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Bed and Bank Stabilisation of a Highly Modified, High Intensity Urban Watercourse.

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SUMMARY: This paper deals with the issues and practical considerations for carrying out bed and bank rock stabilisation works on a highly modified urban watercourse subject to high intensity flow situations. As compared to past 'hard engineering' solutions, that exhibit no environmental values, this is a significant evolvement that equates to more of a 'soft engineering' approach. An example case study examines a total creek re-alignment necessitated by a major road project.

The urban waterways are affected by :
- re-development within catchments and continuing new and more intensive land development;
- increasing pressures as a result of service authorities' and local government works;

Remediation needs to take into account a range of items including :
* increased intensity and recurrence of high volume flows;
* constraints of adjacent land usage and asset protection;
* water quality, stream ecosystem and bio-diversity sustainability;
* increased community demands and expectations for waterway environment;

The urban situation often requires localised bed and bank stabilisation necessitating the use of rockwork. This involves more than just rip rap or the use of placed large rocks. There is a need to attain a combination of structural, aesthetic and environmental outcomes for completed bed and bank rock stabilisation so that a more 'natural' appearance (assisted by revegetation), will be achieved.

Successful implementation of this type of stabilisation is dependent on the experience and understanding of everyone involved, from the designers through to, most importantly, the contractors carrying out the work.

THE MAIN POINTS OF THIS PAPER

- urban watercourses are unique in that there is a need to address recurring high intensity flows within adjacent land constraints, resulting in increasing pressures on bed and banks and subsequent erosion
- past practice would be to adopt a concrete, 'hard engineering' solution, however, 'soft engineering' rockwork for bed and bank stabilisation can be utilised to meet structural, aesthetic and environmental outcomes
- successful implementation is dependent on understanding and experience of everyone involved

1. INTRODUCTION

Melbourne Water manages the waterways, floodplains and major drainage systems within the Port Phillip and Western Port catchments of the greater Melbourne area.

The very nature of urbanisation generates changes which greatly increase impervious areas, reduce times of concentration and increase volumes of run-off. These factors contribute to a growing intensity of flows which combined with bed slope, generates 'streampower'. Urban watercourses have flows which are often quick to rise, but also rapid to recede. In these circumstances there is an increased potential for erosion to occur as a result of a storm event.

Social and economic imperatives also reduce space available for natural floodplains. The high value of land means there is often no longer an opportunity for the 'natural' meandering processes of streams to occur. In addition, past planning practice and limited forethought by earlier generations has resulted in constrained waterway reserves and inappropriately located assets, including bridges, bike paths, and other services.

This paper will focus on rockwork stabilisation, although this forms only part of the options to address bed and bank instability. Other options include flow volume control, grade control, bank layback or intensive revegetation.

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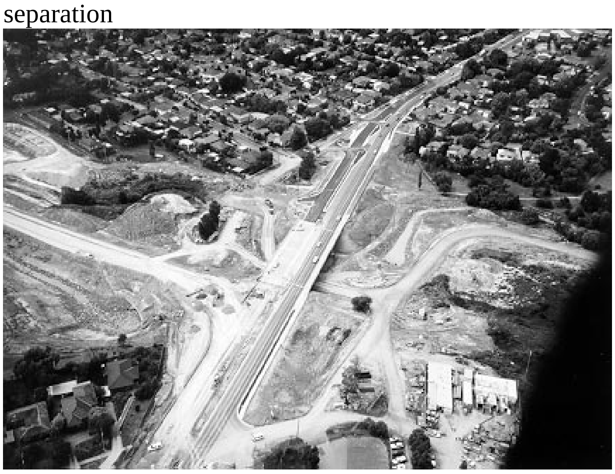
The advantages of 'soft engineering' utilising rock treatments for urban watercourses can be summarised as follows:

- a long term structurally sound bed and bank condition able to accommodate high flow regimes;
- a visually attractive and natural looking appearance and finish able to enhance landscape values and visual character of the stream corridor; and
- an environmentally sustainable stream system possessing water quality capable of sustaining aquatic life and providing indigenous flora and fauna habitat values along the corridor.

2. CASE STUDY

This case study relates to a large road construction project that resulted in substantial works affecting a watercourse. Past practice would have been to adopt a 'hard engineering' approach, that would consider undergrounding, concrete lined channelisation, through to utilisation of retaining walls. Although difficulties were encountered along the way, the final creek treatment adopted achieved a worthwhile result, considering the site limitations.

Initial stages of freeway construction - Tram Rd grade separation



At the time of its planning, the 7.0 km extension of the Eastern Freeway from Doncaster Road to Springvale Road in the eastern suburbs of Melbourne, was to be built along the Koonung Creek valley, with a resultant direct and significant impact on that creek. The preliminary road design had large sections of the creek undergrounded. Previously, the 2.7 km extension of the freeway from Thompsons Road to Doncaster Road, built in the early 1980's, resulted in the entire length of creek being fully undergrounded into a large 1 in 100 year arched drain.

Eventually a compromise solution was adopted which resulted in Koonung Creek being kept as open and as natural as possible with minimal undergrounding. It was thought this approach had the potential to lessen detrimental impacts on long term stream water quality (nutrient levels, oxygen demand) and help retain some of the valley's environmental values.

The adopted approach resulted in the need for major creek works which included significant realignments, control of erosion on the existing bed and banks and substantial rockwork stabilisation.

2.1. Constraints and Issues

The proposed scope of works were constrained by the available land, with the six lane freeway design consuming the major proportion of the valley cross sections at most points. A proposed linear bike path running parallel to the creek added to the demands on the valley space. Options for treatment of the creek were therefore limited.

Loss of much of the associated flood plain and the given criteria of no increase to the designated 1 in 100 year flood levels, meant that flows needed to be almost entirely contained within the realigned cross sections. To provide protection against confined flood flows meant bank protection works would need to continue well up the bank slopes. The extent of these works highlighted the need to give consideration to aesthetic and environmental issues for normal flow conditions.

The tight site constraints meant that future maintenance activities needed to be minimised, as access to some areas along the creek would be limited.

At the time, there was a lack of understanding by consultants and contractors of Melbourne Water's requirements and what was trying to be achieved, for treatment of the creek. This occurred across the spectrum of works, from design to site construction.

2.1.1. Design Considerations

The preferred general notion of preserving and enhancing the natural values associated with the open watercourse and the goal of working towards rehabilitation, needed to be communicated to all the parties involved.

Koonung Creek was seen by the design consultants primarily as a drain, with the road criteria to be met first and foremost. Past practice on other waterways and the poor condition of the creek, added to the initial confusion in attempting to achieve better outcomes for the waterway. There had been no equivalent creek treatment works on the scope or scale of what was proposed.

The preferred maximum velocity component was adopted to be 2.5 m/sec, based on working experience. Extensive steady state hydraulic modelling was needed to check the proposed works for designated flows.

The finished rockwork surface variation led to an increased roughness component, compared to the bare clay surfaces of the clay pan bed and the eroded banks of the existing creek. An increased Manning's 'n' value of .05 was used for the hydraulic modelling. This factor was used as a practical contribution to the reduction of velocities, but localised velocity spikes were a concern. These were addressed with additional stabilisation where they occurred.

When design plans for treatment of the creek were produced, cross sections were interpreted and reproduced as a trapezoidal channel. The dimensions and levels were engineered to the nearest +/- 10 mm!

2.1.2. Works Implementation

A component of the Quality Assured process by the road constructing authority, was the requirement for contractors working on the site to have the appropriate experience and understanding of the issues and objectives for the creek works. Clear communication and direction, from the principal contractor was imperative.

Major realignment downstream of Elgar Rd grade separation

The availability and supply of the correct grading of rock delivered to the site is a potential difficulty that can lead to instances of compromised standards and/or increased costs. In this case study, the large volume of quarried rock required generated problems in supply and delivery. Where possible, stockpiling can be utilised to enable sorting on site. Otherwise it is advisable to ensure correct availability with the supplier if there is to be direct delivery to the work area

3. POSITIVE OUTCOMES FROM THE CASE STUDY:

In aiming to achieve satisfactory implementation of 'soft engineering' concepts, the following points were addressed:

3.1 Design

Major re-alignments were accepted, with horizontal meanderings adopted as the preferred stream type. This was not always possible to achieve. Two sections involved excavation through hillsides and resulted in the creek re-alignment being excavated through in-situ rock and reef material. The surrounding topography and exposed rock features to some extent compensated for localised straightening of the stream. Rock chutes were used to create localised ponding.

3.2 Construction

3.2.1 Structural

For long term bank stabilisation, the use and correct placement of toe rock is critical. This rock is the key point in protecting and supporting the upper bank rockwork. The toe rock must be keyed into solid in-situ ground. This must be to a minimum 50%, but can be up to 75% of the rock diameter. Even to the extent of what I refer to as the 'iceberg principle' - what you see is only the minor proportion of what you get!

For the freeway realignments of Koonung Creek, 1.2 to 1.5 metre diameter rocks were used. The weight of the rock was an important factor in addressing localised bank pressure points which would occur as the creek sought to re-establish its own equilibrium during periods of high flow and for the inescapable vagaries of achieving 100% fully locked structural integrity. There was a need to minimise the potential for localised failure and subsequent rework. The toe rock was critical in being able to achieve this.

Completed realignment downstream of Elgar Rd

The placement of the toe rock was staggered in order to maximise the points of contact and improve interlocking between rocks. This also resulted in variations of surface heights between rocks, which contributed to the final overall visual appearance.

Bank slopes were varied. The maximum slope allowed was 1.5 horizontal to 1 vertical due to the tight site constraints, with a preferred slope of 2 to 1 or flatter. Bank rock sizes for realigned sections were specified from 0.9 to 1.2 metre diameter. For general stabilisation works the rock size reduced to a range of 0.45 to 0.9 metre diameter. Localised erosion control of existing banks adopted fully graded rock placed on the bank, to a minimum thickness of 1.0 metre. The requirement to lock the rocks into one another means that best fit will produce surface variations and as well, quicken the actual laying process, as compared to past practices of laying adjacent rocks to a uniform level and finished surface.

With these similar methods, it is imperative the voids in and around the rocks are infilled to ensure long term structural integrity. With placed rock this is done through the use of what is referred to as 'shot rock'. This is a quarried material collected from the floor of the quarry after blasting and consists of fines through to a maximum 150 mm diameter. This is used progressively to ensure any cavities or overexcavation are fully filled at the time of the rock placement. Excavated site soil is not sufficient as a stand alone medium to be used in filling around the placed rockwork as during periods of high flow when the rockwork becomes submerged, the soils become saturated and readily wash away, with resultant voids remaining. The next high flow results in the water more readily entering the rockwork, due to the voids, with further wash out of base material. Eventually the on-going process can cause localised failure. It should be noted that shot rock is a sacrificial medium and there will be some loss occurring until the creek equilibrium is established with successive high flows. However, the majority of shot rock does lock-in sufficiently to stop the voiding process. Laying bank rockwork separately first, and then attempting to follow-up and fill the 'in between' voids by sprinkling the shot rock over the top of the completed rockwork does not achieve the same long term result. Material tends to be wasted by being more readily washed away and the critical out of sight voids behind the rocks are not properly filled.

The final finishing off of the in between voids included a 50/50 soil/mulch component with the shot rock, to assist revegetation.

3.2.2 Aesthetic

It is most important that the final product of 'soft engineering' is a visually attractive and strongly inclined to the 'soft' and not 'engineered' component. The aim is to attempt to achieve a 'naturalness' which might reasonably relate to former conditions and the unaffected surrounding area.

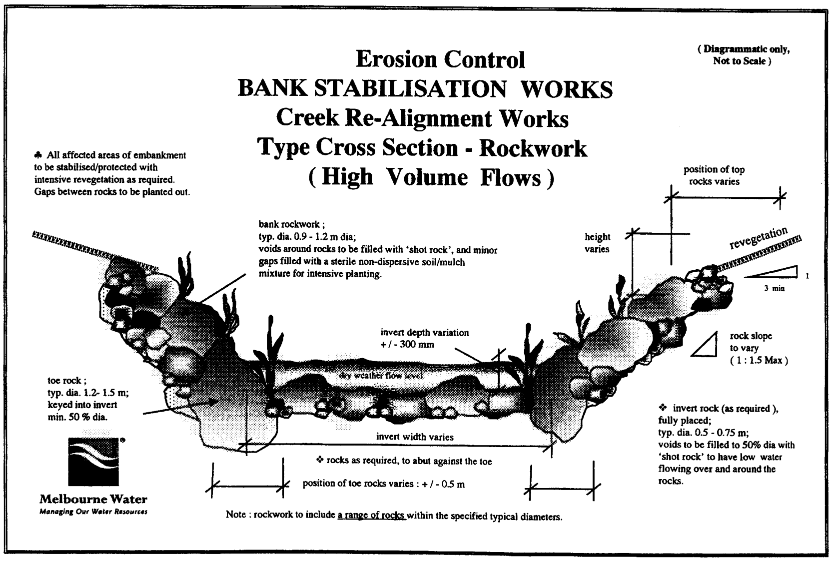
This can be achieved by (Refer Fig 1):

◊ generating a 3-dimensional variation to the cross-sectional and longitudinal placement of the rockwork per :

- bed width (toe rock placement);
- varying bank slope (including rock size); and
- varying the height of rockwork up the bank.

It was important that the operator understood the expected outcome for a finished 'natural' appearance. In order to effectively achieve this, it was preferable that there was a person working as a 'spotter', to overview and direct the operator on manipulation of the

Figure 1 : General Type Section for Creek Realignment



rocks to ensure satisfactory placement. Not every rock picked up for the next placement is going to necessarily be the correct one to readily drop into place. This sometimes requires that the rock is removed, turned around, or sometimes discarded for another rock to provide a better fit. This is where the spotter can assist the process. If a spotter is not used, then the operator needs to regularly get out of the excavator and take a closer look at what has been done - especially at a distance and/or from the opposite bank. Viewing the work area only from the cabin of the machine gives a different perspective to the rock placement that can affect the perceptions of the finished product. To this end, continuity in works programming and the use of more experienced contractors generated an improved end product.

Localised stabilisation requirement at Valda Ave

Where bed rockwork was required on the fully realigned sections, there was a need to ensure that the finished product had water flowing over and around the rocks and not underneath. Bed stabilisation had rockwork laid at varying finished surface levels between rocks, in an attempt to ensure a continuous connection of 'low points' within the bed, for creation of a dry weather flow path. This was the only practical way to try and generate a low flow channel.

Areas of existing natural rock were encountered. These were basically left and utilised in their natural condition. Realignment requiring full excavation through reef, was carried out by breaking or ripping techniques that were done in a non-uniform fashion, ie 'over' and/or 'under break' of the rockwork was accepted as part of the process, to encourage the aspect of a random surface appearance.

Where there was some lateral flexibility, rockwork height was varied and the banks laid back. This preferred option allowed for greater flexibility in the overall visual amenity of the finished product and led to a reduction in the amount of rock used. (Refer Fig 2).

3.2.3 Environmental

For bed and bank stabilisation works, there is the potential for a significant detrimental impact upon water quality. This needs to be minimised. The link is mainly in resultant turbidity and sediment loads. and an initial lack of site water quality management resulted in downstream flows having varying levels of turbidity and sediment loads.
The eventual formulation of a site environmental management plan ensured the correct planning for addressing water quality issues. This included such items as sediment traps of straw bales and filter cloth being placed prior to the commencement of in-stream works. These needed to be regularly maintained, with the straw bales and filter cloth being changed as required. Stockpiled spoil was to be kept clear of the top of bank and run-off from adjacent disturbed surface areas was to be controlled by the use of spoon drains and silt fences. Daily water sampling was utilised to monitor the effectiveness of the control measures.

Revegetation was an essential element of the stabilisation works. The associated desired outcomes relate to :

- ◊ erosion control and bank stability
- ◊ provision of habitat
- ◊ microclimate moderation
- ◊ reduced long term maintenance costs
- ◊ improved community perceptions and involvement.

Appropriate species can include aquatic macrophytes, sedges, herbs, woody shrubs and trees. It is most important that these plantings become sufficiently established in amongst the rockwork, to visually 'soften' the overall appearance.

Completed stabilisation at Valda Ave

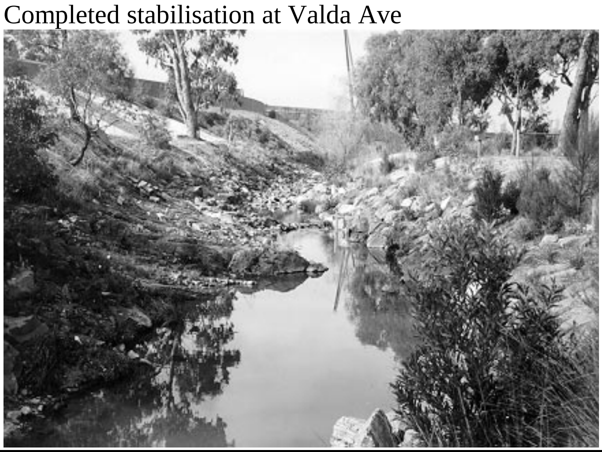
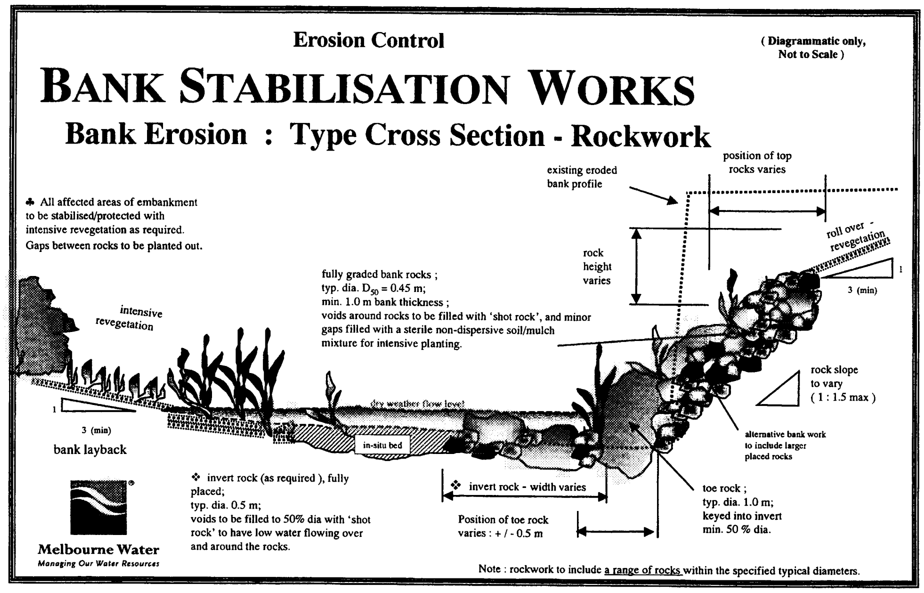


Figure 2 : Type Section for Localised Bed and Bank Erosion



For the case study, all bed and bank areas subject to works, required intensive revegetation. Extensive mulching of the upper banks and a 3-year follow-up maintenance program, was put in place to ensure establishment of plants and to control weed infestation.

4. CASE STUDY SUMMARY RELATING TO ROCKWORK STABILISATION:

- The 'soft engineering' option can be successfully implemented to achieve the required structural, aesthetic and environmental outcomes for major realignments and erosion control of urban waterways;
- Ensure the preferred outcomes for creek remediation are understood by the designers and contractors and there is experience and skill of those directly involved with practical implementation (especially the actual plant operators);
- For large scale works, in the initial stages work closely with the contractors to produce a sample/test section of bed and bank stabilisation rockwork. This can then act as a benchmark and reference section for subsequent works;
- Provide on-going liaison, discussion and regular site review to ensure outcomes by all parties are being achieved. For rockwork bed and bank stabilisation shortcomings, it will be either expensive or impractical to rework, or the final product will be of a compromised standard.

5. CONCLUSION

Melbourne Water's preferred urban waterway management is to address the range of issues that impact on the bed and banks, so as to minimise any effects. Where there is no alternative solutions and bed and banks are affected, then there is a need to try and generate as natural a waterway as possible.

However, this will not just happen. It is vital that there is adequate explanation and understanding of the underlying principles for works and what are the required outcomes.

6. REFERENCES

[1] Standing Committee on Rivers and Catchments, Victoria (1991)
'Guidelines for Stabilising Waterways'