EFFECT OF THE RECENT EARTHQUAKES ON SELWYN INFRASTRUCTURE

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ABSTRACT

At 4:35AM on Saturday 4th September 2010, the Darfield earthquake struck in the Selwyn District. The effects of the earthquake on infrastructure have been felt throughout the district both locally and more strongly and recently with the Christchurch aftershock.

When the earthquakes occurred, they resulted in a number of short term issues which needed to be overcome in haste to restore services. The most significant of these was the complete decommissioning of the Pines Wastewater treatment plant for a week to undertake repairs.

Medium and long term issues related to the disposal of wastewater within the district have also been highlighted as a result of the effect on CCC's ability to accept wastewater following the Christchurch aftershock. The $50 million Eastern Selwyn Sewage System (ESSS) conveyance and treatment upgrade has been planned since 2004 and was due for completion in late 2012. Investigation into the completion of this project using options for fast tracking and undertaking medium term emergency related discharges of partially treated wastewater have been at the forefront of recent work.

Although the effects faced by Selwyn District are minor compared to those faced by Christchurch City and Waimakariri District, they are significant none the less and make for some more interesting work stories.

KEYWORDS

Earthquake Repairs, Rising Main, Pump Station, Treatment Plant

1 INTRODUCTION

The September 4th earthquake shook the district in the early hours of that Saturday morning. The following paper outlines SDC's response both to the September 4th earthquake and the following February 22nd aftershock, and the way forward delivering the $50 million ESSS in the light of effects both locally and further afield. The paper also looks at the lessons learnt from the earthquakes of the past year and how we can prepare for a possible Alpine Fault earthquake which is approximately 90 years overdue.

2 4 SEPTEMBER 2010

When the earthquake occurred, initially all works revolved around assessing the state of the existing infrastructure. Information regarding the state of the district would normally have been fed back to the Council via its SCADA system. The wide spread power outages meant that SCADA wouldn't be returned until late

afternoon for much of the district. Staff were deployed around the various assets in order to determine the impact on the various infrastructure.

2.1 WATER INFRASTRUCTURE

With regards to the water infrastructure, the following damage was observed:

- A number of water main bursts had occurred in our smaller schemes, all of which were minor and quickly repaired
- Ground water had risen resulting in a large number of wells flowing artesian, although no significant damage was reported from any of the wells. Increased ground water levels were observed for up to six weeks.
- A number of reservoirs and the old pump sheds were damaged. It should be noted that these would not have been initially constructed to any significant structural standard
- Water laterals that were supplied beneath the Halswell river had been pulled out of the main due to lateral spreading within the river banks

2.2 WASTEWATER INFRASTRUCTURE - GENERAL

With regards to the district wide wastewater infrastructure (excluding the Pines WWTP), very little damage was observed, the following damage was observed:

- A pressure sewer lateral had pulled out of a rising main resulting in sewer discharge into a local waterbody
- Some sewer man hole floatation observed in Tai Tapu, by up to 150mm

2.3 WASTEWATER INFRASTRUCTURE – PINES WWTP

When staff first arrived at the Pines (Rolleston) Wastewater Treatment Plant (WWTP), it became apparent that serious damage had occurred. The most noticeable effect was that 250m3 of wastewater had disappeared from the bioreactor and first impressions were that a massive structural failure had occurred resulting in partially treated wastewater disappearing into the Rolleston gravels. After a good look at the remainder of the plant, it became apparent that wastewater from the bioreactor had somehow entered the irrigation wet well and had been pumped out into the centre pivots. It became evident that the pipe carrying supernatant from the overflow weirs in the clarifier, through the bioreactor into the UV disinfection unit had separated, allowing water from the bioreactor to enter the irrigation pump station. The centre pivots nozzles had blocked with hair and sludge and had limited capacity to dispose of the wastewater without removing and cleaning all the nozzles individually.

Photograph 1: Photographs of the Pines Wastewater Treatment Plant 4 Sept 2010

Concrete panels within the bioreactor which were used to separate the anoxic and aerobic zones had split down the middle, allowing the panels to fall on to the mixers and diffusers beneath. Generally these are below the water level and therefore it was only during the emptying of the bioreactor that the extent of the damage could be assessed. The panels, around 4m x 5m in dimensions were broken in the east-west alignment, but in the north south alignment, there was minimal damage, indicating that the effects of the earthquake were more prominent in the alignment of the earthquake. This is due to the earthquake producing waves that caused differential water pressure in a north-south direction. The mixers were damaged beyond repair, with the panels taking out the guide rails, and bending the impellers out of shape. Aeration equipment located in the base of the bioreactor had been damaged and disconnected and required prompt replacement from Australia. One of the panels had also dropped onto the sludge recirculation (RAS) system effectively blocking the recirculation process.

Photograph 2: Broken Bioreactor Panels - Pines Wastewater Treatment Plant 4 Sept 2010

In the clarifier, around a third (15m) of the overflow weir had come away from the wall as a result of the scum collection arm support breaking, shearing off at the welded interface. The UV system was covered in around a foot of water from the bioreactor, and wastewater from the initial quake had obviously caused a tidal wave (or "poonami" as it was so elegantly described) that had allowed the water within the plant escape up and over the 1.2m high wall.

Photograph 2: Emptied Clarifier - Pines Wastewater Treatment Plant - 5 Sept 2010

A quick assessment of the site indicated that the plant would need to be completely emptied in order to confirm further damage and facilitate repair work. This was undertaken with the help of 7 sucker trucks emptying the sewage from the treatment plant (~2500m3) on to around 40Ha of disposal field that had recently been levelled for expansion to the irrigation area. The result was far from satisfactory with most of the sucker trucks getting stuck in unconsolidated pasture. After a good 12 hour day on Saturday, the plant was 95% emptied and staff had a much better impression of the issues on site.

During the repair work to the treatment plant, SDC directed its wastewater to the Helpet treatment plant (4,500 population equivalent), which used to service the old part of Rolleston and had sustained no noticeable damage. Additionally a public awareness campaign was enacted to reduce the wastewater flows (we asked people not to flush where possible). This produced moderate success, with daily flows reduced by around 20%, for the week directly following the earthquake, and minimal long term effect.

The Canterbury regional council (ECan) was kept up to date with the required works and let SDC get on with rectifying the issues. In the duration that one plant was out of action and the other was overloaded, ECan did not visit the site but gave a high level support for the works that were being undertaken which was most appreciated.

In the following week, new panels were poured, and installed, new diffusers and mixers were imported and installed and the weirs and scum arm were repaired and replaced. An overall inspection showed no significant structural damage to the tanks. This was primarily due to the site conditions at this location with well founded structures in Rolleston gravels, a groundwater table at a depth of 12m below ground level and a flat site mitigating the risk of lateral spreading.. The treatment plant started to accept sewer flows on six days after the earthquake, and was compliant within resource consent conditions 15 days after recomissioning. During the whole emptying operation all downstream monitoring bores remained compliant for faecal coliform and total nitrogen testing.

3 22 FEBRUARY 2011

Although the February 22nd earthquake was significantly less catastrophic than the September earthquake for the Selwyn District, the results had greater ramifications. The eastern townships of Springston, Lincoln, Prebbleton and Tai Tapu all convey wastewater to western reticulation of Christchurch City as part of a long term agreement set up in the mid-nineties.

Following the earthquake it was widely published that Christchurch City had significant damage to its wastewater infrastructure and as a result, discharges of untreated wastewater were occurring into its waterways and urbanised areas.

Council staff discussed options with the Christchurch City Council, ECan and Ngai Tahu and the decision was made to temporarily divert Tai Tapu wastewater to the Halswell River as it was understood that the wastewater was being pumped to Christchurch, overflowing into the upper reaches of the Halswell River and flowing back towards Tai Tapu, affecting a significantly longer stretch of the river. This was undertaken for a period of around three weeks.

Photograph 3: Breaking Pipe at Tai Tapu

Wastewater from the Lincoln and Springston townships, combined flow rate of around 1600m3/day, is treated using three 500m^3 aeration basins and a 3.6ha oxidation pond located at Lincoln. Wastewater from the outlet of the oxidation pond normally gets pumped to Christchurch under the discharge agreement but following the earthquake the pumps were turned off and the treated wastewater was allowed to overflow into the L2, a tributary to Lake Ellesmere.

Wastewater from Prebbleton was unable to be diverted from Christchurch and the decision was made to fast track the construction of a 1.4km pipeline between Prebbleton and the Lincoln rising main in order to back feed Prebbleton to Lincoln to provide partial treatment of the wastewater utilising the aeration basins and pond prior to discharge to the L2 river. Much of the concept design had been completed previously, so some details were compiled and SDC moved forward by negotiating a pipe supply agreement, fittings supply agreement and construction contract using agreed rates, within a week of the event, in direct response to the identified need.

The pipeline was pressure-tested and was set for commissioning, although it has yet to be utilised as a standard operation. The process of fast-tracking was considered successful by SDC as a timely and high quality finish was provided by the contractor.

4 MEDIUM TERM RESPONSE

Following the completion of the Prebbleton pipeline, SDC took stock of its position in the greater Christchurch rebuild. The Eastern Selwyn Sewerage Scheme (ESSS) had been subject to planning, consenting and design since it was initially proposed in 2004, with construction planned for the 2011-2013 period. The scheme consisted of connecting the sewerage infrastructure within eastern Selwyn district from the townships of Prebbleton, Lincoln, Springston and Rolleston (minus Tai Tapu), and treating the wastewater at a common treatment and disposal facility located at Rolleston. The overall scheme would initially require the construction of two pump stations, 8.5km of 500dia and 8.2km of 630dia pipe and a treatment plant, initially sized for 30,000PE

which would eventually be upscaled to 60,000PE and have an initial cost in excess of $50,000,000. Resource consent for the proposed ESSS was granted in December 2010.

The announcement of the first round of red zone land, defined as land on which houses couldn't be rebuilt within the Christchurch and Waimakariri districts, and the lack of options for suitable residential land available, resulted in a push to proceed with whatever works were deemed necessary to provide sewerage connections.

In late July, SDC assessed its options and undertook works to determine whether a short term consent from ECan to discharge wastewater from its treatment plant at Lincoln on its land in Rolleston would have minor or significant effects. The assessment showed that the effects would be similar to those fully utilising its existing resource consents and the decision was made to apply to ECan for such a proposal. The consent is to be a short term (15 month) consent with the objective to provide disposal capacity prior to the construction of the 30,000PE plant to be constructed as part of the ESSS.

The application and assessment of environmental effects showed that the effects of the temporary discharge could be managed so they would not be greater than the already consented final treatment process. A decision from the consenting process has yet to be reached, although SDC is hopeful that the consent can be granted non-notified. Some key features of the consent application included:

- *Separation distances to boundaries of 150m*
- *Maximum irrigation rate of 8mm/day*
- *Mean and maximum Ecoli*
- *Mean and maximum TN*

The pipeline design was completed in a fast tracked prior to the completion of the pump station design. It was determined that the existing Lincoln outlet pump station could be utilised to pump from the Lincoln oxidation pond through 16.7km of pipe directly to the centre pivots located at the Pines WWTP at a flow rate that would be acceptable for the existing connections to the Lincoln and Prebbleton townships with an allowance for additional short term growth. In order to complete the design, the following elements were considered:

- Use of PVC vs PE pipe
- Pressure classes required given that the pump station volume or pump setup hadn't been completed, including opportunities to reduce the use of emergency storage
- Requirements for tendering in order to fast track both pipe supply and contractor selection

The PVC vs PE debate was one in which all three councils affected by the earthquake participated. For the pressure systems it is understood that Christchurch City Council (CCC) completed its replacements with PE, while it is understood Waimakariri District Council (WDC) installed a large PVC main following the earthquake. There was evidence that both materials had withstood the earthquakes to varying levels and it wasn't clear that either material was unsuitable for the application proposed by the ESSS, given the distance from waterways and to ground water for the majority of the pipeline length. From discussions with the councils, one thing that was highlighted was that the rising mains installed were probably designed to various levels for surge and fatigue resulting in a number of low pressure class pipelines being installed that had failed. In addition the use of air valves and other key items to reduce the effect of surge may have been either not installed or not maintained, resulting in a reduced pipeline life expectancy which was likely to be less able to cope as a result of the earthquakes. As a result of the pipeline being fast-tracked, PE 100 was chosen as the material of choice, due to the historic use within NZ, the flexible nature of the pipe material and the process of butt welding which ensures that pipes can sustain longitudinal forces better than a rubber ring joint pipe. In addition, the initial modelling of the pipe under surge and fatigue indicated that the pressure class required for PVC would be greater than

PN16, thereby making it non-standard, reducing the benefits of utilising such a pipe. Anecdotally, SDC didn't have any concerns with the use of PE or PVC within the district, a fault line ran through the pipe alignment of a 225mm dia PN 10 pipe PE100 pipe with no noticeable effect following the uncovering of the pipeline.

The design of the pipeline without the completion of the pump stations resulted in a number of issues that needed to be resolved. These included pipe diameter and pressure class due to the pumping arrangements yet to be specified. After an intensive surge and fatigue analysis based on the use of pump stations controlled with VSD's coupled with the worst case pumping arrangements, PE100 PN16 DN 500 was chosen for the initial 8.5km from Lincoln to southern Rolleston and PE 100 PN 12.5 DN 630 was chosen for the remainder of the 8.2km from southern Rolleston to the treatment plant. Given that the first leg of the rising main was to be uphill from Lincoln to Rolleston South on an average grade of 1:300, and that the existing ponds at Lincoln will be retained for use as emergency storage, providing up to 40-50,000m3 of live storage, the decision was made that emergency storage should not be installed at the Rolleston South pump station, but that the pipe's vertical alignment and valve work be configured so that sewage from Rolleston can be gravity fed back to Lincoln should the need arise.

SDC undertook a process of procuring the pipes utilising a pipe supply agreement with early involvement by the Principal to purchase lengths of pipe and to commit the manufacturing equipment. This has since been incorporated into the main contractor agreement.

The pipe-laying contract was put out to tender as a measure and value contract to selected tenderers, to either complete pipe installation either as a complete package or as separate portions (Lincoln to Rolleston / Rolleston to Pines WWTP) as a separate contracts or to complete the total pipeline construction. The tender period revolved around a completion date of December 2011, and the construction contract was awarded as a complete package to Downers Ltd on 22 August 2011.

Photograph 4: Pipe installation as part of ESSS

5 LONG TERM RESPONSE

The works to date have been undertaken without compromising the desire to have a sewage conveyance and treatment process that will effectively treat the wastewater from the district's eastern most towns in a long term sustainable manner. With the recent earthquakes, significant efforts have gone in to making sure that projected timeframes are adhered to. In addition, the following features have been incorporated into the design to make every effort to ensure that the treatment plant will withstand any future earthquakes:

- Capacity in the Lincoln treatment plant will be retained as emergency storage. This will provide around 20 days' emergency storage which can be utilised prior to discharging effluent to the environment
- The construction of redundancy into of all key facilities with regards to the new treatment plant (screens, bioreactors, clarifiers, centrifuges, UV and solar dryers)
- Standardising items of plant, both in the treatment facility and within the district. This allows for substitution of equipment at the various sites
- Ensuring that the proposed plant has the ability to facilitate repairs on-site and store spares, with appropriately sized workshop, lighting and emergency backup generation
- The inclusion of 375Ha of disposal field, with the installation of all shelter planting well before the required timeframe.

6 EFFECT ON INFRASTRUCTURE DESIGN

In light of the recent earthquakes, and the potential for an Alpine Fault rupture, SDC has implemented the following generalised measures to reduce damage on future infrastructure assets:

- Ensuring all structures are constructed in accordance with the new structural standards required by the Building Act (to a hazard factor of Z=0.3 for the Canterbury Region)
- Requesting PN12 as the minimum pressure class and full surge analysis for all major trunk mains
- Where possible avoiding the placement of trunk mains adjacent to waterways or sudden drops where lateral spreading of soils are likely to have an effect
- Taking into account the likelihood of groundwater rising 3-4m in the event of an earthquake
- Investigating the requirements for emergency storage and provision for suitable engineered overflow points within the wastewater network
- Encouraging the utilisation of suitable tethers should earthquakes be a plausible risk

SDC has yet to take steps to create a viewpoint on the following:

- Installation of MH's in a way to resist floatation during liquefaction of soils
- A definite position on materials to be used in pipeline design

Operationally, SDC has taken the following steps:

- Implementing a review of standby generation capability
- Undertaking a review of communications with various sites
- Assessing communication requirements during a prolonged civil defence emergency
- Procuring chlorination equipment to facilitate emergency chlorination
- Additional training in the operation of the various schemes
- Ability to control the Pines II treatment plant from multiple locations should one facility on-site become unsuitable
- Ensuring suitable spare parts are available, including the storage of non-standard spares

7 CONCLUSIONS

The earthquakes that have hit the Canterbury region over the past 12 months have given Council staff a lot of things to think about - from how we make repairs to a damaged treatment plant, to what we think is really important in the new infrastructure proposed in the district. Lessons learnt have been able to be incorporated into what is likely to be the biggest investment that the SDC is going to make for many years to come in the ESSS.

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