2.2. Asset Description & Condition

Asset assessment is on-going within the Central City area, with varying levels of progress per asset type. The current level of service and condition of the horizontal infrastructure in the Central City is described in the "Condition Assessment of Horizontal Infrastructure within the Central City – Investigation Report" (Condition Report) appended to this plan.

### 3. Implications of the Central City Plan and other Initiatives on Design of the Rebuild

The Central City Plan programmes the rebuild of roads/infrastructure to be completed over the next 12 years. This is much longer than the life of SCIRT, and therefore it is likely that some work will not be included within SCIRT's scope and be completed by others.

Although there is a phased approach of the rebuild programme, the master planning and concept design for the full Central City rebuild will need to be completed to enable detailed design and construction of the works that remain in scope to be completed.

Specifically, the items in the draft Central City Plan that will have an implication on the design of the horizontal infrastructure are:

- **Changes to zoning & land use**

This will have some effect on the sizing of wastewater and potable water pipes. Pipes will be sized based on the flows expected when areas have been developed to the maximum densities defined in the draft Central City Plan. These design flows need to be determined, as they are not currently included in CCC Infrastructure Design Standards (IDS).

Minimum grades are defined by low flows, and due to the low population versus the design flows used (irrespective of whether the 'Rapid' repopulation scenario is used) will mean increased maintenance costs in the short term until flows are sufficient to provide self-cleansing velocities at flatter design grades.

In most cases, localised changes to land use to accommodate specific developments, not yet defined in the Central City Plan, will be able to be accommodated in the rebuild design. This is because pipe sizes are governed by wet weather flows in the case of wastewater and fire flows in the case of potable water. Neither of which will alter significantly if new developments are proposed.

When designing wastewater and potable water infrastructure then, the following will be used:

- Population modelling will be used for the specific zoned area to design capacity requirements.
- Developments identified in the recovery plans will be incorporated in the design
- Due to the above, during the rebuild process, the flows from a new development may then be accommodated in the system as designed. This is expected to be the case for most circumstances.
- Where the infrastructure has not been rebuilt, and a large development is proposed exceeding the standard designs, then localised sections of the network could be upgraded, i.e. the new development is accommodated in the catchment design.
- Where the infrastructure has been rebuilt, and a new development exceeds the capacity of the reticulation system, measures may need to be adopted inside the development, e.g. storage tanks and pumps installed to boost potable water supplies, or wastewater is stored for off-peak pumping to the reticulation system. This methodology is already commonplace for new development works.

A proposal will be submitted to the Scope & Standards Committee for betterment funding where assets are required to be upsized to accommodate new development work or land zone changes. These issues will be determined during the Concept Design Stage and therefore cannot be quantified at this stage.

- **Construction of “Eco-Streets”**

This will affect

- The design of roading and streetscapes.
- The capacity of the storm water system, as there may be limited roadside storage in the “eco-streets”. This may mean that the existing storm water pipes will be undersized. However, this is likely to be offset, at least to a degree, by soakage through the proposed permeable pavements and rain gardens.
- The location of existing services and utilities may need to be altered to suit the proposed road layout and streetscape.

It will be necessary to have detailed plans of the location and layout of the eco-streets to allow the effect on the storm water system and layout of underground services to be determined. The run-off flow characteristics will be added to the hydraulic model at a later date when the plans have been developed. Because of this, the design of the storm water system may not be possible until these plans are complete. This will mean that the lag time between the finalisation of the design process, TOC development and construction delivery needs to be considered to support the construction of the eco-streets.

The development of the eco-street proposals will therefore need to be added to the critical path of the rebuild of the storm water and roading assets in these areas.

- **Increased focus on water quality from storm water discharges**

This will impact on the design of the stormwater system, streetscapes and greenspaces. Therefore these plans will once again be required to finalise the design of the storm water system, in line with the eco-street development.

- **30m exclusion zone adjacent to the Avon River.**

Generally services will be excluded from within 30m of the Avon River, although some minor services may need to pass through this zone to provide local connections. This is desirable from a resilience perspective, as lateral spread is likely in this zone. To satisfy this requirement services along Oxford Tce will need to be realigned.

Outline details of this proposal will therefore be required within Stage 3 of the infrastructure process to allow consideration for the wastewater design.

- **Provision for light rail, district energy scheme and other new infrastructure**

The Central City plan refers to the construction of light rail, the installation of pipework for district heating/cooling and ground treatment requirements. Provision for these activities will need to be made when positioning services and designing roads. It is likely that the space requirements for a district energy scheme will be significant with the potential for a 1.2m diameter pipe requiring up to a 4m easement. If this is the case, early consideration of this proposal will be needed for the detailed design phase of the wastewater system.

- **Potable Water Pressure Rezoning.**

Another initiative that will impact on the design of the potable water rebuild is the Council's Potable Water Rezoning Project. Levels of service for fire flows (standard pressure

requirements for fire fighting) and normal operating pressure will be reviewed as part of this project. These criteria are required for design of replacement water mains. This work is due to be completed in July 2012.

### • **Transitional Projects**

The CCC will implement temporary projects that improve the central city environment, attract people to the central city, and support private sector and community recovery whilst longer-term recovery projects and programmes come on stream.

The current transitional project work programme (to end June 2013) includes:

- Temporary streetscape improvements to Worcester Boulevard, Oxford Terrace, Colombo Street, Gloucester St. St. Asaph and Victoria Street.
- Temporary public space improvements to Cathedral Square, Tuam/High St corner.
- Improvements to lighting in Latimer Square.

These projects will have direct impact on the infrastructure programme. It is proposed that in Stage 1 of our phased approach, we will identify high risk assets within these areas and accelerate any necessary maintenance and repair work (through the CCC Operational teams) to these assets to secure basic service levels before the transitional projects are undertaken.

At the time of writing, it is unlikely the infrastructure rebuild will occur prior to the initiation of these projects (stage 3 & 4). Therefore further minor works may be required to reinstate the transitional projects following the construction of the wastewater network, before being replaced with permanent streetscape works under Stage 4.

### • **Heritage and Heritage Interpretation**

The Central City Plan specifies that the infrastructure renewal needs to include two aspects of protecting Christchurch's heritage. The first is to ensure that the recognized heritage items (heritage assets) that sit within the Central City's infrastructure are protected. The second is to ensure that some elements that can contribute to the remembering the earthquakes are retained, in order to ensure the story of the earthquakes remain part of the cityscape (heritage interpretation).

Key heritage assets that need to be protected as part of the infrastructure renewal are listed in the Christchurch City Plan

These heritage assets include:

- Cathedral, Latimer and Cranmer Squares.
- High Street and Victoria Street public space triangles.
- Barbadoes Street Cemeteries.
- Ramp for watering horses, Victoria Square.
- Kerbstones outside Canterbury Provincial Council Buildings and Armagh Street.
- Canterbury Club gas lamp.
- Hitching post on Cambridge Terrace.
- Gloucester Street, Colombo Street, Worcester Street, Hagley Park, Armagh Street, Victoria Street, Antigua Street, Bridges, and the Bridge of Remembrance.

In addition, the Client Statement outlines that some visible evidence of the earthquakes should be retained, such as damage to bridges (for example, the CCC has suggested retaining the bent iron of Colombo Street bridge) and pavements and other infrastructure (for example, brick barrels) where it can be safely and cost-effectively done. The CCC will advise on the assets to be included for heritage interpretation and included within SCIRT design work.

- **Construction of Anchor Projects**

The majority of construction activity is, and will continue to be, private sector investment and reinvestment. However, some significant public sector construction projects are planned. The location and timing of these significant construction projects ('top 10' or 'anchor' projects) will be finalized through the CERA and CCDU Blueprints (due 27 July 2012) and the CCC Annual Plan (finalized 31 July 2012).

These projects include:

- **Housing showcase.** Location to be confirmed August 2012. Construction planned to start April 2013.
- **Parking buildings.** Lichfield Street and Manchester Street car parks to be repaired to 100 per cent of new building standards. Construction planned to start 2012 and be complete by mid 2014.
- **Earthquake memorial.** Location to be confirmed. Construction planned to start 2014.
- **Convention centre.** Preferred option 21,000 m<sup>2</sup>. Location to be confirmed through CERA and CCDU blueprints.
- **Metro sports facility.** Preferred option aquatic centre only. Location to be confirmed through CERA and CCDU blueprints.
- **New Central Library.** Location to be confirmed through CERA and CCDU blueprints. Construction planned to start 2014.

## 4. Consenting and Planning Requirements

SCIRT will review the consenting requirements once the Central City Plan has been finalized by the CCDU and changes made to the Christchurch District Plan. Before this time, any work undertaken will comply with current consenting requirements.

### 4.1. Items to be Clarified by the Client Organisations

Appendix B contains a list of items that need clarification by the Client organisations. It is expected that these items will be addressed in the final Central City Infrastructure Implementation Client Statement.

## 5. Proposed Rebuild Strategy

A four stage approach to the rebuild of the Central City is proposed as follows:

1. Works to provide basic service levels whilst the rebuild is being completed, managed and implemented by the CCC Operational teams.
2. Rebuild/rehabilitate wastewater and storm water trunk pipes to secure the network.

3. Rebuild the wastewater network and localised repairs to storm water and water supply networks. Repairing roads where necessary, but in most cases not rebuilding them.
4. Rebuild storm water, potable water and roads, on a street by street basis. These works will be phased in with the re-population of the City.

In conjunction with the above, works will continue to be undertaken to gain a better understanding of the condition and performance of the existing network, particularly with regard to the storm water system.

The four stage approach endeavours to:

- I. Provide service until the infrastructure has been rebuilt/repared in the most efficient and economic manner
- II. Complete, as soon as possible, the deeper services and those services where the design is fairly well fixed and is not significantly influenced by the Central City Plan.
- III. Leave until later, those services which are in reasonable condition and have uncertainty about their design.
- IV. Allow flexibility in programming streetscape works and road reconstruction to facilitate the vertical infrastructure rebuild.

The approach being proposed for the Central City and the extent of services likely to be rebuilt is the same as that being adopted through the rest of the earthquake affected areas of the City. Except that a one pass approach is being targeted in other areas of the City, whereas in the Central City, the wastewater network will be rebuilt and roads made safe under one phase and then the remaining services and final road reconstruction will be completed later.

## 6. The Rebuild of Specific Services

### 6.1. Stage 1 - Works to provide basic service whilst the rebuild is being completed.

Plans will be developed to provide service during the transitional period. This will involve:

- Assessment of the state of the wastewater, potable water and storm water networks to determine the levels of service (LOS) that can be provided at the various parts of the network if no additional works are undertaken. Examples of LOS that will be considered include frequency and duration of supply outages and maximum flow rates.
- Scoping of works to improve transitional LOS to acceptable levels. Improvement works may include repairs to sections of the network, temporary pumping, on-going pipe unblocking or acceleration of the permanent rebuild works. Improvement works will be selected using a risk based approach, undertaking those works that will result in the greatest reduction in the likelihood and/or consequence of failure for the least amount of money. Temporary streetscape and landscaping works can also be considered at this stage if required.
- The appropriate improvement measures will be instigated as new developments are constructed.

When this holistic LOS improvement plan is in place, CCC Operational teams will work jointly with SCIRT to keep it live and up to date as the central city work progresses.



This approach will enable the transitional improvement works to be undertaken in a planned and efficient manner. It will also provide developers with an understanding of the LOS that can be provided.

## 6.2. Stage 2 - Trunk Wastewater and Storm water Pipes

CCC has already confirmed that the trunk network is hydraulically adequate for future development. Therefore once these assets have been repaired, risk is significantly reduced and limited to the local reticulation system.

Assessment of the brick barrel pipes is currently underway. It is expected that the majority of the brick barrels will need to be rehabilitated by trenchless lining. Specialist contractors for this work have been appointed. It is expected that lining will be completed late 2012/early 2013.

Assessment of the other, newer trunk pipes will follow on. However, it is envisaged that these will not require significant repair.

## 6.3. Stage 3 - Wastewater Reticulation

The condition report indicates all but a small proportion of the earthenware pipework needs to be replaced based on the current renewal/repair criteria. However, it is recommended that the remaining earthenware also be replaced to provide resilience from future seismic events.

Due to the extent of the damage, it is assumed that only a representative sample of the network will have further assessment at concept design stage to confirm damage levels.

Consideration will be given to the following high level options (in no particular priority):

- Gravity system replacement
- Pressure systems
- Enhanced gravity systems
- Vacuum Systems

With both Vacuum and enhanced gravity systems it may be necessary to acquire land to site the pump stations. This may be in the region of 80-300m<sup>2</sup> dependant on the type of pump. Although Vacuum and enhanced gravity systems provide significant capital savings and increased resilience, the economics around land value and long term revenue / growth through land use may offset these savings. Some preliminary work will therefore be necessary, to assess this value, before SCIRT undertakes the concept design of these system options. It is assumed that CERA will provide this information.

## 6.4. Stage 4 – Rebuild the Storm water, Water Supply and Roads in-line with the Central City Plan

### 6.4.1. Storm Water

The storm water reticulation is believed to be in a better condition than the wastewater system. However during the assessment of the infrastructure within the cordoned zone, cracking and breaks have been observed. On balance, it is expected that a smaller renewal length will be required along with relining and repair works to secure the system.

However, the system may need to be significantly modified to meet capacity requirements. This is due to the land settlement relative to the level of service required before the secondary flow paths (the roads) operate during storm conditions. Capacity improvements may also be

needed to tie in with the eco-street designs and to satisfy the improved storm water discharge standards. Improvements that may be required include:

- Changing the position of catchpits and catchpit leads, due to new road profiles and widths.
- Changing the alignment and depth of pipes to accommodate the proposed rain gardens.
- Upsizing pipes to prevent flooding caused by ground settlements and changes in road cross-sections for eco-streets.
- Installing storm water quality improvement devices. These could include a combination of catchpit devices, rain gardens, permeable pavements, inline treatment devices, wetlands and treatment ponds.

The entire network may need to be progressively altered to meet these requirements. This work will be consistent with the wider recovery of the central city led by the Central City Plan.

To design improvements to the storm water system the following design inputs are required:

- The level of service for flooding, i.e. is a 1 in 5 year standard acceptable in the Central City, as per the rest of the city, or is a higher level of service desired.
- The water quality discharge standards that are to be achieved.

Once these have been determined, a high level master plan for improvements to the storm water system can be developed. This would involve tasks such as:

- Develop a model of storm water network including overland flow. This will help determine where storage/soakage devices or new pipes are required to be installed.
- Undertake a soakage study. This will feed into the design of soakage/treatment devices and the sizing of pipes.
- LIDAR study to identify low spots where flooding may occur, with confirmation through topographic surveying.
- Develop high level concepts for reducing flooding and improving water quality, determining what measures are appropriate and where they should be installed.
- Consideration of the timing of the improvement works and how these will impact on the rebuild programme.

The Council may need to consider stipulating minimum floor levels, in new developments, to avoid flooding damage. This will depend on the likelihood of flooding occurring.

Although a 4 stage approach is proposed, in some instances a one pass approach may be possible in certain areas of the city where sufficient information is available for the development proposals. SCIRT will liaise with the CCDU and Client Organisations to facilitate, where possible, decisions as to whether storm water pipes should be replaced at the same time as the wastewater network is rebuilt. This will be assessed during the concept design stage, with consideration being given to:

- The likelihood and extent that the storm water network will need to be altered for eco-streets and storm water quality improvements.
- The condition of the storm water pipes.

#### 6.4.2. Potable Water Reticulation

It is believed that the potable water system is generally adequate from an earthquake damage perspective. Localised sections may need to be upgraded due to pipe condition and to meet specific requirements for new developments.

In order to rebuild the potable water in the Central City the following information is required from the rezoning project:

- The level of service to be provided for fire flows and normal operating pressure, i.e. what the system is to be designed to deliver.
- The pressure at the zone boundary.
- Any storage to be provided within the zone to provide security of supply.

As the potable water system is shallow, it is likely that further damage will occur from demolition and rebuild activities. Significant sections of the network may need to be replaced when the eco-streets are constructed to avoid damage during construction. It is probably desirable to replace the older potable water pipes at this time, from a leakage perspective and to avoid future damage and disruption.

In addition, where roads will be rebuilt, it may be more economically viable to replace the water supply infrastructure with modern resilient materials to future proof the system and reduce long-term capital replacement costs within the central city. A full economic analysis should be produced to consider this.

#### 6.4.3. Utilities & Connections to New Developments

There is scope for SCIRT to install common utility trenches. These would take the form of a bank of ducts installed by SCIRT that the various utility companies use to install their respective services. The feasibility and practicality of this proposal is still being investigated by SCIRT working with the other asset owners.

Standard points for connecting services and utilities to new developments need to be determined, to avoid developers digging up recently rebuilt streets to make connections. For example, all lots may be provided with a wastewater lateral at 1m depth, at the boundary with the neighbouring lot.

An execution Plan for these proposals is appended to this report.

#### 6.4.4. Roading

Careful consideration and planning of road reconstruction will be required not only to ensure that no further trenching is needed for developments, but also to support the economic recovery through streetscape works and road layout improvements. The Central City Plan implementation will lead this process and be delivered under Stage 4 of the Implementation Plan.

The following transport and streetscape projects been identified within the Central City proposals:

- Slow Core
- Tram repair
- Eco-streets

The following transport and streetscape projects have been proposed in the draft Central City Plan but are being reviewed by CERA and the CCDU and will be confirmed by end July 2012:

- One-way to two-way
- Improvements to the Avenues and Main Streets
- Buses and Street Stations
- Improvements to the cycling network
- Parking provisions
- Wayfinding

The planning and design work by the CCDU for these proposals is due to be completed by June 2013, with implementation over the following 10 years. Considering these proposals, a three stage approach is proposed, i.e.

1. Make safe (SCIRT Stage 1 to 3) – undertake those repairs necessary to make the roads safe and suitable for traffic and pedestrians. Temporary streetscape and landscaping may be installed at this stage.
2. Road Reconstruction, Transport & Streetscape works (SCIRT Stage 4) – progressively rebuild streets to the final design with permanent streetscape and landscaping over the remaining life of SCIRT where programme permits. All services and utilities requiring replacement will need to be installed before the roading, transport & streetscape works are constructed.
3. Road Reconstruction, Transport & Streetscape works (2016 and beyond) – The work detailed above is undertaken and managed by others.

In the majority of cases, the proposed changes to the roading system will not affect the general routing of underground infrastructure, with the exception of the 30m exclusion zone around the river. However, the specific positioning of services, utilities, roading and streetscape will need to be coordinated to avoid clashes.

As it is likely that services and utilities will be installed before roading designs are finalised, it is recommended that typical road and service/utility cross-sections be determined as soon as possible. Provision for light rail, heating ducts and future ground strengthening works should also be agreed. These typical cross-sections should be developed jointly by SCIRT designers and the Client Organisations.

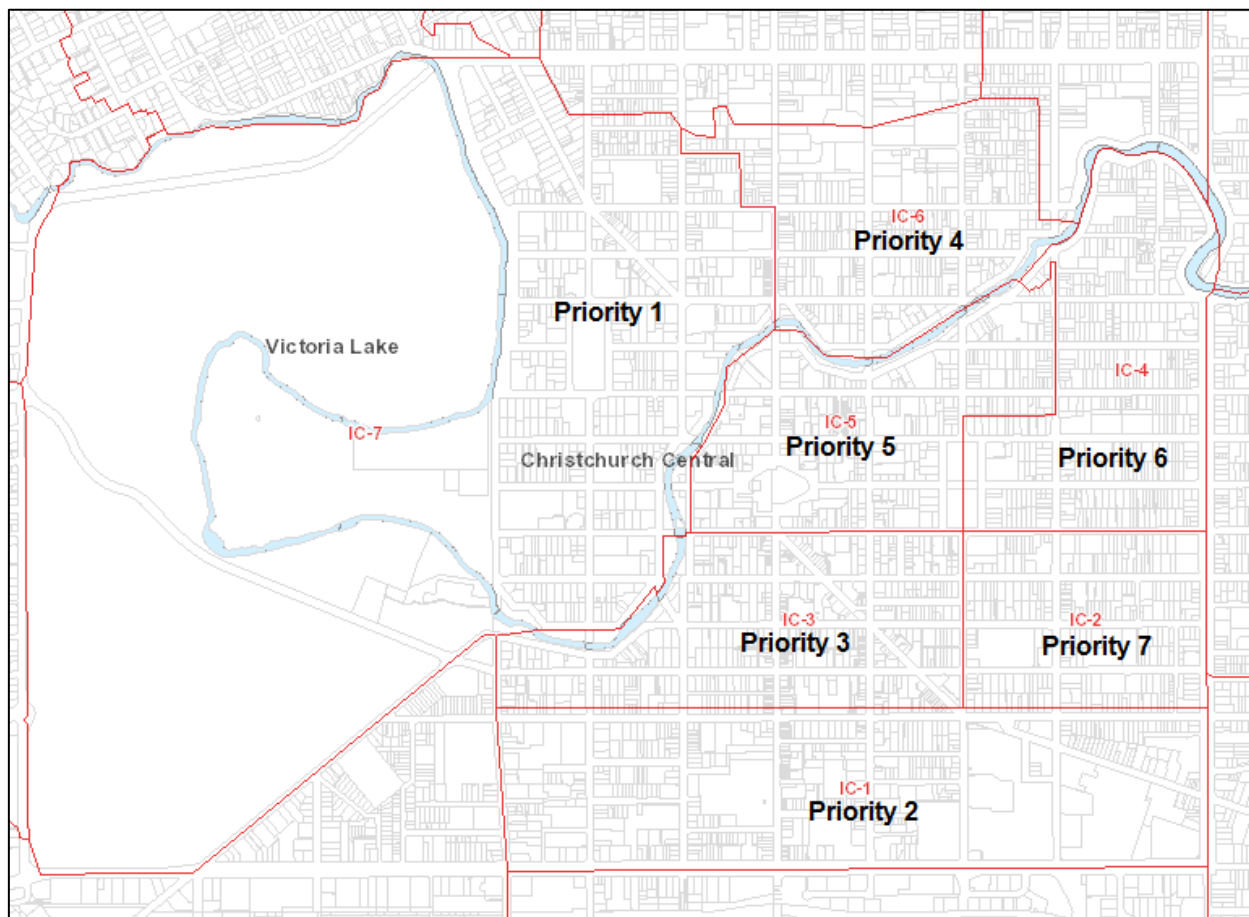
## 6.5. Bridges

There are 17 bridges which require repair within the Central City running on an independent programme of work. The Fitzgerald Avenue Twin bridges need confirmation of the requirements from the Greater Christchurch Transportation Statement (i.e. whether the Fitzgerald Ave bridges require widening). Other bridges are important vehicular and pedestrian access routes into and out of the city.

The bridges are currently prioritised by operational requirements (damage, criticality and service levels) however the order of rebuild and overall programme needs to be considered in-line with the wider recovery plans, restart initiatives and the Central City Plan implementation.

## 7. Prioritisation of Catchment Areas

The general principle of dividing areas into wastewater hydraulic catchments has been adopted to identify suitably sized one pass projects. Through the SCIRT prioritisation process, the operational priorities have been calculated to give an overall priority score per area. This can be seen below in Figure 2.



**Figure 2: Catchment Priorities**

However, rather than the rebuild programme being delivered based on this process, it is assumed that the order of rebuild will be instructed by the CCDU to support the wider rebuild activities and recovery plans. To facilitate this therefore, and to progress with Stage 3 of this staged implementation plan, the concept design of all wastewater within the Central City area will commence, and the detailed design and delivery programmes will be influenced by the appropriate (instructed) priority order. This may be either at a catchment level as above, or at street level if the new system allows this.

## 8. Cost Estimate

WT Partnership (CCC's cost estimation consultants) prepared the September 2011 estimate which has not been reviewed following the Condition Report.

The main changes in scope that are likely to affect the total cost are:

1. Increased extent of wastewater rebuild due to the steeper grade requirements now specified in the IDS and the potential replacement of all earthenware pipework.

2. The extent of storm water rebuild required to construct eco-streets and to improve storm water discharge quality. Further assessment of level of service provision in relation to land damage will also be required
3. The staged approach in this implementation plan will require additional road reinstatement, i.e. repair of roads after the wastewater has been rebuilt, and full reconstruction at a later date.
4. Potential long term benefits for renewing old, undamaged water supply infrastructure where roads are to be rebuilt.
5. Cost of the streetscape works was not included in the original estimate (based on repairing damage only).

It is proposed, at this stage of development, that the CCC estimate for this work is adopted at \$239.3M, broken down as follows (Extract from the Draft Central City Plan):

*Table 13: Infrastructure repair and reconstruction costs*

Network	Total Capex \$m	Capex \$m 1-2 Yrs	Capex \$m 3-4 Yrs	Capex \$m 5-7 Yrs
<b>Alliance</b>				
Transport	76.3	18.3	39.8	18.2
Water supply	15.2	3.1	9.9	3.0
Wastewater	99.0	18.4	48.8	31.8
Stormwater	35.8	4.0	17.0	14.0
Structures	13.0	4.0	6.0	3.0
<b>Total</b>	<b>239.3</b>	<b>47.8</b>	<b>121.5</b>	<b>70.0</b>
<b>Non-Alliance</b>				
Stormwater	7.5	2.5	3.0	2.0
Parks and Open Space	39.5	9.9	19.7	9.9
Buildings	156.8	42.5	81.8	32.5
<b>Total:</b>	<b>203.8</b>	<b>54.9</b>	<b>104.5</b>	<b>44.4</b>

## 9. Proposed Sub-Projects

### 9.1. Rebuild Activities Currently Underway

The following activities are currently underway:

#### 9.1.1. Works to provide service whilst the rebuild is being completed.

Project Name	Budget	Timing	Responsibility
Determine current levels of service	To be determined	July 2012	Joint CCC & SCIRT
Scope works to improve transitional levels of service	To be determined	August 2012	Joint CCC & SCIRT
Undertake works to improve transitional LOS	To be determined	To be determined once scope confirmed.	



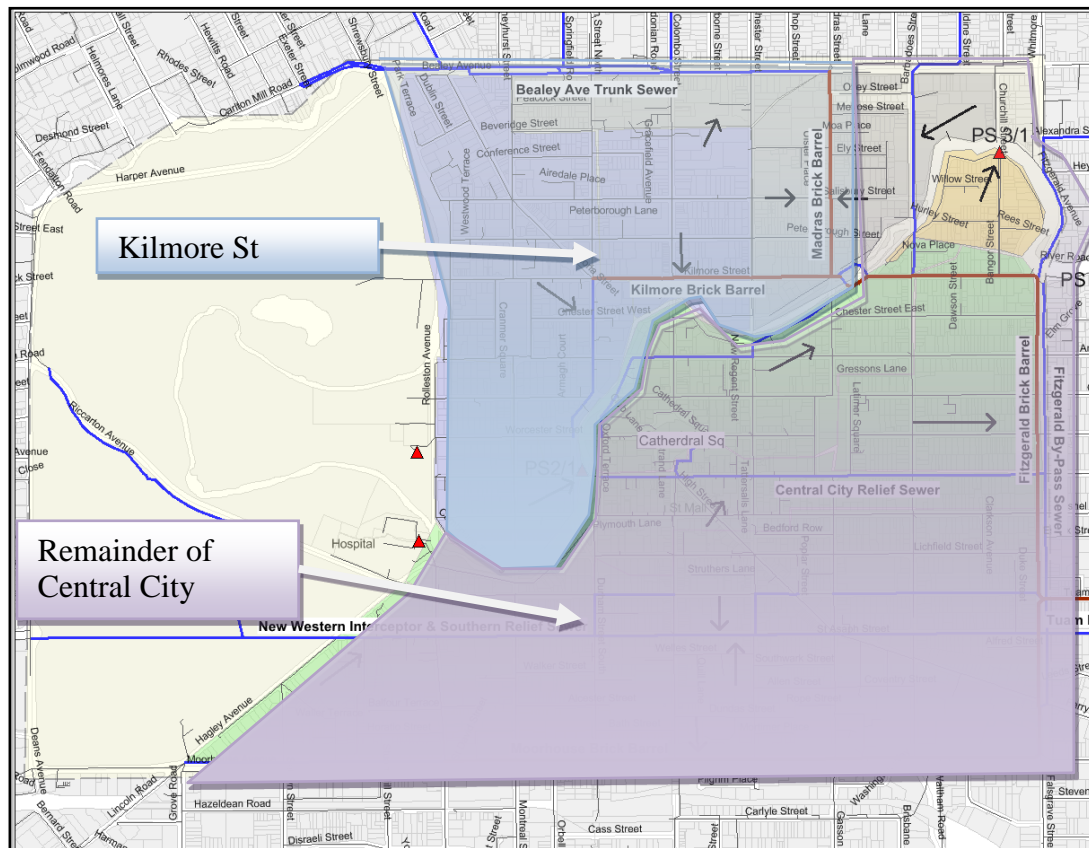
9.1.2. Rebuild/rehabilitate wastewater and storm water trunk pipes to secure the network.

Project Name	Budget	Timing	Responsibility
Rehabilitation/ Rebuild of SW & WW brick barrels in Central City (excluding Kilmore St Brick Barrels)*	\$25.7mil	Complete by 30/4/13	Fletchers Delivery Team
Condition assessment of the remainder of the trunk pipes in the CBD	To be determined	Complete by 31/10/12	Asset Assessment
Rehabilitation of the remainder of the trunk pipes in the CBD	To be determined	Target date 31/8/13	To be determined

\* The Kilmore Street wastewater and storm water brick barrel pipes have sustained significant damage and are located in a liquefaction area. Alternatives to rebuilding them in their current locations are will be assessed during the concept design for the "Central City – Kilmore Street Catchment Areas (Project Number 10844)".

9.1.3. Rebuild the wastewater network and localised repairs to storm water and water supply networks. Repairing roads where necessary, but in most cases not rebuilding them.

Project Name	Budget	Timing	Responsibility
Central City - Kilmore Street Catchment Area (10844) Concept design is required to be completed in order to decide how to rebuild/rehabilitate the Kilmore St Brick Barrel	To be determined	Concept Design to be completed by 27 June 2012	Orange Team MacDow Fletchers allocated for ECI
Remainder of the Central City Area	To be determined	To be determined	Blue Team



### Figure 3 - Central City Wastewater Areas

## 9.2. Rebuild Activities Currently Planned

The following activities are currently planned:

9.2.1. Rebuild storm water, potable water and roads, on a street by street basis. These works will be phased in with the re-population of the City.

Activity Name	Budget	Timing	Responsibility
<b>Develop typical road layouts</b> To ensure that services installed fit in with the final streetscape design	To be determined	As soon as practical	Jointly with CCC & SCIRT
<b>Develop common service trench details</b> Use of common utility trenches could reduce disruption and save money. Defining standard connection details at property boundaries will enable developers to design their works on private property.	To be determined	As soon as practical	David Bain (SCIRT)

9.2.2. Works to gain a better understanding of the condition and performance of the existing network

Activity Name	Budget	Timing	Responsibility
<b>Develop Central City Wastewater Trunk Model</b>	The model for the entire city has recently been developed by the Council		
<b>Develop Central City Storm water Network Model</b>  To determine whether the storm water trunk network is adequate. To assist in design of storage/soakage measures, such as rain gardens and permeable pavements.	To be determined	As soon as practical	SCIRT
<b>Soakage investigation</b>  To design storm water soakage/storage on private and public land. The assessment will also feed into the design of the trunk storm water system.	To be determined	As soon as practical	SCIRT
<b>Condition Assessment of Storm water Outfalls</b>  To identify structures and pipes that have been damaged by lateral spread.	To be determined	As soon as practical	Asset Assessment

## Appendix A - Consenting and Planning Requirements

A review of the proposed changes to the Christchurch District Plan has been undertaken by Sarah Fitzgerald, SCIRT Consents Manager. She considered the Transport and Parking, Conservation 5, Heritage, and Noise provisions Draft Central City Plan. The key issues for consideration in the SCIRT work programme are:

- Defining a Compact 'Core' area which is distinct to the remainder of the Central City.
- Introduction of a new road hierarchy which categorises roads in terms of vehicle movement functions and 'place' functions. There are consequent design guidelines for these roads, such as roads in the Compact CBD having wider footpaths, narrower carriageways, slower speeds (30km/h or less).

Categories of road hierarchy are:

- People streets (people priority ahead of vehicular traffic)
- Main streets (iconic approach to heart of city from Avenues, particularly for cyclists and pedestrians. Probably separated cycle lanes)
- Local streets (access to property. Not intended as through route for vehicle, but for pedestrians and cyclists)
- Distributor streets (key movement corridors)
- Avenues (key traffic route, some access and parking may be restricted)
- Removal of one-way system.
- New vehicle crossing / access design.
- Rezoning of parts of the Avon river corridor (including some of the Road zone) to Conservation 5 zone. May have impacts for some utilities on/in/adjacent to river banks (e.g. above ground).
- Changes to rules about heritage repairs/reconstruction. These may become permitted activities. Alterations for Building Code compliance may require consent (for Cat 1 and 2 structures).
- There is a noted increase in focus on the remaining heritage items.
- There is a noted focus on Crime Prevention Through Environmental Design (CPTED) principles.
- There are rules relating to construction noise (which are currently exempt in the District Plan). These are the same limits provided in NZS Construction Noise 6803:1999. This may have implications for any night works or for any prolonged 'very noisy' activities.
- Urban design rules for any new buildings (implications for any new pump stations)

The other aspects that have not been looked at in any detail are Central Core and Fringe zones, Mixed Use zone, Living zones, Business zones, sustainable buildings.

## Appendix B - Items to be Clarified by the Client Organisations

Item	Issue
Programme	<ul style="list-style-type: none"> <li>Identify the initial priority areas to be rebuilt to support the wider rebuild activities or transitional projects.</li> </ul>
Recovery Activities	<ul style="list-style-type: none"> <li>Confirm the location of construction traffic routes for demolition and rebuild of the vertical infrastructure.</li> <li>Confirm the demolition programme</li> </ul>
Utilities/Infrastructure	<ul style="list-style-type: none"> <li>Confirm the need for common utility corridors and interaction with current utility owner works programmes.</li> <li>Confirm potential layout requirements of the district energy scheme, light rail network and any extension proposals for the tram line.</li> <li>Confirm whether any ground strengthening works are proposed</li> <li>Confirm whether there are any other services/infrastructure that needs to be allowed for</li> <li>Confirm the proposals for the 30m exclusion zone around the Avon River for realignment of infrastructure</li> </ul>
Wastewater	<ul style="list-style-type: none"> <li>Confirm that the current population modelling/land use mapping with applied population densities should be used for calculation of flows within the Central City, or the average sewerage flows (ASF) defined in Pages 6-9 of IDS should be used.</li> <li>Confirm whether the sections of the 130 year old earthenware pipework, which does not meet threshold levels for full renewal, should be replaced to provide future resilience within the system.</li> <li>Confirm the availability of land within the Central City for possible pump station locations if alternative systems are used. (This may limit the number of options SCIRT considers if land is unavailable).</li> </ul>
Storm water	<ul style="list-style-type: none"> <li>Confirm the level of service to be provided in the Central City for storm events to allow development of the hydraulic model.</li> </ul>
Potable Water	<ul style="list-style-type: none"> <li>Confirm the level of service for fire flows and normal operating pressure.</li> <li>Confirm the pressure to be provided at the zone boundary.</li> </ul>
Bridges	<ul style="list-style-type: none"> <li>Confirm preference for order of rebuild to support wider recovery initiatives.</li> <li>Confirm any requirements for heritage interpretation</li> <li>Confirm the proposals for the Moorehouse Overbridge and Fitzgerald Ave Twin bridges (through the Greater Christchurch Transportation Statement)</li> </ul>

## Appendix C – Sub-Projects

Tactic	Project Name	Budget	Timing	Responsibility
<b>Provide service whilst the rebuild is being completed.</b>	<b>1.1 Determine current levels of service</b>	To be determined	July 2012	Jointly between CCC & SCIRT.
	What the work involves	<ul style="list-style-type: none"> <li>Assessment of the state of the wastewater, potable water and storm water networks to determine the levels of service (LOS) that can be provided at the various parts of the network if no additional works are undertaken.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>To enable the transitional improvement works to be undertaken in a planned and efficient manner.</li> <li>To provide developers with an understanding of the LOS that can be provided.</li> </ul>		
	Key Dates	July 2012		
	Notes	<ul style="list-style-type: none"> <li>Examples of LOS that will be considered include frequency and duration of supply outages and maximum flow rates.</li> <li>When this holistic LOS improvement plan is in place, CCC Operational teams will work jointly with SCIRT to keep it live and up to date as the central city work progresses.</li> </ul>		
	<b>1.2 Scope works to improve transitional levels of service</b>	To be determined	August 2012	Jointly between CCC & SCIRT.
	What the work involves	<ul style="list-style-type: none"> <li>Scoping of works to improve transitional LOS to acceptable levels.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>To enable the transitional improvement works to be undertaken in a planned and efficient manner.</li> <li>To provide developers with an understanding of the LOS that can be provided.</li> </ul>		
	Key Dates	August 2012		
	Notes	<ul style="list-style-type: none"> <li>Improvement works may include repairs to sections of the network, temporary pumping, on-going pipe unblocking or acceleration of the permanent rebuild works.</li> </ul>		



		<ul style="list-style-type: none"> <li>Improvement works will be selected using a risk based approach, undertaking those works that will result in the greatest reduction in the likelihood and/or consequence of failure for the least amount of money.</li> <li>Temporary streetscape and landscaping works can also be considered at this stage if required.</li> </ul>		
	<b>1.3 Undertake works to improve transitional LOS</b>	To be determined	To be determined	Jointly between CCC & SCIRT.
	What the work involves	<ul style="list-style-type: none"> <li>Undertaking appropriate improvement measures as new developments are constructed.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>To enable the transitional improvement works to be undertaken in a planned and efficient manner.</li> <li>To provide developers with an understanding of the LOS that can be provided.</li> </ul>		
	Key Dates	To be determined		

Tactic	Project Name	Budget	Timing	Responsibility
<b>Assess the condition and rehabilitate brick barrel and trunk pipes (Storm &amp; Wastewater)</b>	<b>2.1 Rehabilitation/ Rebuild of SW &amp; WW brick barrels in Central City</b>	\$25.7mil	Complete, including assessment by 30/4/13	MacDow Fletchers
	What the work involves	<ul style="list-style-type: none"> <li>• Removal of silt and debris</li> <li>• CCTV and laser profiling</li> <li>• Assessment of investigation data</li> <li>• Design of rehabilitation works</li> <li>• Rehabilitation works</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>• To identify those pipes that require rehabilitation/repair</li> <li>• To ensure that service is maintained.</li> <li>• To rehabilitation of pipes identified as being in urgent need of repair.</li> </ul>		
	Key Dates	<ol style="list-style-type: none"> <li>1. EOI to appoint specialist contractor issued April 12</li> <li>2. Start lining May 12</li> <li>3. Lining complete April 13</li> </ol> <p>Priority should be given to the brick barrels in the following areas, as these are located under heavily trafficked roads and the sections of pipe inspected to date are in poor condition:</p> <ol style="list-style-type: none"> <li>1. Moorhouse Ave</li> <li>2. Fitzgerald St</li> <li>3. Kilmore St</li> <li>4. Madras St</li> </ol>		
	Notes	<ol style="list-style-type: none"> <li>1. Wastewater pipes are egg-shaped with nominal diameters between 400mm to 900mm. Total length is approximately 5.2km.</li> <li>2. Storm water pipes are circular with nominal diameters between 300mm to 1,100mm. Total length is approximately 6.9km.</li> <li>3. For programming purposes it is assumed that all of the brick barrels will require rehabilitation.</li> <li>4. This project has been allocated Project No. 10845. It is proposed that the work be undertaken as a design and build project. A detailed design report for this project was completed in February 2012. Delivery has been allocated to Fletchers</li> <li>5. This sub-project does not include the Kilmore Street wastewater and stormwater brick barrel</li> </ol>		

Tactic	Project Name	Budget	Timing	Responsibility
Assess the condition and rehabilitate brick barrel and trunk pipes (Storm & Wastewater)		pipes. These pipes have sustained significant damage and are located in a liquefaction area. Alternatives to rebuilding them in their current locations are will be assessed during the concept design for the "Central City – Kilmore Street Catchment Areas (10844)".		
	<b>2.2 Condition assessment of the remainder of the trunk pipes in the Central City</b>	To be determined	Complete by 31/10/12 (To be confirmed)	Asset Assessment Section
	What the work involves	<ul style="list-style-type: none"> <li>Removal of silt and debris</li> <li>CCTV and laser profiling</li> <li>Assessment of investigation data</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>To identify those pipe that require rehabilitation/repair</li> <li>To ensure that service is maintained.</li> </ul>		
	Key Dates	To be determined		
	Notes	1. When the extent/type of damage is known a decision can be made as to whether to appoint an LDO or to complete repair works under an extension to the design and build process being undertaken for Project 2.1.		
	<b>2.3 Rehabilitation of the remainder of the trunk pipes in the CBD</b>	To be determined	Target Date 31/8/13	To be determined
	What the work involves	<ul style="list-style-type: none"> <li>Rehabilitation of trunk pipes and repair of manholes.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>Rehabilitation of pipes identified as having been damaged by earthquakes.</li> </ul>		
	Key Dates	To be determined		
	Interfaces	1. Asset assessment to be completed under Sub-project 2.1 by Asset Assessment		
	Notes	1. It is expected that these pipes will be in reasonable condition. For programming purposes it is assumed that only 20% will require rehabilitation. 2. Rehabilitation is to be programmed to be completed prior to the rebuild of other shallower services.		

Tactic	Project Name	Budget	Timing	Responsibility
Rebuild the wastewater network and localised repairs to stormwater and water supply networks	3.1 Central City – Kilmore Street Catchment Area” (10844)	To be determined	Concept Design to be completed by 27/6/12	Orange Team (Concept Design)
	What the work involves	<ul style="list-style-type: none"> <li>Wastewater reticulation feeding into the Kilmore St (West) brick barrel pipes, including Pump Station 2, and assessment of the trunk sewer pipe.</li> <li>Stormwater reticulation design, limited to that directly associated with the Kilmore St West brick barrel.</li> <li>Roading - make safe repairs.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>The brick barrel pipes in Kilmore St are located in an area which settled by more than 300mm and experienced significant liquefaction. The trunk pipes are believed to be in poor condition (although this needs to be confirmed through detailed condition assessment).</li> <li>It may not be appropriate to line the trunk sewer.</li> <li>Concept design of the upstream catchment is required to be undertaken to determine the most appropriate course of action of the brick barrel pipes.</li> </ul>		
	Key Dates	1. Concept design 31/6/12. Packaging and timing for detailed design and delivery is to be determined after the completion of the concept design.		
	Interfaces	<ul style="list-style-type: none"> <li>Design and construction of the Hagley Park siphon, which drains into the area, is being undertaken under Project 10506.</li> <li>Rehabilitation of wastewater and storm water brick barrel pipes in the Central City (Project 10845, ref 2.1 above).</li> </ul>		
	Notes	1. This project has already been allocated Project no. 10844. 2. Storm water works are limited to those associated with the Kilmore St brick barrel. Potable water and roading repairs are limited to those required to maintain service. These services will be rebuilt when the eco-streets in the area are constructed. The timing of these works is still to be determined by Council. 3. This project has been allocated to MacDow Fletchers for ECI.		

Tactic	Project Name	Budget	Timing	Responsibility
	<b>3.2 First Stage Rebuild For Remainder of Central City</b>	To be determined	To be determined	Blue (Concept Design)
	What the work involves	<ul style="list-style-type: none"> <li>Assessment and rebuild of the Central City wastewater system south of Avon River and the section north of the river to the east of Madras St.</li> <li>Localised repairs to storm water and wastewater to maintain service.</li> <li>Make safe repairs to roading.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>The wastewater pipes are predominately earthenware and are expected to have sustained significant earthquake damage.</li> <li>Significant liquefaction has occurred in parts of this area.</li> </ul>		
	Key Dates	To be determined		
	Interfaces	<ul style="list-style-type: none"> <li>Rehabilitation of wastewater and storm water brick barrel pipes in the Central City (Project 10845, ref 2.1 above).</li> <li>Completion of assessment and rebuild/rehabilitation other of wastewater and storm water trunk pipes in Central City Area (Ref 2.2 &amp; 2.3).</li> </ul>		
	Notes	<ol style="list-style-type: none"> <li>Consideration is to be given to rationalising the wastewater system to utilise the: <ul style="list-style-type: none"> <li>Fitzgerald Bypass Sewer</li> <li>Central City Relief Sewer</li> <li>Western Interceptor &amp; Southern Relief Sewer</li> </ul> </li> <li>Sewers should be realigned so there are no significant pipes within 30m of the Avon River. This affects sewers along Oxford Tce.</li> <li>The abandonment of PS8 should be considered as this area has been zoned red.</li> <li>Works at and adjacent to the Cashel St Mall may need to be delayed for several years to avoid disruption to businesses.</li> <li>Other areas to be developed in the short to medium term are to be determined by Council. These are to be considered in the planning of the rebuild works.</li> </ol>		

Tactic	Project Name	Budget	Timing	Responsibility
Rebuild other services	<b>4.1 Develop typical road layouts</b>	To be determined	As soon as practical	Council & SCIRT
	What the work involves	1. Develop and agree with Council standard layouts and details for roading and utilities in the following types of streets: <ul style="list-style-type: none"> <li>• Lanes</li> <li>• Malls</li> <li>• People streets</li> <li>• Main streets</li> <li>• Local streets</li> <li>• Distributor streets</li> <li>• Avenues</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>• This work is required for detailed design to ensure that services installed fit in with the final streetscape design.</li> </ul>		
	Notes	1. Consideration will need to be given to storm water rain gardens and landscaping.		
	<b>4.2 Develop common service trench details</b>	To be determined	As soon as practical	Council & SCIRT
	What the work involves	<ul style="list-style-type: none"> <li>• Investigate the feasibility of utilities being incorporated into common service trenches and service laterals.</li> <li>• Establish costs, programming implications and cost sharing arrangements.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>• Installing all services in a common trench will reduce the number of times that a street is required to be dug up, reducing disruption and saving money.</li> <li>• Defining standard connection details at property boundaries will enable developers to design works private properties.</li> </ul>		



Tactic	Project Name	Budget	Timing	Responsibility
Understand Performance of Existing Network	<b>5.1 Develop Central City Wastewater Trunk Model</b>	The wastewater model for the entire city has recently been developed by the Council		
	What the work involves	<ul style="list-style-type: none"> <li>Complete model of wastewater trunk network passing through Central City.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>To identify those existing pipes that:</li> <li>Have spare capacity. In which case the local reticulation network could be reconfigured, if beneficial, to make use of this spare capacity.</li> <li>Do not have adequate capacity. In which case duplicate pipes may need to be installed or the existing trunk pipes replaced.</li> </ul>		
	Notes	1. To also include all significant pipes upstream of the Central City Trunk Network.		
	<b>5.2 Develop Central City Storm water Network Model</b>	To be determined	As soon as practical	To be determined
	What the work involves	<ul style="list-style-type: none"> <li>Develop a model of the storm water network.</li> <li>The first interaction of the model should answer the following questions, for various containment standards: <ul style="list-style-type: none"> <li>What is the capacity of the network?</li> <li>Assuming that the network is to be retained, what capacity advantage can be gained from storage or soakage?</li> </ul> </li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>Will help determine whether the storm water network, as it, is adequate.</li> <li>Will assist in the design of storage/soakage measures such as rain gardens and permeable pavement.</li> </ul>		
	Notes	1. This model is to be coordinated with model of the Avon River and other rivers being built by the Council.		
	<b>5.3 Soakage investigation</b>	To be determined	As soon as practical	To be determined
	What the work involves	<ul style="list-style-type: none"> <li>Undertake desktop study and field investigations to determine the expected soakage across the city.</li> </ul>		

Tactic	Project Name	Budget	Timing	Responsibility
	Why the work is necessary	<ul style="list-style-type: none"> <li>To design soakage/storage measures on both private and public work.</li> <li>This assessment will also feed into the design of the trunk storm water system.</li> </ul>		
	Notes	1. The Central City Plan proposes extensive use of rain gardens and permeable pavement. To the District Plan are proposed requiring developers to install soakage.		
	<b>5.4 Condition Assessment of Storm water Outfalls</b>	To be determined	As soon as practical	Asset Assessment
	What the work involves	<ul style="list-style-type: none"> <li>Inspect all storm water outfalls and the pipes immediately upstream.</li> </ul>		
	Why the work is necessary	<ul style="list-style-type: none"> <li>These structures and pipes are located in areas where there has been significant amount lateral spread. As a result they are probably damaged.</li> <li>Damage to these pipes and structures could cause flooding, as they take all of the storm water from the upstream catchment.</li> </ul>		
	Notes	1. It is envisaged that assessments can be undertaken through visual inspection and inspection of pipelines using a pole camera.		



Appendix D: Central City Infrastructure Renewal: Client Statement



Appendix E: Central City Condition Report





Appendix F: Central City Utilities Coordination & Shared Corridors Project  
Execution Plan



## Appendix G: Central City Storm Water Modelling Proposal

## Appendix H: Risks to Basic Service Levels

### Storm Water

#### Layout

There are three groups of stormwater catchments within the four avenues:

- North of the Avon River the land slopes toward the river. The gradient on the land should be sufficient to permit continued drainage even with compromised pipe capacity.
- The city centre, between the river and St Asaph St and Madras St is rather flat and relies on good capture in catchpits (street sumps) and unimpeded conveyance to the river.
- South of St Asaph St and east of Madras St the catchments discharge to large pipes (Moorhouse Ave brick barrel, City Outfall Drain, Fitzgerald Ave brick barrel) that discharge beyond the CBD. Connectivity between these pipes and adjacent trunk mains provides useful redundancy.

Much of the central city area falls at a gradient of about 1 in 500 either toward the river or toward a trunk main. This is a flat gradient but is mostly sufficient for stormwater to run down road channels to a collection point even if some sumps are blocked.

Some areas are flat and rely on the network operating unimpeded. Flat areas where blockages will cause ponding are mapped in Figure x

#### Inspections

Inspections to date have concentrated on:

- All brick barrels within the four avenues (5 km length), on the basis that these are the oldest and most brittle of the trunk mains.
- Accessible pipes within the Red (safety) Zone (4 km length), on instruction from the CCC:

Under 20% of the central city stormwater pipes have been CCTV inspected. These results are therefore regarded as a sample of pipe condition.

Half of the pipes surveyed displayed cracks, breaks and joint displacements. Three urgent repairs were carried out but the remainder were judged not to need urgent repair. This is a small number in relation to the length and the number of faults observed and indicates that the stormwater network is tolerant of cracking because it is mostly above the water table.

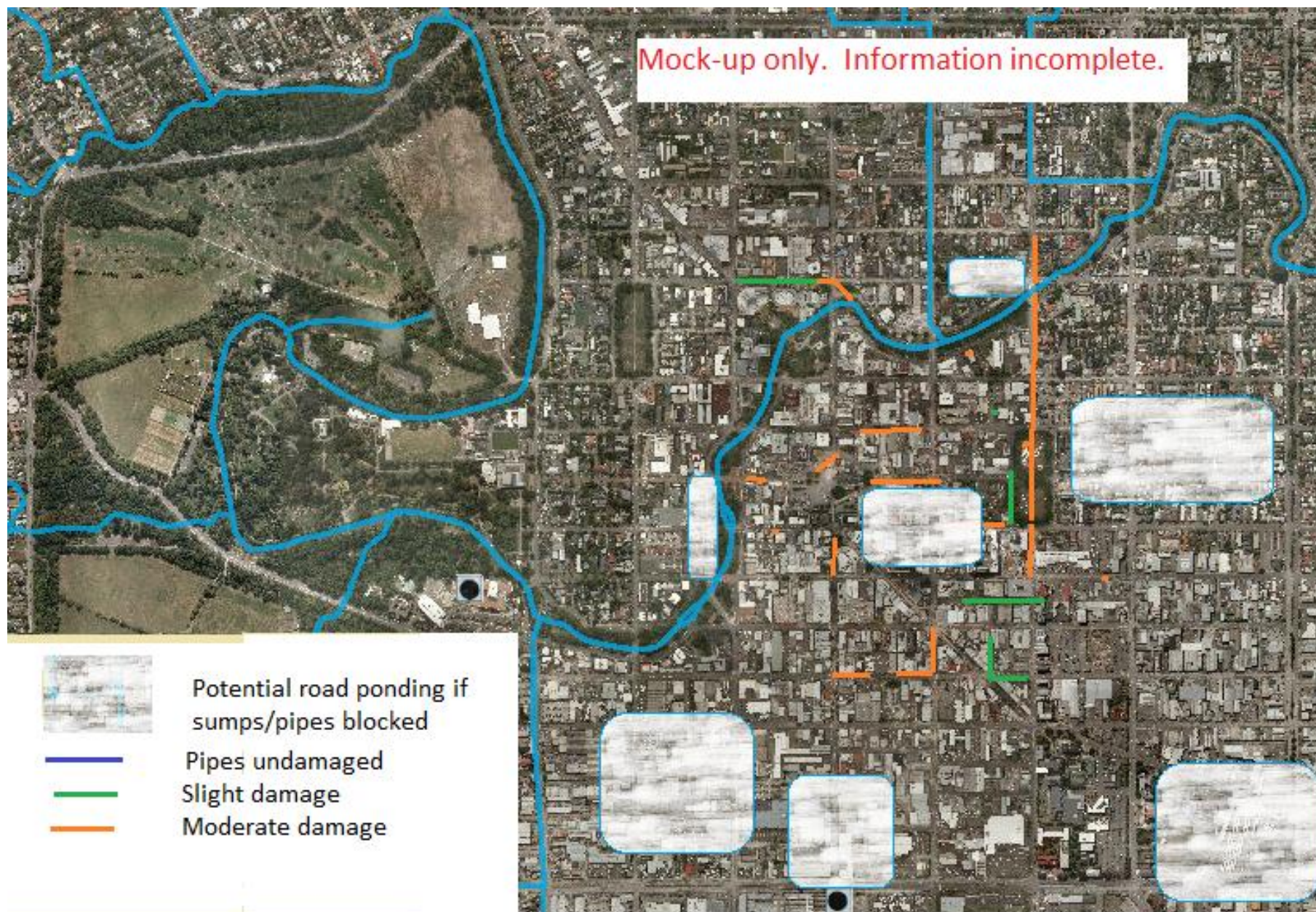
There is a presumption that repairs should be deferred where possible until the rebuild phase.

The indication is that, subject to cleaning where necessary, adequate drainage is available. Observations during rainfall events to date tend to confirm this.

## Threats

Threat	Cause	Mitigation
Road ponding	Street sumps and pipes blocked by demolition or construction debris or liquefaction	<ul style="list-style-type: none"> <li>Inspect pipes or infer service level from observation during rainfall</li> <li>Proceed with SW pipe inspection as resources permit</li> <li>Continue central city catchsump sucking programme (normal operations)</li> <li>Cover street sumps during demolition</li> </ul>
Property flooding	<ul style="list-style-type: none"> <li>Severe street flooding</li> <li>Property located in a hollow (or road is humped)</li> <li>New or temporary building has floor level too low</li> </ul>	<ul style="list-style-type: none"> <li>Street flooding measures apply.</li> <li>Continue with central city stormwater modelling</li> <li>Temporary buildings to have floors at least 0.2m higher than highest adjacent road crown</li> </ul>
Basement flooding	<ul style="list-style-type: none"> <li>Kerb has settled allowing water to flow down access ramp</li> <li>Cracked CCC SW pipes nearby</li> <li>Outfall for basement pump impeded</li> </ul>	<ul style="list-style-type: none"> <li>CCC needs to be aware of kerb settlement near access ramps. Urgent repair if necessary.</li> </ul>
Brick barrel collapse	<ul style="list-style-type: none"> <li>Earthquake damage undetected</li> <li>Future earthquake</li> <li>Traffic or construction loads</li> </ul>	<ul style="list-style-type: none"> <li>CCTV reviewed, condition assessed, relining under way</li> <li>Ditto</li> <li>Cover should be adequate</li> </ul>
Pipe collapse	<ul style="list-style-type: none"> <li>Breaks/cracks cause collapse</li> <li>Traffic/construction loads collapse pipes</li> </ul>	<ul style="list-style-type: none"> <li>Deal with this reactively. Believed unlikely</li> <li>Possible. Deal with this reactively.</li> </ul>







## Wastewater

