CHRISTCHURCH COLLAPSED BRICK BARREL STORMWATER REPAIR

Preston, Tim

ABSTRACT

The Antigua Burke Stormwater rebuild project, undertaken by Stronger Christchurch Infrastructure Rebuild Team (SCIRT) as part of EQ repair for Christchurch City Council, included a section of brick barrel pipe with several unusual features. These provided significant challenges for asset investigation and design, prompting a variety of uncommon techniques for investigation, repair and rebuild, and several changes of direction as the investigation and design proceeded.

The unusual features and challenges included:

- Existing pipe is a brick barrel material, of unknown age and with no 'as built' records
- Pipe running diagonally on private property between and very near to, two residential houses
- Pipe is curvilinear between manholes, the initial GIS recorded alignment was wrong, difficulty surveying the true alignment, and no line of sight for inspections
- Pipe is 50 percent collapsed next to one of the houses with reasonably heavy internal debris
- This collapse pre-existed the recent earthquakes and was practically unaffected by the earthquakes

As well as providing historic background from CCTV records this paper will outline the various cleaning and inspection techniques considered, those applied, and their results.

This paper will also outline the twisted path of the design process, with assessments of costs, risks and differing hydraulic performance implications given to options (and sub options) as diverse as:

- Large scale realignment away from private land
- Dig and replace on private land from manhole to manhole
- Lining though the pipe (supporting but not restoring the collapsed area)
- Dig and replace with partial realignment to road reserve, some dig and replace on private land but including installation of a new connecting manhole breaking into the brick pipe (the selected option)
- Pipe lining specialists and construction team input used to help assess the constructability and construction risks of each option and the landowner views and input will also be described.

The project was constructed in May/August 2013.

Construction team feedback on constructability of the final design is also included.

KEYWORDS

Brick barrel, stormwater, pipe collapse, Drag bucket, CIP lining, Tomo, Christchurch, earthquake damage

1 INTRODUCTION

The focus of this paper is a 43m length of 750mm dia brick barrel stormwater pipe which was part of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) Antigua Burke project, within the Christchurch CBD. The pipe was found to have earthquake damage and a significant partial collapse in it on private land and within close proximity to an existing residence. The project determined how best to deal with the damage and return the pipe to a functional condition with acceptably low levels of future risk, at a minimum cost.

Figure 1, Aerial view showing location of the worst collapse (red triangle) and proximity of pipe to dwellings at 40 and 42 Antigua St. (note other damage is toward Antigua St to manhole 5073).

Progress through design of this project was convoluted with several surprises and twists discovered during the course of the project, resulting in several changes of direction and approach. This paper does not attempt to fully report this chronological complexity but rather focuses on the diversity of technical challenges and points of interest.

2 ASSET INVESTIGATION

To investigate Antigua Street many methods were pursued with varying success. The following section describes the use of CCTV and polecam, tracing sonde and surveying, drag bucket cleaning, jet cleaning, ground penetrating radar and 3D laser scanning.

2.1 CCTV AND POLECAM

Initial CCTV investigation from the road end of the pipe indicated trouble but was unable to progress due to heavy debris in the invert. A second attempt from the downstream (private land) end was more successful, traversing half of the length and reaching the point of partial collapse. However, fear of further collapse and debris on the invert prevented further progress.

Photograph 1, Close-up CCTV image of 50% collapsed pipe, March 2012

This initial view of the 50% collapsed pipe prompted significant and urgent concern, with what appeared to be an imminent risk of full collapse. Based on the GIS mapped horizontal alignment, it appeared that the collapse was 3-5m distance from the nearest house, but this alignment was unverified and appeared likely to be incorrect.

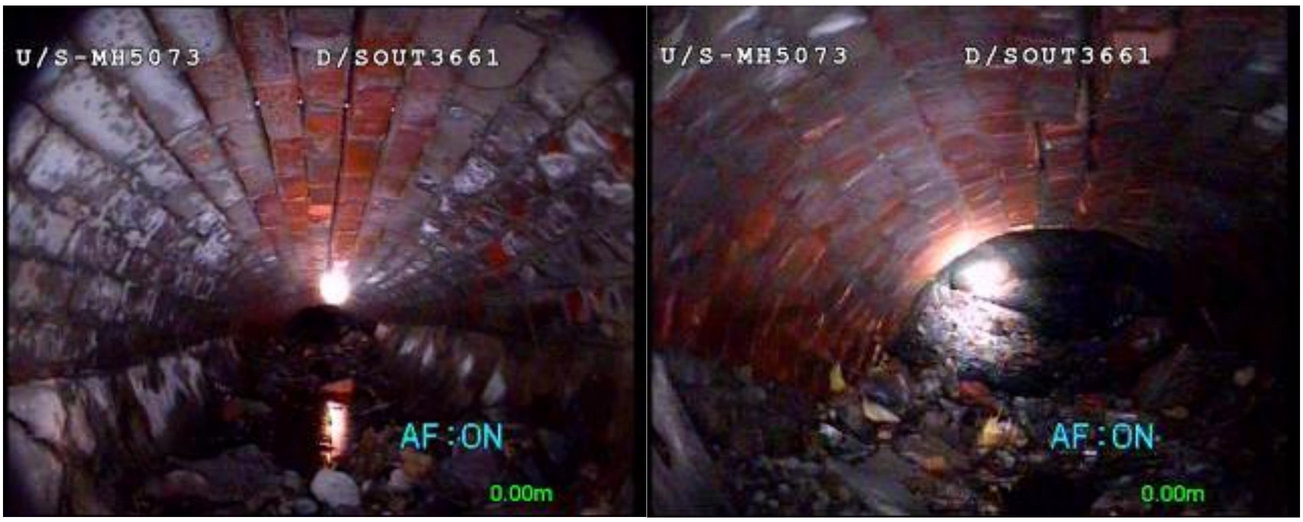
On reference to Paul Dickson (CCC staff member working at SCIRT), we learned that this collapse area had been known to Council for approximately 15 years. Paul provided CCTV footage from January 2009. This confirmed the collapse existed pre-earthquakes, and there was no material change in the collapse, despite the cumulative disruption of all the major Canterbury earthquakes (September 2010; February, June, September &December 2011). This remarkable observation effectively mitigated concerns as to the imminent risks of collapse and allowed a somewhat more normal urgency to prevail.

Photograph 2 and 3, Current CCTV images of the collapsed pipe in March 2012

Photograph 4 and 5, Historic CCTV images of the collapsed pipe in January 2009 showed little difference

CCTV inspection from the upstream end was largely unsuccessful due to the camera's inability to traverse the heavy debris, with high risks of causing more damage associated with attempted cleaning of this debris. Polecam was therefore deployed to gain a more comprehensive visual of the upstream end of the pipe. While polecam has since become a standard asset assessment tool in SCIRT, at the time this was one of SCIRT's earliest project uses of the technique.

Photograph 6 and 7, Where CCTV was risky Polecam was used to enhance the process



Polecam footage showed clear distress in the soffit of the upstream end of the brick barrel, with ovality appearing to various degrees along the length and some brick movement evident. In the absence of pre quake CCTV footage of this section, this damage was cautiously attributed to earthquake damage.

At this stage the CCTV and polecam footage combined provided strong evidence of a gross error in the GIS mapped horizontal alignment. Given that As Builts for this pipe could not be located it was possible that the GIS alignment was based only on guesswork, and was considered unreliable. So the next key investigation was to determine the horizontal location of the pipe.

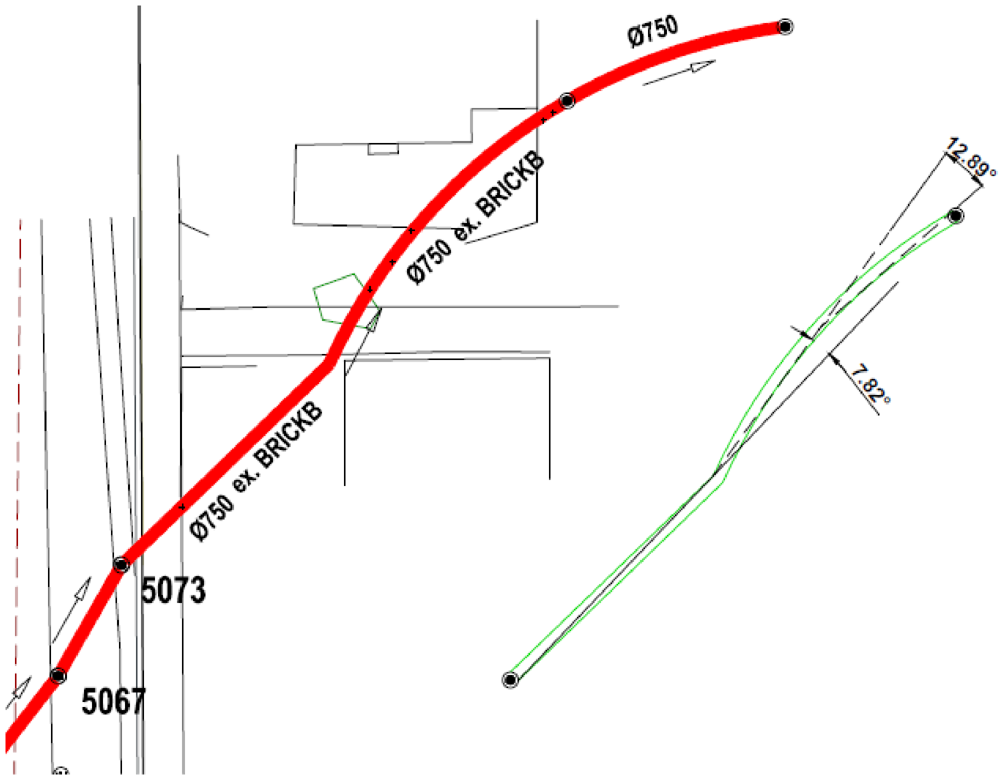
2.2 TRACING SONDE AND SURVEY

Two techniques were considered for horizontal survey of the pipe, being a CCTV type tractor unit carrying a sonde for tracing, and ground penetrating radar (GPR). The tracing sonde was considered to give more definitive positional accuracy. While it was recognized that it could only traverse the downstream half of the pipe, the upstream end was visually confirmed to be straight and the collapse section was visible at the distant end of this upstream section. Therefore a survey of the downstream curved section of pipe was considered sufficient to determine the general location. The tracing sonde method was effective and marks on the ground surface were subsequently surveyed in.

The next step was to 'join the dots' to create a complete estimated alignment. This was done using AutoCAD geometry tools, based on the surveyed points. Together with visual evidence that the curvilinear section had a circular horizontal alignment that continued with the same radius out into an open channel section that was already correctly mapped as could be confirmed through aerial photography.

The resulting alignment is shown below in the figure 2, together with geometric analysis which was relevant to drag bucket considerations discussed later.

Figure 2, Alignment geometry resulting from survey work



This new alignment was submitted to the CCC GIS team and the core GIS data was updated to suit. The new alignment was quite different to the previous GIS alignment and confirmed that the pipe was much closer to both houses than previously indicated.

2.3 CLEANING

At this stage the preferred repair strategy was to clean and install a CIP liner. A prerequisite (and known risk) to this strategy was a mechanism to remove debris from the pipe. High pressure jet cleaning was known from recent post-quake experience in trunk sewers to have a high risk of damage to brick barrel pipes, even when the pipes were straight and in reasonable condition. Jet cleaning of this curvilinear and substantially damaged pipe was therefore considered extremely high risk. The heavy concrete block and brick nature of the debris made the cleaning challenges all the more substantial.

A strategy was developed to deploy drag buckets to remove the majority of the heavy debris, in the hope that any residual debris could be cleaned by jet cleaning with low pressure, avoiding further damage to the pipe. Instructions were issued that an engineer be present during the initial cleaning attempts.

2.4 DRAG BUCKET CLEANING

At the time of this project, CCC had disposed of their drag bucket equipment many years ago and we learned that it had been dismembered and sold on as parts for other uses. With no equipment or staff with operational experience we were fortunate to have contact with now retired Neville Stewart as an ex CCC Engineer, who had observed its use first hand on several occasions.

We also found that Delta Utility Services Ltd in Dunedin had several drag buckets still in operational order, although they hadn't been used for many years, and none of their current staff had experience with the equipment.

Photograph 8 and 9, Drag buckets and equipment

We learned that drag buckets could reasonably be deployed into either end of the pipe, although up from the downstream end was generally preferred. The bucket would be dragged, using cables and pulleys, mouth open into the debris, filling up as it was pulled in. A bucket lid was arranged so as to close when the pull on the bucket was reversed in order to remove the bucket when full. The operator typically had no visibility of the bucket during this process, therefore considerable skill would need to be developed from experience operating, to gauge how much weight to pull the bucket with and whether (from the feel of the winch) the bucket 'felt' like it was ready to remove. To use this equipment, our operators would have to develop these skills on the job.

Drag bucket cables pull in a straight line, with pulley in the base of the manholes at either end of the pipe. This works well for typical straight sections of pipe. In our case, the curved and bent horizontal pipe alignment meant further challenges with the cables. The curve radius was considered broad enough to have only a minor impact on operations, with the cables expected to run partially along the inside curve of the pipe. The bend midway along was more of a concern, but the angle of cable bend was evaluated and considered small enough that the method still had a reasonable chance of success (refer geometry diagram above).

The other consideration with the drag bucket was that heavy debris was concentrated exclusively in the straight upstream section of pipe. It was also recognised that the greatest force on the cables was required while filling the bucket. It was determined that operating the bucket from the downstream end would be preferred because by the time the heavy pull came onto the bucket, the pulling cable would be unhindered along the straight section of pipe. This did however mean the bucket would have to traverse the 50% collapsed section of the pipe both on approaching the debris and exiting when full. This restricted the maximum size of bucket that could be deployed and added risk to navigating past the collapse area and horizontal bend.

It was recognised however that much learning would take place in the initial field work and that optimal methods and approach would likely be found from that learning more than any prior planning. It was also envisaged that field crews would find a way to install pipe sleaves over the cables to protect both cable and pipe walls from damage, and that CCTV may be deployed with the process initially to observe how it was working.

As a side note, Citycare have since been using drag bucket equipment on other projects and found it is well suited to larger pipes with heavy volumes of debris and that in those conditions it can be much more cost effective than jet cleaning.

2.5 JET CLEANING

A miss-communication resulted in the cleaning crew attempting a preliminary clean with the jet unit prior to deploying the drag bucket. Crews were familiar with jet cleaning, the equipment was more readily available and the drag bucket approach had not been used in Christchurch for many years.

Unfortunately, the jet cleaning resulted in further damage to the pipe, in the immediate area of the worst of the collapse. Based on post cleaning CCTV it appears that the jet head penetrated the wall of the pipe and opened an underground cavity outside the pipe wall. We knew from the alignment that this cavity was within 1-3m of the corner of the residential house. To make matters more interesting, this occurred a few of weeks before Christmas 2012.

Photograph 10, View of pipe showing hole in wall caused by jet cleaning

This incident effectively changed the course of the project. With no apparent way to fill the tomo without either undermining the house or spilling grout into the pipe, it was decided that there was now no likely practicable method for cleaning debris from the pipe and therefore the CIP liner option was no longer practicable.

2.6 GROUND PENETRATING RADAR (GPR)

This underground cavity (tomo) was explored using GPR. It was found to be circa 0.5m in diameter slightly less than this in height, and centred approximately 2m from the corner of the neighbouring house. The hole in the pipe wall was circa 0.5m long and 0.3m high. This triggered an urgent CCC monitoring effort through the Christmas period to observe any further deterioration and assess risk of further collapse which may have damaged the house. It also affected the detailed design phase which was still aiming for a CIP lining solution with design due to be complete before Christmas.

Fortunately, the CCC monitoring efforts showed the tomo was stable and monitoring frequency and efforts were able to be scaled back. Also fortunately the risk with cleaning was recognised early on and a contingency plan for the detailed design was somewhat advanced and was thus put into action. The detailed design was still completed on schedule prior to the Christmas deadline.

2.7 3D LASER SCANNING

Prior to the jet cleaning incident, another aspect of the preferred CIP liner repair was whether a liner could reasonably be installed given the varying pipe cross section shape (the collapse) and its irregular horizontal alignment.

Early on it was evident that a good understanding of this geometry would be a pre-requisite to any attempt at lining, so that the liner could be made to fit. Pipe scanning technology was evaluated which uses a rotation laser scanner to create accurate cross sectional shape measurements. Repeated measurements are made down the length of pipe to define the overall geometry. The cross sectional accuracy was found to be more than adequate for our purposes. The factor of concern though was that relating sequential cross sections to each other relied on having a reasonably predictable straight path for the tractor scanner unit, with distance measured using cable length per CCTV techniques. We were concerned that this technique may not adequately capture the shape of sudden bend, and the sudden collapse, that the cable length may be inaccurate as it traverses the bent pipe section and that the pipe invert may not be smooth enough to produce sufficiently consistent results.

Experts from two CIP lining companies were then consulted, together with the SCIRT designated brick barrel advisor. They reviewed the pipe condition and both expressed confidence that lining was feasible, using custom shaped liners with a higher than usual degree of elasticity, installed in overlapping sections to fit the different sections of pipe. In this manner the positional accuracy of each section could be controlled individually, rather than relying on a single length of liner with multiple cross sections having to be installed in a single process.

With this lining process imperfections in the 3D scanning method would not materially impact on lining results and the scanning would provide sufficient accuracy to enable liner fabrication and installation.

We concluded that, if we could clean the pipe, that CIP lining was feasible and at that time it remained the preferred repair option.

3 CONCEPTUAL OPTION EVALUATION

Five options, often with variations and sub-options were considered for this project. These were

1) Dig and replace along Brougham St

2) Dig and replace on current alignment

3) Dig and replace on new alignment

4) CIP lining

5) Do nothing.

Each is detailed in the following section.

3.1 DIG AND REPLACE ALONG BROUGHAM ST

The 45m section of brick barrel is part of 360m of Jacksons Creek drainage from Antigua St to Brougham St. This total length runs through private land, and often at the backs of houses where there is poor access for maintenance or replacement works. For this reason Council staff have previously proposed to realign this drain into a fully piped drain along the southern (west bound) lane of Brougham St. Records show the two westbound lanes are free of other utilities apparently in anticipation of this potential project.

Of the total of 360m length of existing drain, only 72m of it was thought to be sufficiently damaged requiring repair, with 25m of this to be lined and 47m to be replaced. The full realignment option along Brougham St would require installation of 250m length of new pipe. It would also require additional new small pipe to serve local connections into the existing drain.

The cost for the realignment option was estimated to be $1,000,000 compared to the more standard repair costs of $270,000. In more usual economic times this would have warranted serious consideration given the long term benefits of retiring substantial lengths of old pipe and the difficult location. In the post-earthquake circumstances it was generally recognised that total programme funding was likely to be insufficient to repair all damage. The various projects also presented Council with many major opportunities for ‘betterment’ in conjunction with required repair works that would likely never be repeated. Funding for betterment was extremely limited so only exceptional opportunities would be successful. On this basis the full replacement option was not pursued due to its high cost and likely inability to be funded.

A side issue also against the full realignment was Council’s more recent environmental policy to seek daylighting opportunities for Jackson’s creek where possible. The existing alignment included some daylighted sections and had potential for more in the future dependant on landowner’s sympathy. The Brougham St option was all under road pavement, eliminating existing daylighting and without any future daylighting opportunity.

3.2 DIG AND REPLACE ON CURRENT ALIGNMENT

The most conventional option for repair was to dig up and replace the brick barrel with new pipe. The total length of pipe was 43m length, although the downstream half of this was in good condition and could possibly have been retained.

The challenges with this option related to the proximity of the residential houses. These challenges could not be properly evaluated until the horizontal alignment was reasonably determined. While not particularly deep (2.2m to invert) from work in the vicinity, ground conditions were expected to be poor with high water table and very soft ground having been encountered.

Contractor E Carson and Son's Ltd evaluated the site conditions during concept design and advised that they expected using semi proprietary trench support techniques that dig and replace on the existing alignment was difficult but almost certainly feasible.

The significant disruption to residents, residual risk of damage to the houses, higher cost of either full 43m pipe replacement or partial 25m pipe replacement with the need to make a difficult join with the remaining brick barrel were key reasons that this option was not preferred. This option was not favoured by the landowner, although he recognised Council had a right to renew their pipe.

3.3 DIG AND REPLACE ON NEW ALIGNMENT

Installation of new replacement pipe on new alignments generally with the property boundaries (rather than diagonally across property) allowed for much greater separation distance from the houses, significantly reducing risks of damage. The square new alignment was significantly longer than the direct diagonal existing alignment, resulting in flatter pipe with more bends and hence a need upsize to retain capacity.

The larger diameter, greater length and additional manholes resulted in this option having a considerably higher known cost for construction, but offset by a considerably lower risk profile in terms of potential damage to housing.

Again two options were considered, one being new replacement of the full length of pipe and the other being replacement of the damaged portion only and construction of a difficult joining manhole over the remaining brick barrel.

The significant disruption to residents, and even higher cost were key reasons that this option was not (initially) preferred. This option was favoured by the landowner, as the pipe realignment with property boundaries significantly enhanced the future development potential of his land.

Partial diagonal realignments were also considered which could have provided most of the benefits of separation from the houses, without adding significantly to the length or the need for abrupt bends and retaining the existing pipe size. These were not favoured by the landowner as he would gain considerably more advantage from the square to boundary alignment.

3.4 CIP LINING

On initial viewing of the pipe damage, most Engineers would disregard CIP lining as being fundamentally unsuitable to the situation. There were however factors motivating it's consideration including;

- Likely lowest cost if successful
- Less disruptive to residents
- Negligible risk of damage to houses
- A fully structural ling was not considered essential given the remarkably good performance through some thorough earthquake 'testing'

For these reasons the option was investigated further.

Practical questions such as pre-cleaning requirements and need for 3D geometry measurement and ability to install a liner have been discussed in preceding sections. Of primary interest from the design perspective were hydraulic performance of the reduced pipe cross section and the structural effectiveness of lining.

The collapsed cross sectional shape was estimated from CCTV footage and evaluated using orifice plate theory, with flow rate determined at the pipe running full condition. It was determined that the additional headloss in this condition was only 200mm which was not considered material given that there were no recognised capacity concerns with the pipe nor suggestions that it need upgrading.

Of more interest related to the hydraulic performance were maintenance implications. Usually the greatest velocities in gravity pipe systems are developed between 50% and 85% of pipe full flow. When these conditions exist much debris is transported along the pipe and they are self-cleaning. The collapse restriction in the pipe would constrain flows before they reach 50% pipe full, reducing velocity upstream of the restriction and creating a length of pipe which would thus never reach normal 'cleansing' velocity. This section upstream of the collapse would be expected to accumulate debris and require periodic maintenance cleaning. The accumulation of solids and debris actually observed in the pipe was concentrated upstream of the collapse area, entirely consistent with this theoretical expectation.

A key benefit of lining the pipe was that it would protect the brick structure from damage during future jet cleaning operations. An interception screen in the upstream manhole was also considered in the concept design and partially developed in the detailed design process, to keep debris in the upstream manhole where it could be more cheaply extracted.

The conventional use of pipe lining is to fully replace the existing pipe, thus the lining is designed with sufficient structural integrity that the existing pipe is not required for support. Conventional design also relies on the structural efficiency of a circular pipe shape. Our situation especially in the core of the collapsed section was highly irregular and far from round so we did not comply with conventional design requirements.

Several factors were considered from this. Primarily given the performance through the earthquakes we felt it reasonable to continue to rely on the brick barrel structure through the collapse area. While there was generally still good pipe curvature in the collapse area meaning some structural capacity would be achieved, the irregularity of the shape meant it would not be practicable to design any definitive structural capacity. The principal motivation for lining the collapsed section of pipe was then to prevent further brick movement either through nature and passage of time or through maintenance activities such as future cleaning, with any structural benefit being a bonus.

In the upstream area where modest ovality of the pipe had occurred, lining to a slightly reduced circular diameter was the intended approach using a balloon type liner to ensure a circular structural shape and grout filling the remaining void space.

A secondary factor in favour of the CIP lining option was the existing houses were old and a single landowner owned several adjoining properties. Given their prime location it seemed likely that these may be redeveloped in the future at which time a full replacement of the pipe would both be easy (no risk of housing damage) and beneficial (could realign to suit the redevelopment). From this viewpoint the CIP liner option was viewed as suitable as a probably temporary measure.

So, although dependant on successful cleaning, and despite the irregular circumstances, in what was yet another significant plot twist, lining was eventually considered a feasible option, with significant advantages including lowest cost. On completion of the concept design phase and for most of the detailed design phase it was also considered the preferred option.

3.5 DO NOTHING

Even though this section of pipe was clearly sufficiently damaged to justify repair or renewal, the final alternative considered was to do nothing. The primary risk associated with this is the potential for full collapse of the pipe, with associated damage to one or both houses and some risk of upstream flooding if the collapse was triggered by a storm event (although it is likely that the collapsed section would naturally form an open drain so the risk of catastrophic flooding upstream was considered unlikely). Council have lived with this risk in relation to the existing collapse section of pipe for at least 15 years, however the damage to the section upstream from the collapse is most likely earthquake related and significantly increases this risk.

One of the other reasons against 'do nothing' was the high cost, difficulty and risks with future cleaning of this damaged brick barrel pipe. As discussed under the CIP lining option the collapse constriction would be expected to reduce self-cleansing performance in the 20m section upstream of the constriction, therefore future accumulation of solids and debris at this location would be expected to continue at a higher than average rate. An ability to clean this pipe is therefore important and a do nothing option fails to provide this.

This option was not preferred due to the risks associated with unplanned failure and the severe difficulty of future maintenance.

3.6 OPTION SELECTION AND RESELECTION

Until the jet cleaning damage occurred in early December 2012, cleaning and CIP lining was the preferred conceptual option. After this damage occurred, the pipe was then considered much more fragile due to this damage such that cleaning was no longer considered feasible and CIP lining was ruled out as an option.

The preferred option then changed to dig and replace on a new alignment for the damaged portion of pipe only. The difficulties and cost of joining the new pipe to the remaining good brick barrel were considered modest compared to the greatly increased length of new pipe required for a full replacement. In addition the full replacement would have required a much greater length of trench closer to and between the two houses increasing risks of settlement and house damage.

4 DETAILED DESIGN

The crucial aspects of the detailed design were the junction manholes to the existing brick barrel, abandonment of the existing brick barrel, filling the tomo and the ability to maintain reasonable flow capacity during construction. The following sections describe those aspects of the design.

4.1 JUNCTION MANHOLES

Manholes joining the existing brick barrel pipe to the new replacement pipe were required at both ends of the work. Construction of the upstream junction manhole was considered easier as there was an existing brick manhole at this location, so there was no requirement to break into a continuous length of brick pipe.

In recent experience with sewer brick barrel projects in Christchurch, problems had occurred where the breaking into an existing pipe had caused the pipe to collapse progressively along the pipe as soon as it was not constrained by surrounding fill material. This had been resolved by excavating down to an intact part of the pipe and installing a supporting cement 'bandage' over the top half of the pipe which successfully arrested this collapse and eventually allowed the pipe to be cut through. This approach was incorporated into the design (refer Appendix, sequential note 1)

A small number of similar projects had been carried out in Christchurch previously and Council staff assisted in location of drawings from those projects. Consideration of those designs, together with invaluable practical advice from contractor E Carson and Son's Ltd was combined to develop the design detail.

A sequenced series of notes (1) – (10) in the Appendix, provided clear guidance to the contractor to mitigate risks associated with what could be a relative fragile brick barrel structure once exposed. Key design features included;

- Cement bandage - note (1)
- Temporary internal supporting formwork - note (3)
- Staggered cut / demolition line of existing brick to retain natural support (4)
- Reinforced mass concrete pour between the existing brick and the new precast manhole wall, and around the temporary formwork – note (10)

This detail improved on previous design detailing in terms of giving greater clarity to expected contractor method, specifying concrete encasement around the full perimeter of the remaining brick barrel and improved reinforcement especially of the mass concrete surround.

4.2 MAINTAINING FLOW

Through the early contractor involvement it was determined that the contractor was likely to prefer to start at the downstream end of the project and work upstream. For that methodology a temporary arrangement in the downstream junction manhole was required in order to allow stormwater flow to continue. Given the modest expected duration of construction and structural advantages of a smaller temporary flow path, this was specified as 450 dia (compared to the existing 750mm dia).

This flow path is drawn on detail A with the associated note at 2 o'clock position from that detail.

4.3 ABANDONMENT

Abandonment of the existing brick barrel insitu was specified with flowable light-weight concrete, with the tomo to be separately injected if required and GPR used to demonstrate that all voids had been suitably filled. The age of the brick barrel, triggered archaeological interest in the pipe and manholes, and specialist archaeological documentation was allowed for prior to work commencing and as the brick pipe was exposed.

5 CONSTRUCTION OUTCOMES

The construction did begin as intended at the downstream end of the pipe, where the most critical junction manhole was to be built.

The latest plot twist was when the Citycare construction crew exposed the brick barrel pipe. They determined that it was a double skin brick barrel and at the point of connection it was in very sound condition. While the design precaution of the cement mortar bandage was applied, they found it was not needed and were able to successfully sawcut into and remove the top portion of the pipe intact in the same way as would be normal for a concrete pipe material (refer photo 9).

They did not require the temporary internal pipe formwork either. The existing brick barrel was able to be retained right up to the new manhole wall and in part on the invert of the manhole, with consequently less reliance on the concrete surround and made the sequencing less critical. The precautions applied during the design development while prudent at the time proved not to be required once the condition of the brick barrel was better understood through the construction process.

Photograph 11, Section of brick barrel saw cut out and removed intact.

The new pipe construction work has subsequently been completed. There was a further challenge with a sewer lateral having to be installed through the new pipe in a ductile iron carrier pipe, but otherwise construction went smoothly. The final phase to complete the construction is now filling and abandonment of the brick pipe and underground void, which has not deteriorated during the construction phase.

Photograph 12, New manhole construction with remaining brick barrel pipe exiting downstream

6 CONCLUSIONS

This project required the use of an unusually wide range of investigative techniques for such a small area. It was an early adopter of polecam technology and investigations into the feasibility of the lost art of drag bucket cleaning techniques were ground breaking locally. This has helped to reintroduce drag bucket equipment where advantageous into Christchurch's industry.

1. Despite obviously severe damage at the collapse area, the pipe survived the entire earthquake sequence with no material deterioration

2. The misadventure with jet cleaning causing damage triggered initially urgent concern as to risk to the adjacent house required regular monitoring through the Christmas break, as well as severely dislocating the detailed design process as it was nearing completion

3. Despite circumstances initially appearing entirely unsuitable it was determined that CIP lining was a feasible (and preferred) option - contingent on being able to successfully clean the pipe

4. During construction the structure and condition of the remaining brick barrel was found to be excellent, negating the need for many of the design features intended to allow for what was expected could be have been highly fragile.

7 FOOTNOTE

The following image is from another section of 750 diameter brick barrel, about 200m further downstream, as it crosses Montreal St. Just goes to prove that there is no knowing what you might find until you start looking.

Photograph 10, Surprise!

ACKNOWLEDGEMENTS

Various individuals and groups within the wider SCIRT team contributed significantly to this project at various phases, in particular the asset investigation team patience in responding to various unconventional investigation requests

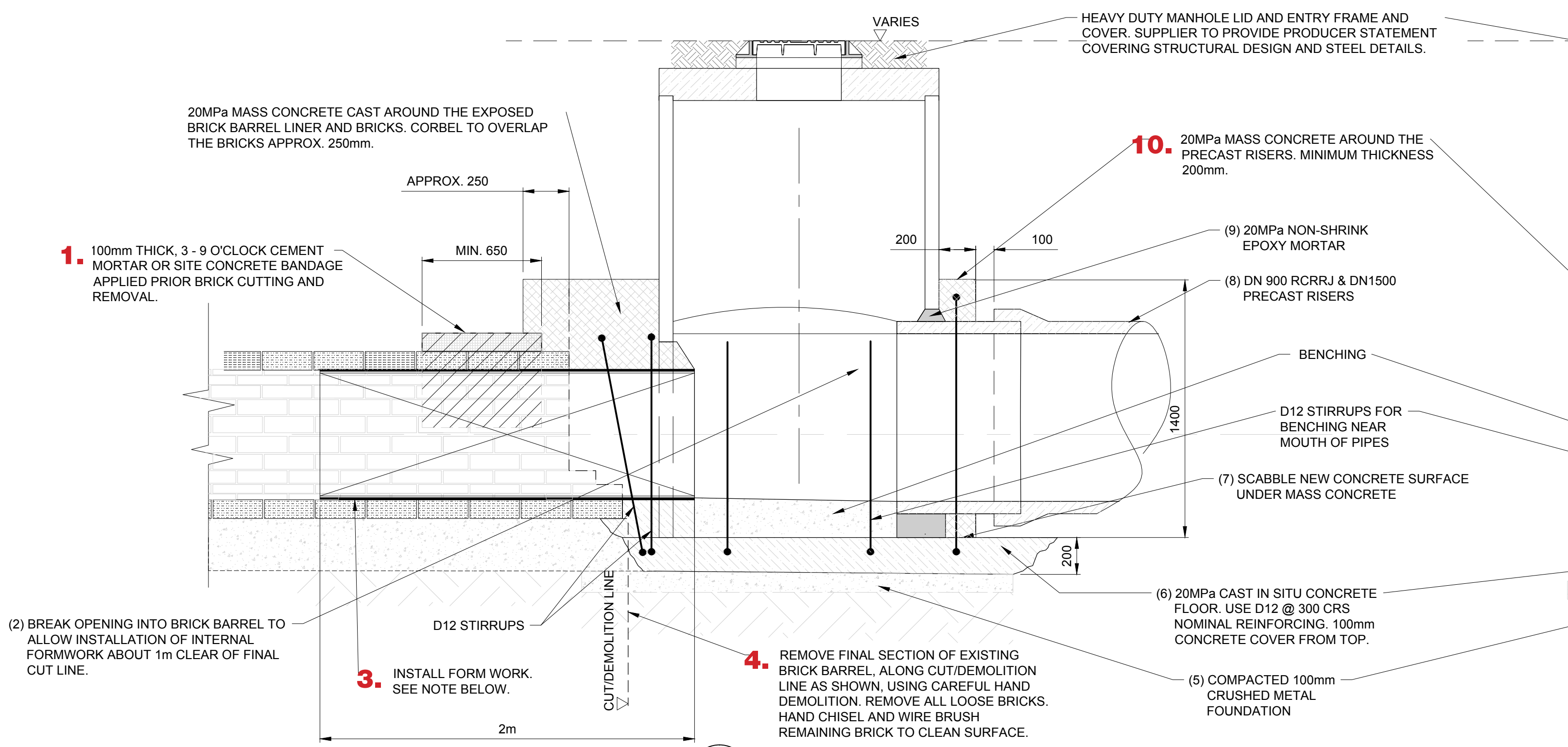
Paul Dickson (CCC staff working at SCIRT) provided substantial historic knowledge, valued advice and an ever positive outlook throughout this project

Neville Stewart (retired ex CCC staff), Delta Utility Services Ltd (Dunedin) and Paul Cooper (Citycare) assisted with the evaluation of drag bucket feasibility for this project

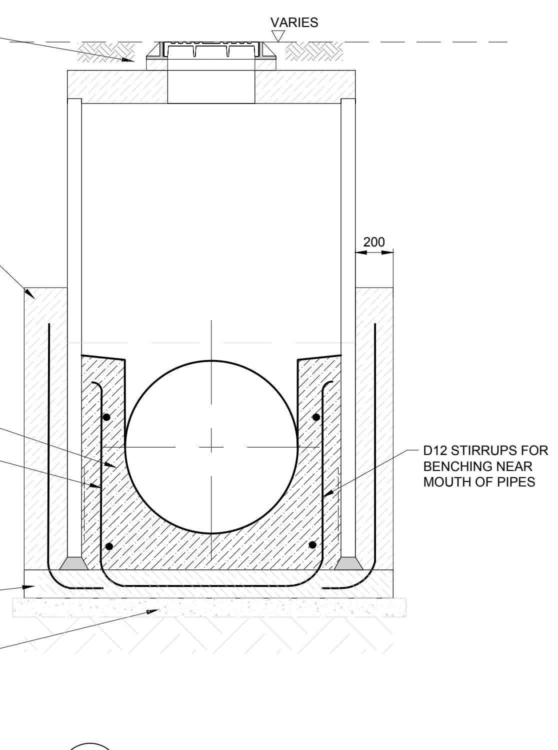
Contractor E Carson and Son’s Ltd helped to assess the risks and practicality of dig and replace options for this project and in contributing ideas toward the detailed design of the critical junction manholes.

Drain Surgeons Ltd and Pipeworks helped with advice regarding 3D laser scanning and feasibility of CIP lining for the irregular shaped pipe

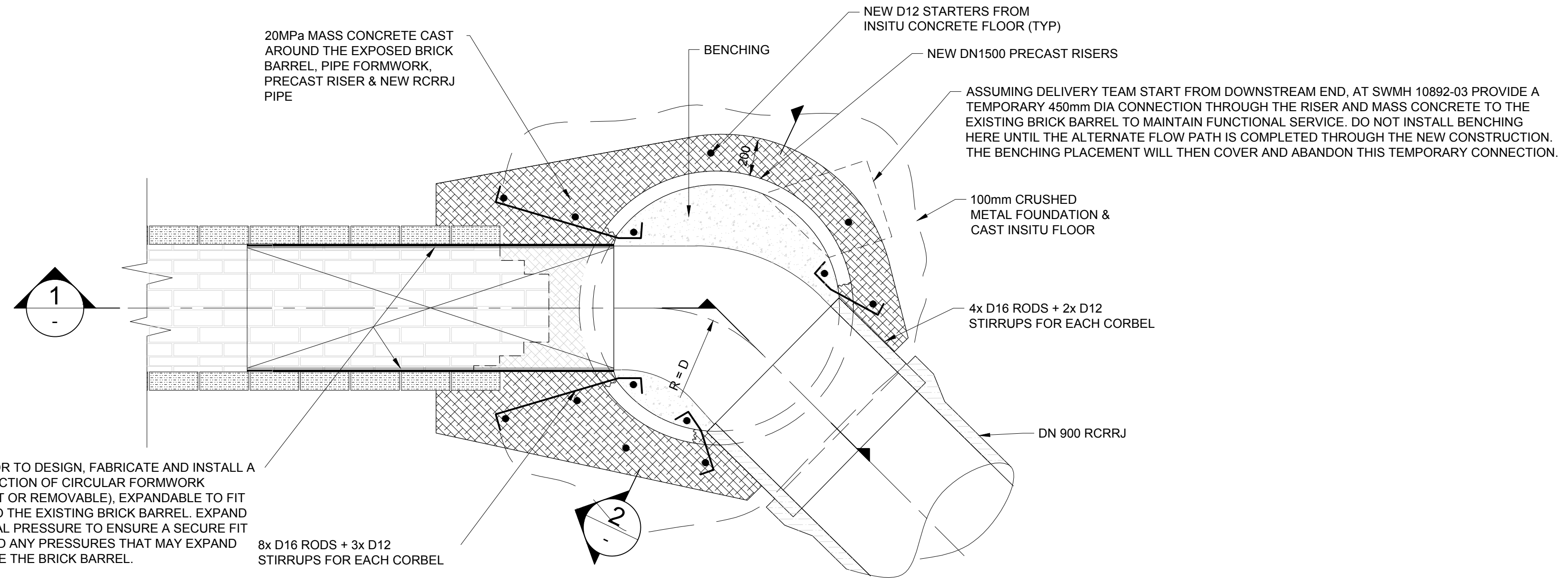
Citycare construction staff, particularly Kees Swanink, Marcia Beuth and Stacey Sheppard provided regular input to the concept and detailed design thorough the SCIRT early contractor involvement process.



1 - SECTION
SCALE 1:20



2 - TYPICAL SECTION
SCALE 1:20



CONTRACTOR TO DESIGN, FABRICATE AND INSTALL A 2m LONG SECTION OF CIRCULAR FORMWORK (PERMANENT OR REMOVABLE), EXPANDABLE TO FIT NEATLY INTO THE EXISTING BRICK BARREL. EXPAND WITH MINIMAL PRESSURE TO ENSURE A SECURE FIT ONLY - AVOID ANY PRESSURES THAT MAY EXPAND AND DAMAGE THE BRICK BARREL.

IF PERMANENT, THIS SHALL BE NOT THICKER THAN 20MM WALL THICKNESS AND OF A CCC APPROVED MATERIAL THAT ADHERES WELL TO EPOXY MORTAR (IE: NOT PE) AND SHALL BE SMOOTH AND CONSISTENT THROUGHOUT THE BOTTOM 90% OF THE CIRCUMFERENCE AND SHALL BE SECURED ALL ROUND TO THE BRICK BY EPOXY INJECTION AND ITS FINISHED STRUCTURE SHALL RELY ONLY MATERIALS WITH A 100 YEAR DESIGN LIFE.

A (WW2002) TYPICAL DETAIL-BRICK BARREL PIPE CONNECTION MANHOLE
SCALE 1:20

FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE
1	ISSUE FOR APPROVAL	M.D.	21.12.12

300 Original size mm 200 150 100 50 30 10 0

New Zealand Government
Christchurch City Council

	NAME	SIGNED	DATE
DESIGNED	T.Preston	T.P.	21.12.12
DES. REVIEW	R. SMITH	RNS	21.12.12
DRAWN	J.Ray	J.R.	21.12.12
DRW. CHECK	N. HOPMAN	N.H.	21.12.12
FILE LOCATION	J:\10892 Antigua Burke Stormwater (SW)\Drawings		
10892-DE-SW-DG-4003.dwg			
PRINTED ON 21-Dec-12 BY rayj			

APPROVED

FOR RECOMMENDATION	
DATE	SIGNED
21.12.12	M.D.
FOR CONSTRUCTION	
DATE	SIGNED
21.12.12	M.D.

CONSULTANT: SCIRT Rebuilding Infrastructure
CONSULTANT FILE REF. 10892-DE-SW-DG-4003

PROJECT TITLE
INFRASTRUCTURE REBUILD
ANTIGUA BURKE STORMWATER

DRAWING TITLE
BRICK BARREL
CONNECTION DETAILS

SCIRT PROJECT REF. 10892
CPG CAD DRAWING FILE REF.
ORIGINAL SHEET SIZE A1
SCALES 1:20
CPG PROJECT FILE NUMBER
DRAWING No. SW4003