PITFALLS OF DESIGNING AND CONSTRUCTING SOAKAGE AND RETENTION SYSTEMS

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ABSTRACT

This paper outlines the steps taken by a community grappling with stormwater problems arising from its remoteness from significant watercourses and past policies of 1 – 2 year design storms for its piped systems. Recent trends to more infill housing and to industrial developments with large impervious areas have been the last straw.

Similar situations arise with the capacity of piped stormwater systems in its other communities and as a result the Matamata-Piako District Council has adopted a policy that in general all stormwater generated by developments within a premises boundary shall be disposed of on that site.

Any connection permitted where there is sufficient pipe capacity may be subject to the provision of retention capacity on the premises.

However there has been an apparent difficulty in designing suitable systems and in the correct installation and maintenance of pre-treatment devices and of the soakage systems themselves.

The paper will highlight some of the pitfalls that arise from trying to adapt the policy from a pipe design and discharge approach to that of soakage system and retention design.

It also outlines some of the pitfalls we have encountered in the design, installation and maintenance of such systems.

KEYWORDS

Urban stormwater soakage systems, retention systems, pre-treatment devices

PRESENTER PROFILE

Graham Robertson commenced work as a Cadet in the Railways in 1958; but since 1962 has worked within Local Government ranging from a catchment board to a city council and both urban and rural orientated counties/district councils. He has worked for the Matamata-Piako District Council for the past 11½ years.

1 INTRODUCTION

The township of Matamata is a classic example of a township being established in the early days of New Zealand's settlement in a handy location in an existing clearing without any thought to the need to dispose of stormwater in the future.

Matamata is generally flat with little or no natural watercourses within the township. The nearest significant natural watercourses are the Mangawhero Stream to the east and the Waitoa River to the west.

In addition there are two land drainage systems on the boundaries – the Waihekau Drain on the northern side which is the point of discharge for the Tawari Detention Pond and the Peria Drain along the western boundary. Both of these appear to have been constructed to drain farm land and lack capacity for urban development.

In the early development days with large properties and unsealed roads there was no problem disposing of stormwater via soakage. With the advent of sealed roads and more intensely developed properties, this changed.

The standard requirements in the post war period was to design a stormwater system for a 1 in 2 year storm and generally to drain the road network only. This was not a problem when houses were built on piles, there tended to be limited use of impervious ground surfaces and some ponding of water during higher intensity storms was generally accepted.

The first evidence of concern with the stormwater system in Matamata was in 1962. The former Matamata Borough Council commissioned a report on the issue in that year.

This 1962 report noted that the bulk of water which fell in open areas was absorbed, but there was a need to have all roads and streets sealed and this runoff would need to be disposed of through stormwater sewers. Other reports soon followed as the Council sought to find an affordable solution to the matters being raised.

In the meantime the Council installed a retention pond on the main outlet to better handle the flows and extended existing pipelines to service catchments much greater than they were originally designed for. While this reduced some problems upstream it inevitably aggravated the situation downstream.

By the 21st century (and a further 7 reports later) matters were coming to a head particularly because of the trend to build houses on concrete slabs close to the ground, but also because of the greater percentage of impervious areas in recent developments.

Stormwater modelling in 2003 recommended major upgrading of part of the stormwater reticulation servicing the CBD and a small industrial area. The design was for a 1 in 5 year storm due to constraints of the Resource Consent to discharge into the downstream rural drain and the lack of fall. This system was installed over the next 3-4 years.

A comprehensive proposal prepared in 2005 for a stormwater Soakage Assessment in Matamata noted that:

- Private stormwater is generally not reticulated, but goes to soakage;
- Some of the public drainage system, such as street sumps, goes to soakage;
- There was no comprehensive records of soakage rates in Matamata;
- There was no formal design criteria for soakage systems;
- There was no comprehensive records of age or performance of the soakage systems;

- Some of the flood prone area is on an old swampland with high ground water levels;
- On-site practices which discharge contaminants or litter may block the soakage system.

Also in 2005 a report was prepared on options for flood mitigation and stormwater discharge within the main Matamata industrial area and this report was updated in 2006 to refine a preferred pipeline route. However the estimated cost of around $17 million, and the available budget being about 20% of that amount, meant the project did not proceed.

Unfortunately a significant residential development in the catchment of this pipeline had been allowed to proceed on the basis of that no soakage was available and that the pipeline would soon be upgraded and be able to handle the full drainage from the development. The developer was required to install a temporary retention pond.

A further adjoining small development was also allowed to proceed on the same basis.

With the deferment of the pipeline upgrade an assessment was undertaken in the major subdivision of the effect of ponding within the subdivision and a number of sections had a minimum floor level placed on them. Fortunately none of these had been built on.

A similar assessment on the smaller subdivision indicated that these sections were well above ponding level based on the as–built data supplied by the surveyor concerned.

2 MATAMATA STORM 15 APRIL 2008

On the 15 April 2008 a significant rainfall event occurred in Matamata when some 24 mm fell between 8.00am to 2.30 pm, and then a further 75 mm fell between 2.30pm and 3.45pm. Within this later period 33 mm fell in the 15 minutes from 2.55pm to 3.10 pm and 49 mm fell in the 30 minutes from 2.42pm to 3.12pm

This storm was rated as a 1 in 150 year return period storm in Matamata. In contrast the rainfall in the other two towns in the district (Morrinsville and Te Aroha) only about 30 kilometers away was rated as a 1 in 2 year return period storm.

Significant localized ponding took place for a period of up to 3 - 4 hours and the flood waters entered some garages, and prevented access to a number of streets. Only one house was flooded and this to a height of 150mm above the floor level.

This house was in the smaller subdivision upstream of the main industrial area and subsequent investigation revealed this was the first house built in the subdivision and was down an access leg in a local small hollow. The floor level was still some 300 mm above the centerline of the road and on the basis of the as-built levels for a sewer manhole adjacent to the house should have been well above the flood level assessed for the area.

However a check of levels revealed that the supplied as-built levels were 1.68 metres higher than actual and thus the floor level was 100mm lower than the anticipated flood level assessed after this house had been built.

It was also discovered that the information supplied to Council that the adjoining larger subdivision was unsuitable for soakage was not correct. Soakage was feasible provided some storage was designed into the soakage system.

3 STORMWATER STRATEGY

The storm in April 2008 hastened the development of a suitable Stormwater Strategy for Matamata which would also be applicable to the other urban areas in the District.

A consultant was engaged to prepare this strategy and their report presented a summary of previous investigations, the options for further mitigation of stormwater issues and recommendations based on a Strategic Stormwater Management Approach and an Annual Stormwater Improvement Programme.

It noted that MPDC has made a huge financial investment into stormwater infrastructure in Matamata but had reached a decision point where further investment in piping stormwater was difficult to justify and fund. Rather the emphasis should be on soakage disposal of stormwater.

It further agreed with earlier reports that a focus on the public system alone was unlikely to resolve all stormwater flooding issues in Matamata and the strategic approach should include incorporating the private soakage systems into the stormwater assets to be managed.

Essentially only one major stormwater project was suggested and that was an overland flow path to cater for the flows in the vicinity of the main industrial area and the two recent subdivisions upstream (included the flooded house).

Fortunately the Council already owned (or was in the process of acquiring for other reasons) all the land required and a 1,600 metre long flow path able to handle the 1 in 100 year storm was subsequently constructed at a cost of under $1 million excluding land cost (as against the piped alternative for a 10 year storm of $17 million).

Other measures proposed included adopting a Stormwater Bylaw and developing a Soakage Strategy.

This strategy was duly adopted by the Council.

4 FOLLOWUP

Council has since prepared and adopted a Stormwater Bylaw and published Soakage Design Guidelines and a simplified Soakage Calculator for residential properties.

It is also intending to include provisions in its District Plan and its Development Manual to further encourage the concept that all runoff resulting from a development is disposed of on the site. In effect this means that the soakage systems (including retention) must be able to accommodate the 1 in 10 year storm but where no overland flow path is available then the system must handle the 1 in 100 year storm. These requirements are similar to that of NZS 4404:2010.

This also meets the requirements of the Waikato Regional Council with respect to disposal of stormwater to land (without special consent) and also Council Stormwater Discharge Consents which require that there be no increase in the peak discharge rates to, or the flow volumes in, receiving waters unless there no additional adverse effect on the environment or downstream properties.

However this process has been delayed while trying to meet the concerns of an interested party.

5 SOAKAGE DESIGN

An analysis of data supplied to Council to justify soakage designs (or the claimed inability for soakage systems to be suitable) revealed a vast array of methodology and interpretation – generally in favour of the applicant. In particular E1 which is intended for individual lots is open to (mis)interpretation and is not considered appropriate for large developments.

Council therefore commissioned the preparation of a Soakage Design Procedures and Guidelines Manual and this was undertaken by Aurecon (and the preparation was the subject of a paper at the 2011 Conference by Neill Raynor and Robert Kelly, Aurecon).

Council has also developed a Simplified Residential Soakage Calculator for individual lots which complies with E1 and the Waikato Regional Council Regional Plan. Both these are available on the Council's website.

In particular the Guidelines removes the uncertainty of calculating the site percolation using E1 by prescribing the exact methodology to be used; and the Calculator provides for two options – the first where overland flow path exists and thus soakage need only cater for the 10 year return period storm; and the second where there is no overland flow path and thus the soakage has to cater for the 100 year storm.

The calculator uses the simplified concept that that rate of soakage (provided a minimum level exists) is not important if the soakage system can store the runoff from a 10 year two hour storm.

There has been reluctance by some to accept these requirements and an expectation that the excess runoff over a 10 year storm can be discharged to the road. However established Common Law is that a higher owner is entitled to discharge to lower land any water that falls naturally on the higher land, and can even use a an artificial structure to discharge that water as long as it does not appreciably increase the burden on the lower land (i.e. cause increased damage).

An example is that higher owners cannot seal a road and therefore increase the velocity of the natural flow to the extent that it causes damage to the lower land when no damage occurred before the road was sealed.

In the Matamata-Piako District virtually all its roads overflow onto private property and not directly to water courses. Water that arises from developments is not "natural water" and if the Council accepts it, it then becomes liable for the effects downstream.

In new subdivisions the expectation is that onsite soakage in the individual lots will handle the 10 year return storm with overflow to the street channel; and that the street system will accommodate the overflow plus the full 100 year runoff from the remaining area. The soakage system associated with the streets must be able to handle the 10 year storm without overflow and the 100 year with acceptable ponding (retention capacity) in the street as per the NZS 4404:2010 requirements unless an approved flow path is available.

Council's experience is that there is some confusion with the design requirements for pipe systems (peak runoff) and soakage systems (generally the total runoff over a 24 hour period), and also with the design of retention capacity. It should be noted that some elements of a soakage system do need to cater for peak runoff rates and in particular treatment devices.

In a pipe system treatment devices are generally sized to deal with the initial runoff only and higher flow rates bypass the device. It is my view that pre-treatment devices prior to a soakage system should be sized to accommodate the peak runoff able to be delivered by the upstream pipework.

This is because the minimization of the "blinding" of the soakage surfaces is critical to the operation and the life expectancy of soakage systems. Flows exceeding the treatment capacity of the device, and which bypass the treatment process, are still full of contaminants which will severely restrict the life of the soakage surfaces. It is much more cost effective to size the treatment device so that it treats the maximum flow in the upstream system.

6 SOAKAGE CONSTRUCTION AND MAINTENANCE

Soakage systems construction and their subsequent maintenance need to be undertaken by persons with knowledge of how the system is expected to operate. Too often the system is not installed as the designer intended and the maintenance requirements are not passed on.

There has been a rapid increase in recent years in the number of proprietary soakage devices and also pre-treatment systems. These all rely on proper installation and an understanding of maintenance requirements. Unfortunately too often these requirements are not passed onto the installer or the owner and/or the persons contracted for subsequence maintenance.

Some systems are even designed without thought to the practicality of maintaining them, thus ensuring the soakage system will have a limited life!

This can have expensive repercussions sometimes not that far down the track as the case study which follows illustrates.

7 CASE STUDY

About 8 years ago the redevelopment of a site within the Matamata-Piako district commenced. This site is outside the boundaries of the stormwater reticulation of the town it is located in and there is no natural drainage path. There was thus a requirement to discharge all stormwater to soakage and that the car park should be designed as a retention area to handle high intensity rainfalls.

The construction of first stage commenced in 2003 comprising one main shop occupied by a well known retail chain plus a number of smaller shops and most of the car park; and the second stage commenced in 2004 which was the construction of a supermarket.

The total area of the site is a little over 26,000 m² with most of it being developed as an impervious surface.

The drainage system is privately owned and Council was neither involved with its construction nor involved with its maintenance apart from the issue of the relevant building consents.

It is understood that problems with ponding commenced soon after construction was completed but Council was first aware of problems during the storm in April 2008 when

the local fire brigade acted to prevent flood water entering the shops by pumping into the adjacent public road.

This only transferred the problem elsewhere and caused flooding of a nearby Council wastewater pumping station and the overloading of the sewer system. It was noted that the once the water level did not threaten the shops and pumping ceased, it took about 8 hours for the stormwater to dissipate and that the last of the surface water was around a sump nearest the shops.

By this time the site had been subdivided into two by the developer and the larger site including the soakage system sold to an investor and the other site to the supermarket operator. Both owners have responsibility for the maintenance of the stormwater disposal system.

Both owners were written to and requested to investigate the stormwater disposal system and to remedy the problems as Council did not want stormwater pumped off the site in future in contravention of the consent requirements for the sites.

By late 2009/early 2010 it is understood that ponding on the site was occurring on the site up to 20 times per year and taking up to 20 hours to subside. Compare this with the total of say 10 hours for a 1 in 150 year return period storm less than 2 years before. It was clearly obvious that the soakage system was not working.

A contractor was being employed to pump ponded stormwater water into tankers and to dispose of it offsite.

The owners were naturally concerned about this cost and it appears the original designer was employed to investigate the situation. He subsequently produced a report that stated there were minor changes to the pipework but these had not caused the problems to date and concluded the problems arose from a lack of maintenance to the proprietary pre-treatment device.

He also conceded that the car park levels had been altered so that the deepest ponding occurred closest to the shops – and not the farthest side as originally proposed.

The report recommended three additional deep soakholes be installed; that the drainage trench be flushed to remove as much of the contaminants as possible; and that a maintenance program be instigated for the sumps, pipes and the pre-treatment device.

I had by now undertaken my own review of the background and had obtained a copy of the design of both the drainage and soakage system which had not been previously supplied to Council. I also obtained a different "as built" to that previously supplied to Council and this revealed that neither the drainage system nor the soakage system had been constructed in accordance with the plans submitted to Council.

The Council's building control staff had relied on a Producer Statement certifying the design of the Stormwater Disposal and General Drainage to be in accordance with E1 and further Producer Statements certifying the construction to be in accordance with E1 & B1.

The information now available to Council revealed that the pipe system had been designed for a 10 year, 10 minute storm but that during construction a large area of a roof had been connected to the car park system without any upgrade to pipe sizes.

The two smaller soakage systems intended for the first stage buildings had not been installed and all runoff fed to the car park soakage system which had also been

constructed with a significantly smaller capacity than in the plans submitted to Council. This extra drainage comprised 20% of the site

A detailed review of the design calculations for the soakage system by the Council showed that the percolation had been calculated on the basis of a paper presented to the Geological Society and not the method in E1 or other usually accepted methodology. The soakage system was then designed for a 2 year return storm with no specific consideration given to the retention requirements for the balance of the runoff.

The pre-treatment device specified and installed was stated to have about the same flow capacity as the pipes feeding into it but was in fact only able to treat about 42% of this flow rate with the balance being bypassed direct into the soakage system. In my view as stated earlier the pre-treatment should be able to treat the total flow for a soakage system.

Soakage systems have different needs to a piped system being disposed of to a watercourse. In this instance the next size up unit could have treated the entire flow and was the appropriate unit to have been used and would have been extremely cost effective compared with the cost of rehabilitating the soakage system.

Furthermore the device used only had one entry point being a standard manhole lid offset to one side. The details submitted with the building application shows two openings with one being directly over the storage chamber. Maintenance required a vertical entry to the central sediment storage chamber..

Records supplied stated that the treatment device had been cleaned on a regular basis since 2008. An inspection revealed that only the outer (oil) storage tank could be cleaned via the one off-centre manhole and a standard suction hose could not be bent to access the inner (sediment) storage tank.

In summary the drainage and soakage system was not designed in accordance with recognised practice, did not comply with E1 and the Waikato Regional Council Regional Plan, was not installed as designed, the pre-treatment device was too small and incapable of being readily maintained, the system did not have adequate retention storage and the car park was shaped to overflow into the buildings. There was no maintenance plan for the system and especially the pre-treatment device and it appeared none occurred during the early critical years.

When maintenance did occur the contractor was not sufficiently informed of the requirements to understand that his work was not achieving the required results

There was considerable activity with lawyers sifting through Council files (presumably to find if Council could be held liable) and approval was also sought to run a limited capacity stormwater outlet into the nearest Council piped system. This could not be allowed as that system is designed for a limited area, is already under capacity and discharges into a detention pond which has specified limits on its catchment.

Council also commissioned a report from an independent consultant to examine the options available. This report confirmed Council's views that off site disposal was not a viable option and "*strongly recommended that that any improvement options need to include a better understanding of the existing system and its operational requirements as well as improvements to the system to improve the rate and security of soakage. From our understanding of Regional Plan requirements the on-site system should be designed to soak away the 10 year flow without surface ponding. Flows in excess of the 10 year flow will need to be ponded on-site.*

There may be options to progressively improve the on-site system to maximise its performance, however this is unlikely to achieve the 10 year standard, and is subject to the performance of the existing soakage system, which is likely to be compromised".

However the eventual outcome was that a contractor was employed by the owners to "upgrade" the system. Council was not consulted over this work but it is understood the complete soakage system was removed and the plastic boxes cleaned and reused. There was talk of upsizing the pre-treatment device but whether this occurred is unclear.

It would appear that the fundamental problems of insufficient soakage and retention capacity still remains and that the overflow is still into the shops.

8 CONCLUSIONS

The design, construction and maintenance of soakage drainage systems require a different approach to that of piped drainage systems.

The designer needs to be aware of appropriate requirements, the contractor needs to be aware of the designer's intentions and the owner needs to be aware of the maintenance requirements.

Otherwise the system is not going to meet expectations and can easily become a costly white elephant.

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