BROWNFIELD STORMWATER UPGRADES : LEARNING THE HARD WAY

Angus Emslie, Thomas Fritz –Emcon New Zealand Ltd

ABSTRACT

In May 2005, Tauranga City suffered an extreme storm event that caused extensive flooding and damage. The recovery programme that followed involved upgrading existing stormwater drainage systems and retrofitting new ones in well established residential, commercial and industrial areas. It was not easy. In very short order, projects had to be prioritised, budgets had to be secured, easements had to be negotiated with property owners, consents had to be obtained, and the works often constructed under very difficult conditions. Mistakes were made and lessons were learned. But there were many successes too and the upgraded areas are now much safer places in which to live and work.

This paper has been prepared by Emcon New Zealand Ltd - the company appointed by Tauranga City Council to manage the recovery programme. The paper describes some of the situations that were encountered, how they were managed and the lessons that were learned. In each case, it offers suggestions on how to approach and implement brownfield upgrade projects and how to avoid many of the pitfalls waiting to trap the unwary.

KEYWORDS

Brownfield, Upgrades, Retrofitting, Stormwater Drainage.

1 INTRODUCTION

Most brownfield stormwater upgrades are now needed because of developments that took place prior to 1980. Up to that time, most primary drainage systems were designed for a two year storm event and there was little thought given to overland flow paths. It didn't matter then. Sections were large and there was plenty of space for stormwater to escape. Over the ensuing years, sections have been subdivided several times and property owners have built larger houses and paved larger parts of their properties as they have become wealthier. There is now high run-off and little soakage. It's also raining harder and the big storms are occurring more frequently. In the last twenty years, Tauranga City Council has twice had to increase its rainfall design tables.

The inevitable result of all this is a substantial increase in run-off which is far in excess of the capacity of the existing drainage system. Flooding of habitable floors is almost inevitable.

2 TYPICAL BROWNFIELD CATCHMENT CHARACTERISTICS

Some of the characeristics typically displayed by brownfield areas requiring an upgrade of the stormwater drainage system are:

- They are built up areas with medium to high density residential dwellings on lot sizes generally between 400 m^2 and 600 m^2.
- Coverage is likely to be:

Roof area	~ 45%
Driveways and sealed areas	~ 15%.
Remaining unsealed area	~ 40%.

- Soakholes collect roof run-off, but are seldom connected to driveways and other paved areas. That run-off flows overland.
- The footpaths and road berms have become crowded with services. Even the road pavements can contain services. There may be very little space for adding large diameter stormwater pipes.
- Natural overland flow paths are mostly blocked by dwellings, fences and roads. Man-made hollows are created and ponding levels need to rise above the obstruction to escape the hollow.
- Many newer dwellings built with the slab-on-grade technique have very little freeboard, especially garages that have been converted to habitable space. In addition, slab-on-grade structures are usually more vulnerable to flowing flood water than buildings on piles.
- In some cases, house designers have chosen lower than desirable floor levels in order to maximise accommodation within the building height restrictions.

3 THE PLANNING STAGE

3.1 PRIORITISING PROJECTS

The first step in any upgrade programme is to decide which projects to do first. The difficulty is that there are usually far more projects requiring attention than there are funds available. When the need for a new project is identified, it may be urgently needed and it may not be appropriate to add it to the end of the list. As those at the end of the list may well complain, some form of logical prioritisation process must be applied in a manner that will stand up to scrutiny.

Table 1 below shows one method of prioritising stormwater upgrade projects, but it is certainly not the only way and the criteria and weightings can be modified to suit the Council's particular circumstances. The important point is that there must be a clear and well defined logic that is applied equally to all projects. This will help counter any accusations from affected parties that another party is receiving preferential treatment.

Table 1: Priority Criteria and Weightings

Criteria to Consider		Weighting	Evaluation
1	Number of habitable dwellings/commercial buildings/industrial buildings that are currently at risk from a 50 year event or less.	10	5 = Many dwellings 1 = One dwelling
2	Frequency of flooding	25	5 = Frequent 1 = Extreme event only
3	Consequences of flooding (depth, likely damage)	20	5 = Severe 1 = Minor
4	Cost per habitable dwelling protected	20	1 = Expensive 5 = Economical
5	History of complaints/warnings	15	5 = Long reasonable history 1 = One recent unreasonable complaint
6	Previous commitment by Council	10	5 = High up LTCCP list 1 = Not previously on list

3.2 DEALING WITH TENANTS AND PROPERTY OWNERS

3.2.1 PRIVATE CONSULTATION

The first step is to define the problem and it is usually beneficial to talk to the affected locals about this. This will help them feel that Council is paying attention to their problems and they are more likely to be helpful as a

result. However, while locals may provide good information about the flooding that happened, they are often wrong about the cause of the flooding, partly because they are lay people and partly because they are not in possession of all the facts. So accept their data, but research the causes carefully yourself.

Research the options thoroughly and ensure that you have considered all the alternatives and that you know what you want to do. You must have good reasons for your choice of route over the alternatives because most property owners will want you to build the works "somewhere else".

Once you have reached this stage, the property owners who should be individually consulted are:

- The owners of properties through which you wish to construct the works. Beware of multiple or joint owners, such as a husband and wife. The approval of both is required.
- The owners of properties that will be affected by the proximity of the works or by the construction process (even if the works will not actually be on their properties).
- Affected tenants, but first check with the owners, as they may prefer to inform the tenants themselves.
- Other residents in the street whose access will be affected. (If there are many residents affected in this way, they can be informed via a general meeting. Invitation to the meeting should be by letter drop as well as a notice in Council's newsletter.)

Be prepared to deal with high conflict people – there are always one or two with a grudge against Council. The main thing in the beginning is to listen to the complaints (whether they are relevant or not) and avoid argument. Seek advice from an expert in conflict resolution and be prepared for a potentially long and frustrating consultation process. It can easily delay the project by a year or more.

3.2.2 SURVEY ON PRIVATE PROPERTY

If survey is required on private property, it is necessary to inform the owners by means of a letter drop several days in advance of the survey and to give them an opportunity to call the Council and find out more information. The trouble is that the letter drop requires an additional visit to the site, so there is a tendency for the surveyor to do the letter drop on the same day as the survey with potentially damaging results. One property owner was so incensed to come home and find surveyors in his back garden unannounced that he has refused to grant consent for the pipeline to be laid there. Since there is no alternative route for the pipeline in that particular case, Council will either have to cancel the project or use time consuming legal procedures to secure the necessary easement.

3.2.3 DANGERS OF INCOMPLETE INFORMATION

For obvious reasons, most property owners are very concerned about the impact that the proposed works will have on their properties and will want to ensure that they are not compromised in any way. In many cases, they will want to dictate restrictions on what Council may or may not do. Early meetings are therefore needed to discuss proposals in principle before any drawing is produced.

Once the principle has been discussed, do not proceed on the basis of a preliminary drawing that does not have all the detail worked out and correct. Property owners are very quick to notice poor details on drawings and will not readily accept that 'the detail will be sorted out later'. From that moment on, they will be deeply suspicious of Council's intentions and will be reticent to accept any futher Council proposals. Only when all issues have been agreed and the drawing has been completed and checked, should it be sent to the property owner for approval.

3.2.4 SECURING EASEMENTS

Approval from property owners has proved to be the most troublesome and time consuming activity. Consultation usually requires several meetings or exchanges of correspondence with each affected person and

almost always takes a lot longer than expected. Most people are understanding and keen to help, but each project seems to require the consent of at least one or two reluctant people, necessitating a large investment in senior management time to resolve the problem. Make sure that all agreements are recorded and signed by the property owner(s) and put into the peoperty file. That way it will be binding on future owners. Start securing land and easements as soon as the pipeline route is known and long before there is any commitment to the construction stage.

3.3 DEALING WITH BUSINESS OWNERS

Business owners must be consulted too. Not only are business owners just as concerned about their properties as residential property owners, there is the added complication of their livelihood being affected by the works. This applies particularly to shop owners who rely on passing trade. Note that passing trade can be affected by the temporary closure of a through-road somewhere else – not just in front of the shop. Most Councils have a policy on how to deal with business owners who are affected this way, so make sure you know what it is before consulting them.

3.4 DEALING WITH THE PUBLIC

Except where their own properties are affected, most members of the public don't expect to have much of a say in public works on public property (some do, of course), but they usually do want to know what is going on and they do want to be kept informed of any changes. Some guidelines in dealing with the public are:

- Group consultation in the form of an evening meeting at the local school hall is usually the most efficient method of communication. A strong chairperson is essential.
- Advertise the meeting in the Council newsletter or local media. Don't use letter drops because you will probably not be able to spread the net widely enough. (People who live elsewhere, but pass through the project area, may also be affected.)
- Don't consult the public until you have consulted the affected property owners and businesses individually.
- Don't consult the public until you have a very good idea of the works you want to build and why your proposed solution is better than the alternatives. You must also be sure that you have the budget and that the project will go ahead when you say it will.
- If postponements become unavoidable, notify the public immediately, giving reasons for the postponement.

3.5 CONSENTS

The resource consent process is not unique to brownfield upgrades, but there are usually fewer options available for compromise and the process can take a lot longer than expected. It is, of course, a huge subject in its own right and will not be examined in any detail in this paper. Suffice to say that plenty of time should be allowed in the project programme for the consent process and there should be no commitment to subsequent stages until all the consents have been obtained.

3.6 BUDGETING

When a contractor prepares a budget estimate, he will probably only state the construction cost itself. When a consultant prepares an estimate, he will cast the net a little wider, but will probably only include the construction cost, his own fees and perhaps some geotechnical investigations. As often as not, his estimate will state a number of exclusions, but by no means all of them. Typically there is no mention of other consultants' fees or the client's own costs. A budget shortfall is the almost inevitable outcome.

If a budget shortfall is to be avoided, somebody has to budget for <u>all</u> the costs likely to be encountered, and that somebody should be the client, using the spreadsheet shown in Table 2. It sets out most of the cost

components of a typical brownfield upgrade project and should be issued to the consultant with instructions to complete the Fees and Physical Works sections in their entirety. The client completes the Council Expenses section.

Table 2: Template for Capital Works Budget Estimate

Capital Works : Budget Estimate

Project: **[Name of project]**

Updated:
LIPS Number:
Job code:
Prepared by:

	Total	Year 1 20??	Year 2 20??	Year 3 20??	Year 4 20??
Budget Estimate	**0**	**0**	**0**	**0**	**0**
Consultants' Fees	**0**	**0**	**0**	**0**	**0**
Planning stage:					
Planning and feasibility studies	0	0	0	0	0
Modelling	0	0	0	0	0
Topographical survey	0	0	0	0	0
Geotechnical survey	0	0	0	0	0
Archaeological survey	0	0	0	0	0
Consultation	0	0	0	0	0
Resource consent applications	0	0	0	0	0
Other? (Specify)	0	0	0	0	0
Design stage:					
Engineering fees - preliminary design	0	0	0	0	0
Engineering fees - detailed design	0	0	0	0	0
Landscape architect	0	0	0	0	0
Other?	0	0	0	0	0
Tender and Construction stage:					
Engineering fees	0	0	0	0	0
Other? (Specify)	0	0	0	0	0
Physical Works	**0**	**0**	**0**	**0**	**0**
Preliminary and General	0	0	0	0	0
Scheduled items	0	0	0	0	0
Contingencies	0	0	0	0	0
Secondary contracts (e.g. landscaping)	0	0	0	0	0
Other? (Specify)	0	0	0	0	0
Tauranga City Council Expenses	**0**	**0**	**0**	**0**	**0**
Easements	0	0	0	0	0
Land purchases	0	0	0	0	0
Any other compensations	0	0	0	0	0
Consent costs:					
TCC	0	0	0	0	0
EBoP	0	0	0	0	0
HPT	0	0	0	0	0
OnTrack	0	0	0	0	0
NZTA	0	0	0	0	0
Legal expenses	0	0	0	0	0
Communications and publicity	0	0	0	0	0
Location of underground services	0	0	0	0	0
Tender costs	0	0	0	0	0
Salaries capitalised	0	0	0	0	0
Escalation to end of construction	0	0	0	0	0
Other?	0	0	0	0	0

Notes: The estimate must include costs already incurred.
Enter cost estimates in the shaded cells. The total column contains formulae.
If the cost of one item is included in another, enter "Included" in the cell.
If there is no information about an item at this stage, enter "Unknown" in the cell.
A zero will be taken to mean that there is no anticipated cost.

4 THE DESIGN STAGE

4.1 DESIGN PHILOSOPHY

Most codes of practice state that the primary system must be designed for a moderate storm (usually between a two and ten year event) and that the overland flow path must be capable of accommodating a major storm (usually a 50 or 100 year event). There is no issue with this philosophy for greenfield sites, but it is unlikely to be practical for brownfield upgrades. If it is rigidly applied, it will require most of the existing pipes to be ripped out and replaced with larger ones and there will almost certainly be insufficient space for a detention dam or an overland flow path with adequate capacity (if there is any space at all). Brownfield design therefore requires a different approach.

At Tauranga City Council, it is recognised that any increase in the capacity of the existing system is an improvement and a less rigid application of the design standards has been adopted for brownfield applications. The design philosophy states:

> "For stormwater upgrades in brownfield areas, the combined primary and secondary drainage system should ideally prevent any building from flooding in a 2% AEP event (1:50 year event). This is not an absolute requirement, but should rather be regarded as a target to be achieved only where feasible. Practical considerations may dictate that the system be designed to cater for a lesser event. The existing primary system must be utilised wherever possible, and new pipes should only be installed where there is no practical overland flow path or where the existing pipes can no longer be utilised."

In other words, don't limit yourself to design codes. Think outside the square and don't be afraid to do nothing. It may be the best option (as long as you have logical reasons for your decision).

4.2 STORMWATER PUMP STATIONS

Design engineers will often find themselves tempted to resort to a stormwater pump station to solve an upgrade problem, especially in low lying areas or where there is no space for an overland flow path. In most cases, however, it is not practical for the following reasons:

- Stormwater pump stations are large and expensive to build. It is usually cheaper to provide gravity drainage or to purchase and demolish the flood affected buildings.
- Storage volume is usually limited, so the pumps must have the capacity to pump the major storm flow away as it arrives. This means that they have to be very large and will make high demands on the local power supply. The line charge could be prohibitive.
- The pumps must work when they are needed (no exceptions). A reliable power supply is therefore essential. The trouble is that a major storm is the very event that is likely to cause a power failure. Backup diesel generators of sufficient size are expensive and need regular maintenance and fresh diesel. The generator will have to be above ground and may be difficult to consent for environmental, noise and aesthetic reasons. Spillage of diesel could be a problem.
- If the pump station is designed to augment a gravity system, it will only be used in significant storm events. These may be several years apart and the pumps may not work after a long period of inactivity. Testing the pump station at regular intervals is unlikely to be practical because the water will probably not be available.
- When the pumps switch on, there will be a sudden and unexpected rush of water into the downstream environment which could be dangerous or damaging.
- Good access for heavy maintenance vehicles may be expensive.

- The local authority may not have the facilities and resources to undertake maintenance or emergency repairs during significant storm events, given that maintenance staff are likely to be in demand all over the city at such times.

(By way of comparison, pump stations for draining rural flood plains do not suffer from most of these problems because:

- There is usually a very large natural storage volume which means that there is a slow build up of water level, rather than a sudden high flow rate. Pumps therefore do not have to be excessively large or have high power demands.
- It usually takes several days or weeks to drain the water. Therefore it does not matter much if the pump station does not work immediately and takes a day to repair.)

It follows that the criteria below must all be met before deciding on a stormwater pump station for an urban application. If any single one of the criteria is not met, then a stormwater pump station is unlikely to be feasible.

- Gravity drainage is not practical or cost effective.
- Demolition of the flood-affected buildings will be socially or financially unacceptable.
- There must be sufficient storage or sump volume that the pump size is practical and that the motors do not switch on too often or make excessive demands on the local power supply system.
- A dependable or backup power supply can be provided. If this is in the form of a diesel generator, it must not create an environmental, noise or aesthetic nuisance.
- At least one pump must be in use virtually every time it rains, even during minor rainfall. (Usually duty alternating, with duty assist during big storms).
- The downstream environment must not be adversely affected when the pumps switch on, nor must there be any danger to an unsuspecting member of the public.
- There must be good, all-weather access for heavy maintenance vehicles.
- The local authority must have the resources to undertake emergency repairs during significant storm events.
- The operating cost must be appropriate for the benefit received.

4.3 INTER-ALLOTMENT DRAINAGE

Inter-allotment stormwater drainage is defined as a system for draining the stormwater runoff from one private property through the downslope property or properties.

Tauranga City Council does not normally involve itself in constructing drainage for private properties. There are, however, some circumstances under which a local authority could be obliged to do so. These include the following situations.

- Where overland flow from Council property and road reserves onto private property:
  a) has been concentrated or increased over the naturally occurring flow, and
  b) is discharged onto private property in such a way that it causes a nuisance.
  (Note that both (a) and (b) must apply.)
- Where Council works have caused stormwater to enter private property whereas it did not before.
- Where Council has caused the existing private drainage system to become dysfunctional (e.g. the disconnection of soakholes).
- Where the safety of downslope property owners is at risk. Since the upslope property owner will not have the authority to construct drainage works through the downslope neighbour's property, Council may have to construct the works. In such cases, it may be possible for Council to recover costs from the upslope owner.

- Where Council has allowed development to proceed which subsequently causes downstream flooding on private property.
- Where Council has allowed a development to proceed in a location which is subject to flooding.

Unless there is strong incentive for the majority of property owners to connect their properties to the system at minimal expense, there is no point in installing inter-allotment drainage. The sad fact is that very few people care about the properties downstream and will only pay for their own connection if it benefits them directly. In most cases, Council will have to pay for the private connections and may even have to struggle to obtain approval from the property owners to make the connections.

If you decide against inter-allotment drainage, you will still need to give careful consideration to the design capacity of the downstream collection system. Do you design it on the assumption that there will be no inter-allotment drainage or do you design it on the assumption that Council may change its mind and may wish to install inter-allotment drainage at some time in the future? You also need to consider the possibility of a single major development replacing several houses in the future. Each situation will be different and will have to be assessed on its merits.

4.4 EXISTING SERVICES

Common practice is to use as-built records to show existing services on drawings, but to wait until the construction stage to prove the exact location of the services. This can be a big mistake. All too often, unexpected services are encountered and known services are not where they are shown to be on the as-built drawings. Stormwater pipes, megapits and the like require a lot of space and their positions cannot easily be adjusted on site at short notice. If the pipes have to be rerouted onto another alignment, it could cause weeks of delay. All the while, the Contractor could be claiming standing time. It is far better to prove the exact location of existing services at design stage.

Also, don't assume that existing works were constructed properly. If you have to lay a new pipe at the foot of an old retaining wall, don't assume that the foundations are at an appropriate depth. They may not be. Chances are that they are shallower than you think and you may not be able to lay your pipe where you would like.

Another common error is to concentrate on the design of the main service (e.g. a stormwater line) and to pay insufficient attention to other existing services such as sewers or water lines that will have to be relocated to accommodate the new stormwater line. These other services can cause significant problems or delays if they are not carefully detailed at design stage. It may also be necessary to decommission a service for a considerable length of time while it is relocated and this may require temporary works and careful planning.

4.5 ATTENTION TO DETAIL

The key to success of any brownfield design is the attention to detail. It increases the design cost, but it is worth it in the long run. Some examples are:

4.5.1 INLET CAPACITY

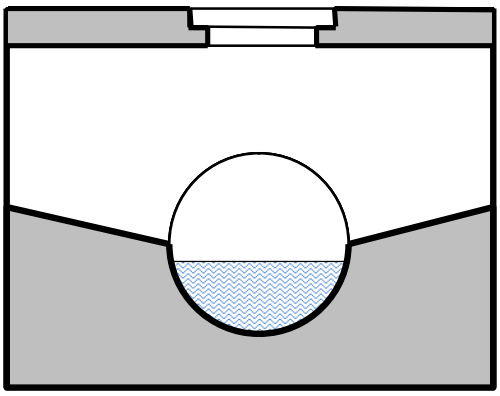
Make sure that there will be sufficient sumps for all the water to enter the piped system, especially at the head of the line and at manholes where the pipe diameter is increased. For example, a subcatchment run-off to the head of the pipeline may be 200 L/s, requiring a 450mm diameter pipe at a gradient of 1 in 230. This would require approximately eight sumps to convey the water from the street surface into the pipe. All too often, only two are provided which means that the pipe will never flow more than 25% full. What a waste!

4.5.2 MANHOLE DESIGN

Where flow velocities are high (typically > 3.5 m/s) manholes must be individually designed for two reasons, firstly that they do not blow their covers when they surcharge (with potentially tragic consequences) and secondly that they do not become bottlenecks in the system.

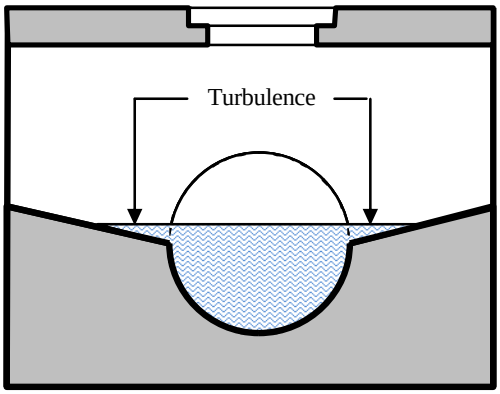
Consider each of these factors in turn. *Figure 1* explains why strormwater manholes can surcharge rapidly and *Figure 2* why they can be a bottleneck in the system.

Figure 1: Rapid Surcharge in Stormwater Manholes



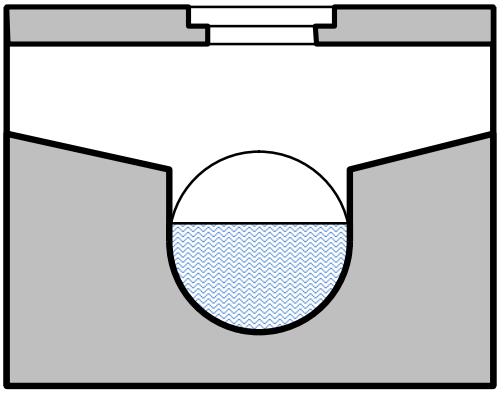
(i) Water Depth • 50% Pipe Diameter.

Provided there is no bend at the manhole, the water will stream uniformly through it and there will be no surcharge. However, if there is a bend and velocity is high, the water will mount the benching on the outside of the bend and the problem described in (ii) below will arise.



(ii) Water Depth > 50% Pipe Diameter

As soon as the water overtops the benching, there will be severe turbulence at the downstream side of the manhole, causing very rapid surcharge (a few seconds). This, in turn, causes a sudden increase in air pressure in the manhole which can easily blow the cover off. This is only a problem in high velocity stormwater applications. If the pipes are small (e.g. foul sewers) or velocities are low (typically < 2 m/s), the rate of surcharge will be low and air pressure will dissipate slowly, leaving the cover in place.



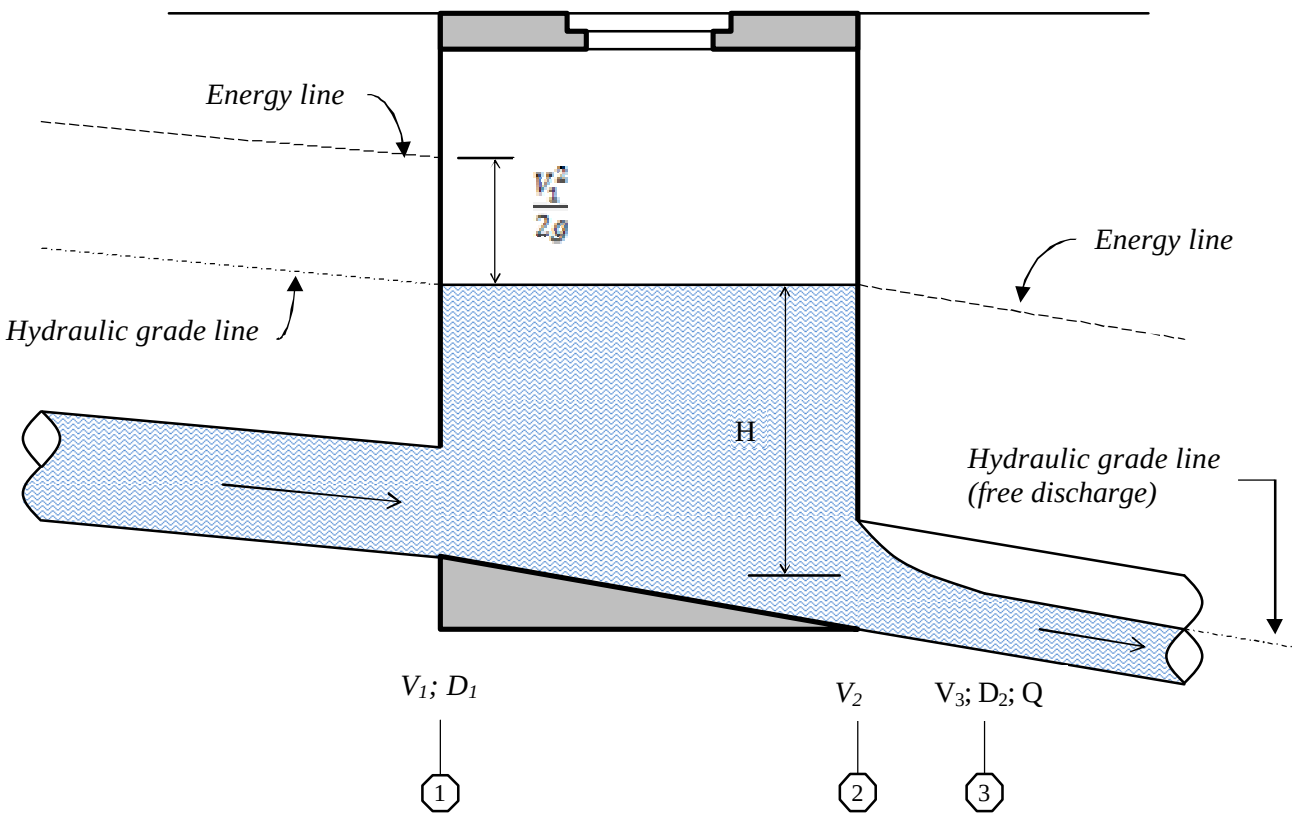
(iii) Raised Benching

Raising the benching as shown may help a little, but as soon as the downstream turbulence starts, the problem described in (ii) above will arise.

Figure 2 below shows that the maximum flow through the manhole occurs when the surcharge depth, H is equal to the depth of the manhole. It follows that this is the system capacity. If H is any greater than the depth of the manhole, the cover will be displaced and water will overflow the manhole.

The figure shows the free discharge condition, but the equations apply equally to the drowned discharge condition (i.e. outlet pipe flows full).

Figure 2 : Hydraulic Manhole Capacity



Discharge equation: $Q = C_D . \sqrt{2gH} . \frac{\pi D_2^2}{4}$ ……. *Equation 1*

Where
Q = Outflow rate (m^3/s)
H = Head (m) required to drive water out of the manhole
D = Pipe diameter (m)
C_D = Discharge coefficient • 0.8

Therefore $H = \frac{1}{2g} . \left[\frac{Q . 4}{C_D . \pi D_2^2} \right]^2$ ……. *Equation 2*

Note $Q \neq V_2 . \frac{\pi D_2^2}{4}$ because the area of flow is not known at (2)

As most stormwater manholes are greater than 1m deep, it will not be necessary to check manhole capacity for outflow velocities of less than 3.5 m/s. For higher velocities, it may well be essential, especially if the manholes are shallow.

4.5.3 CONSTRUCTION PRACTICALITIES

- Make sure that all designs are fully detailed before you start the tender process.
- Make sure that the works can be constructed without undermining adjacent buildings.
- Make sure that there will be space for traffic to pass open excavations.
- Make sure that new sumps will not obstruct private driveways.
- Make sure that the required drilling tolerances can reasonably be achieved, especially when drilling around a bend. Failure to do this may result in encroachment under the adjacent property.

4.6 DON'T MAKE IT WORSE

'Don't make it worse' might sound obvious, but it happens all too often. Typical examples are:

- Band aid fixes, which are intended to show that Council is doing something about the problem, such as adding a sump to eliminate local flooding. If the main drainage system doesn't have the capacity to deal with the water, the extra sump may simply transfer the problem downstream, instead of solving it, rather like poorly considered traffic congestion changes. In the end, the net benefit may be zero and Council will have wasted money and done itself no favours at all.
- If a new drainage system reduces flooding on ten properties, but causes a small amount of water to encroach onto the corner of another property (whereas it didn't before), that property owner will most likely demand that Council prevents a further occurrence. For example, as a result of changes to the drainage system, water may back up in a new location and overflow a private driveway.
- Adding noise is sometimes an unintended consequence of a new manhole cover or surface grating. If passing traffic causes it to clatter, complaints from nearby residents will almost certainly follow.

5 THE CONSTRUCTION STAGE

5.1 BEFORE YOU START

Talk to the affected residents, both individually and at a public meeting. The reason for the public meeting is that it is not always obvious who the affected residents actually are. People passing through the area may be affected, even though they are not local residents. Tell them what to expect, especially the bad. Don't leave this to the Contractor. People want to talk to Council because they know the Contractor has little scope to change things.

Undertake a thorough condition survey of all properties that might be affected by the works. The best way to do this is with date stamped photographs, but make sure that the whole property is photographed, not just damaged areas. If you can show that a wall was cracked before construction started, the property owner will not be able to make a false claim. If you suspect that a house built on poor ground conditions may settle as a result of vibrations from dewatering or other construction activities, measure the floor levels at the corners of the house. Ideally, the Contractor should carry out the condition survey. Don't do it yourself because you could be held responsible if there is damage to an area that you did not photograph.

5.2 DURING CONSTRUCTION

When monitoring construction, we tend to concentrate on things like laying the pipes straight and compacting the backfill thoroughly, but if we don't pay attention to the softer issues affecting the public, we will be dealing with endless complaints.

- Dust can be a major nuisance for adjacent properties and it may not be sufficient to water the site twice a day. If there is dirt lying on the road, it will dry very quickly and the dust will start flying within half an hour of the watering. In such cases, the ground must be kept wet virtually all the time.
- Fumes from a generator can be very unpleasant for a downwind property, especially if it is close by.

- Noise at night from a generator or dewatering pump can be a real problem. It may sound quiet enough during the day, but can be overwhelming at night when there is no other background noise. Adequate noise insulation is essential.
- Maintaining access to private property may not always be possible. If it isn't, make sure that the Contractor makes arrangements with the affected residents (and notifies the property owner if it is a rental property.)
- Interrupting the water and power to private property. If this is unavoidable, make sure that the duration is short and that the occupant and the owner are notified in advance. If the interruption is likely to be a long one, talk to them rather than just dropping a flyer in the letter box.
- Everyone knows that the site must be properly fenced to protect public safety, but it is surprising how often it is ignored – not at the start of construction, but towards the end when everyone is getting a little weary.
- Remember the cyclist. With more and more people using bicycles, provision must be made for them when closing shoulders or diverting traffic.

5.3 AT THE END

- Keep the residents informed if construction is running behind time.
- Tidy up footpaths as soon as possible.
- Obtain the as-built information promptly and record improvements on the property files. Everybody hates doing it, but planning brownfield projects from poor as-built information is frustrating and risky.

6 IN CONCLUSION

Upgrading services in a brownfield area is very different from a greenfields project. The key elements are:

1) Make sure you have well documented and logical reasons for prioritising and selecting your projects.
2) Consult residents, tenants, property owners and all those who will be affected by the project as early as possible in the planning process.
3) Secure land and easements as early as possible.
4) Use a template to reduce the likelihood of a budget shortfall.
5) Do not be tempted into proposing a stormwater pump station unless all the prerequisites have been satisfied.
6) Prove the location of existing services at design stage. Do not wait until the Contractor is on site.
7) Do not underestimate the importance of "other" services. Plan their relocation as carefully as the main service.
8) Pay attention to detail at design stage. Don't leave it to the Engineer's representative to determine on site.
9) Even if you solve the main problem, don't make anything else worse, no matter how trivial. If you do, you will have to spend a lot of time and money dealing with the public complaints that follow.
10) Give careful consideration to the needs of the public and residents during the construction stage.
11) Talk to affected residents. Don't leave it to the Contractor. On the other hand, have the Contractor undertake a detailed condition survey of surrounding properties before starting construction.

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