A (not so) beginner's guide to waterway rock installation

Elsa Burnell[1], Greg Peters[2], Nicholas Kerr[3] and Penny Rogers[4]

1 Water Technology, Melbourne, VIC, 3168. Email: elsaburnell@watertech.com.au

2 Riverness, Torquay, VIC, 3228. Email: greg@riverness.com.au

3 Melbourne Water, Melbourne, VIC, 3001. Email: nicholas.kerr@melbournewater.com.au

4 Melbourne Water, Melbourne, VIC, 3001. Email: penny.rogers@melbournewater.com.au

Key points

- In circumstances where waterway rock installation, such as grade control structures (rock chutes) or waterway bank protection rockwork (rock beaching), is required, the performance of these structures depends not only on rigorous engineering design but also on correct installation.
- Historically, knowledge of proper installation techniques has been held primarily by experienced field staff and contractors, and as such has become vulnerable to workforce turnover and retirement.
- This project aimed to capture, consolidate and formalise that practical expertise to ensure Melbourne Water's rock installations align with industry best-practice and deliver strong geomorphic and environmental outcomes.
- Key project stages included: (1) Establishing best-practice installation techniques through a review of available literature and expert interviews; (2) Reviewing Melbourne Water's current standard drawings and installation practices; and (3) Developing installation guidelines and updated standard drawings.
- The resulting guidelines represent the first known attempt to document installation knowledge traditionally held only by experienced practitioners, and will support more consistent and robust waterway rockwork installation across Melbourne Water's region.

Abstract

Engineering interventions are rarely the preferred option for contemporary waterway management. Despite this, there are situations where structural solutions, such as grade control structures or bank protection rockwork, are the only viable means to protect assets or manage geomorphic risks. When such rockwork is required, the performance of the structures depends not only on rigorous engineering design, but also on correct installation. Many failures of rock structures can be attributed to sub-optimal installation and finishing techniques, rather than design deficiencies. Historically, waterway rockwork installation has often relied on the knowledge of experienced field staff and contractors. This knowledge is rarely documented and therefore vulnerable to workforce turnover and retirement. This project aimed to capture, consolidate and formalise that practical expertise to ensure future Melbourne Water rock installations align with industry best-practice and deliver strong geomorphic and environmental outcomes.

Key stages of the project included: (1) Establishing best-practice installation techniques through a review of available literature and expert interviews, noting that most literature focuses on design rather than installation; (2) Reviewing Melbourne Water's current standard drawings and installation practices with reference to established best-practice; and (3) Developing installation guidelines and updated standard drawings for grade control structures (rock chutes) and waterway bank protection rockwork (rock beaching).

The installation guides produced in this project represent the first known attempt to document installation knowledge traditionally held by experienced practitioners. Both the guidelines and drawings will support more consistent and robust waterway rockwork installation across Melbourne

Water's region and provide a valuable best-practice resource for waterway practitioners across Australia.

Keywords

Waterway Management, Waterway Rock Installation, Grade Control Structure, Waterway Bank Protection Rockwork, Rock Chute, Rock Beaching

Introduction

Project background

Although hard engineering interventions are no longer the preferred option for waterway management (DEECA, 2024), there are situations where structural solutions, such as grade control structures and waterway bank protection rockwork, are the only viable means to protect assets or manage geomorphic risks. When such interventions are required, their performance depends not only on rigorous engineering design but also on correct installation, and accurate interpretation and understanding of design documents.

In the Melbourne Water region, waterway rockwork installations are often completed by external parties, who may not have substantial best-practice experience in installing waterway structures. As such, guidance documents are essential to ensure proper installation. Prior to this project, the primary guidance on waterway rock installation at Melbourne Water was provided by four standard drawings (the MW Standard Drawings), these being:

- 7251_08_101 Bank Stabilisation for Embankment less than 1 in 1.5 (Standard)
- 7251_08_102 Bank Stabilisation for Embankment greater than or equal to 1 in 1.5 (Standard)
- 7251_08_104 Rock Chute (Standard)
- 7251_08_118 Bank Protection at Bridge Crossing (Standard)

These drawings deal predominately with design features, and there is little guidance on correct installation techniques, or interpretation of the design features and material specifications.

Project purpose

To address the identified need, this project aimed to capture knowledge held by experienced waterway practitioners, both within Melbourne Water (MW) and across Victoria, and use this knowledge to:

- review and update existing guidance on rockwork installation at Melbourne Water; and
- develop additional guidance resources for waterway rockwork installation at Melbourne Water.

Methodology

Key project stages included the following:

1. Establishing best-practice installation techniques through a literature review and expert interviews.
2. Reviewing Melbourne Water's current standard drawings and installation practices.
3. Developing installation guidelines and updated standard drawings for grade control structures (GCS) and waterway bank protection rockwork (WBPR).

Stage 1 commenced with a literature review, including consideration of the following key documents:

- Technical Guidelines for Waterway Management (DEECA, 2024)
- Guidelines for the Design of River Bank Stability and Protection using RIP-RAP (RIPRAP, 2004)
- Guidelines for the Design of Rock Chutes using CHUTE (Keller, 2003)
- Guidelines for the design, approval and construction of fishways (O'Connor, 2017)

While the above documents are aimed primarily at the design of waterway structures, some information is also provided on installation techniques and commonly observed failure modes that relate to both poor design and suboptimal installation.

During Stage 1, interviews were also conducted with experienced Melbourne Water delivery staff and Catchment Management Authority (CMA) staff from across Victoria. Interviews were conducted on MS Teams, over a period of 1 – 3 hours. Key discussion topics included:

- key structural features of grade control structures and waterway bank protection rockwork;
- commonly observed failure modes;
- interpretation of design drawings;
- interpretation of materials specifications;
- materials sourcing and quality assurance;
- site preparation;
- installation processes and sequencing; and
- demobilisation and finishing checks.

In Stage 2, Melbourne Water's existing guidance on rockwork installation was reviewed and compared to the best-practice approaches established in Stage 1. This included consideration of the MW Standard Drawings, and recent installation examples provided by the Melbourne Water project team.

During Stage 3 of the project, installation guides and updated standard drawings were developed based on the findings of Stage 1 and 2.

Key findings and outputs

Stage 1: Establishing best-practice

Stage 1 found that a relatively consistent set of best-practice installation techniques exists within the waterway industry, despite the lack of documentation in official literature.

It was noticed during Stage 1 that there was some overlap between what was considered a design element and what was considered an installation practice. This was particularly true for WBPR, which has a number of established 'rules-of-thumb'. To capture this knowledge, the final installation guides included sections on *Design Checks* and *Structure Geometry*. These sections provide a fundamental understanding for novices to waterway rockwork installation, and assist with the important sense and practicality checks that experienced practitioners complete before installation. The potential overlap between design and installation decisions is important to keep in mind when interpreting the findings presented below.

Topics that received general consensus

Waterway Bank Protection Rockwork (Rock Beaching):

- Rock type, shape and description (rough, angular, appropriate hardness and size variation as specified).
- The importance of proper rock handling in retaining integrity of the size mix.
- Rock size should be determined by design; however actual installed rock size is often limited by availability. This limitation should be flagged early in the design process.
- A finished slope of no steeper than 2H:1V is ideal.
- Determining suitable tie in points up and downstream or rock beaching is essential to success. This typically needs to be determined onsite and include consideration of factors such as vegetation, bank angle changes, angle of attack and re-entry points.
- Toe protection is essential, but construction can be challenging and limit options.
- Prior to rock placement, the bank should be cut back to the required slope, rather than infilled. If infill is unavoidable, it should be completed with rock of the same specification as the main structure.
- Prior to bank shaping, topsoil should be scraped back, saved, and spread over the top section of rockwork during finishing (this aids connection to bank and facilitates vegetation establishment).

- Rock should be placed not tipped.
- Excavator(s) should typically sit on the top of the bank while placing rock.
- Surface roughness should reflect the size variation of the rock mix. Effort should not be made to create a perfectly smooth surface.
- Supplementary fencing and revegetation are essential for success.

Grade Control Structures (Rock Chutes):

- Rock type, shape and description (rough, angular, appropriate hardness and size variation as specified).
- The importance of proper rock handling in retaining integrity of the size mix.
- Rock size should be determined by design; however actual installed rock size is often limited by availability. This should be flagged early in the design process.
- Crest is typically constructed to the width of an excavator bucket.
- Installation would typically start at crest in larger waterways that have not been dewatered. Can start at apron in a small or low flow waterway.
- Surface roughness should reflect the size variation of the rock mix. Effort should not be made to create a perfectly smooth surface.
- It is important to check the crest for even and consistent flow before demobilising from site.
- Supplementary fencing and revegetation are essential for success.

Topics that received varying opinion

Grade Control Structures (Rock Chutes):

- Installation techniques for filter cloth. This can be very challenging to install, and most practitioners had attempted multiple strategies.
- Need for dewatering to install. Options on dewatering were observed to vary based on regional geography and associated feasibility and cost.

Commonly observed failure mechanisms were also considered during this stage. A thorough understanding of failure mechanisms (both within Melbourne Water and in the broader waterway industry) was important to inform which structural elements and installation practices were most important to emphasise in the guidelines. Examples of commonly observed failure modes are discussed as part of the Stage 2 findings.

Stage 2: Reviewing MW current practice

The first task in this stage was to identify common failure mechanisms of rock installations in the Melbourne Water region, via interviews with experienced staff and a review of existing installations.

MW staff identified the following key failure mechanisms for WBPR:

- Incorrect rock gradation, such as the use of single sized rock, with small fill placed in voids (Figure 1).
- Insufficient lead in and lead out length (to adequately cater for angles of attack).
- Inappropriate use of filter cloth (leading to rock sliding failures).
- Infilling of bank (building into the channel) due to space constraints (Figure 2).
- Overly steep rock bank face, typically due to space constraints (Figure 1 and Figure 2).

MW staff identified the following key failure mechanisms for GCS:

- Incorrect rock gradation, such as the use of single sized rock, with small fill placed in voids (Figure 1).
- Undersized or single sized rock.

- Rock displacement in the apron (e.g. from continued bed deepening downstream, from low tailwater leading to hydraulic jump occurring on or downstream of the apron), leading to a cascade effect of rock displacement up the structure.
- Outflanking due to poor rock placement, insufficient extent/depth of crest cut-off into the banks or insufficient rock extent along banks (upstream and downstream).
- Localised areas of smaller rock size, due to supplied rock not being to specification, unintentional separation of size classes during rock delivery or intentional separation of size classes during installation.
- Chute grade being too steep.
- Poor consolidation of structure around concrete cut-off walls.

Figure 1 Waterway rock installations showing use of predominately single sized rock, placed to create a smooth surface and infilled with small gravels. LHS image also shows bank slope significantly steeper than 2H:1V

Figure 2 Waterway bank protection rockwork showing use of predominately single sized rock, slope steeper than 2H:1V and building-out into channel

Similar failure mechanisms to those discussed above were noted in the industry interviews and literature review (Stage 1) with the addition of:

- Insufficient vegetation establishment around structure post works.
- Unintentionally concentrated flow paths down rock chutes.
- Inexperienced machinery operators.

The second task in this stage was to review the existing MW Standard Drawings. This review found that some elements did not reflect current industry best-practice, and could potentially be linked to the observed sub-optimal installations. For example, drawing *7251_08_101 Bank Stabilisation for Embankment less than 1 in 1.5 (Standard)* shows a scour hole in-filled with structural clay (or rock) (Figure 3Figure) and drawing *7251_08_102 Bank Stabilisation for Embankment greater than or equal to 1 in 1.5 (Standard)* allows for slopes steeper than 1V:1.5H, and shows large single sized rocks with voids infilled by small graded rock (Figure 4).

Based on the review, it was determined that the existing MW Standard Drawings required updating to align with the proposed best-practice installation guides, and ensure consistency of documentation.

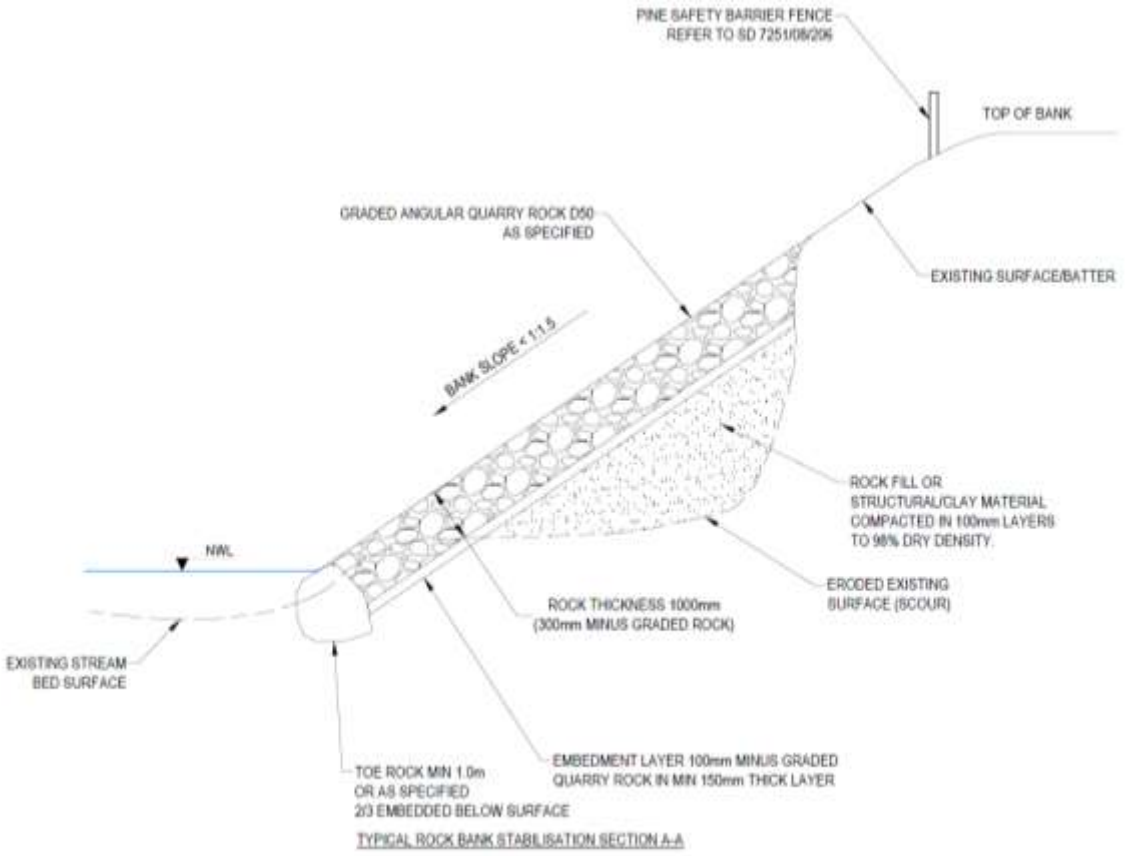

Figure 3 Excerpt from 7251_08_101 Bank Stabilisation for Embankment less than 1 in 1.5 (Standard), showing scour hole can be infilled with structural clay (Melbourne Water, 2018)

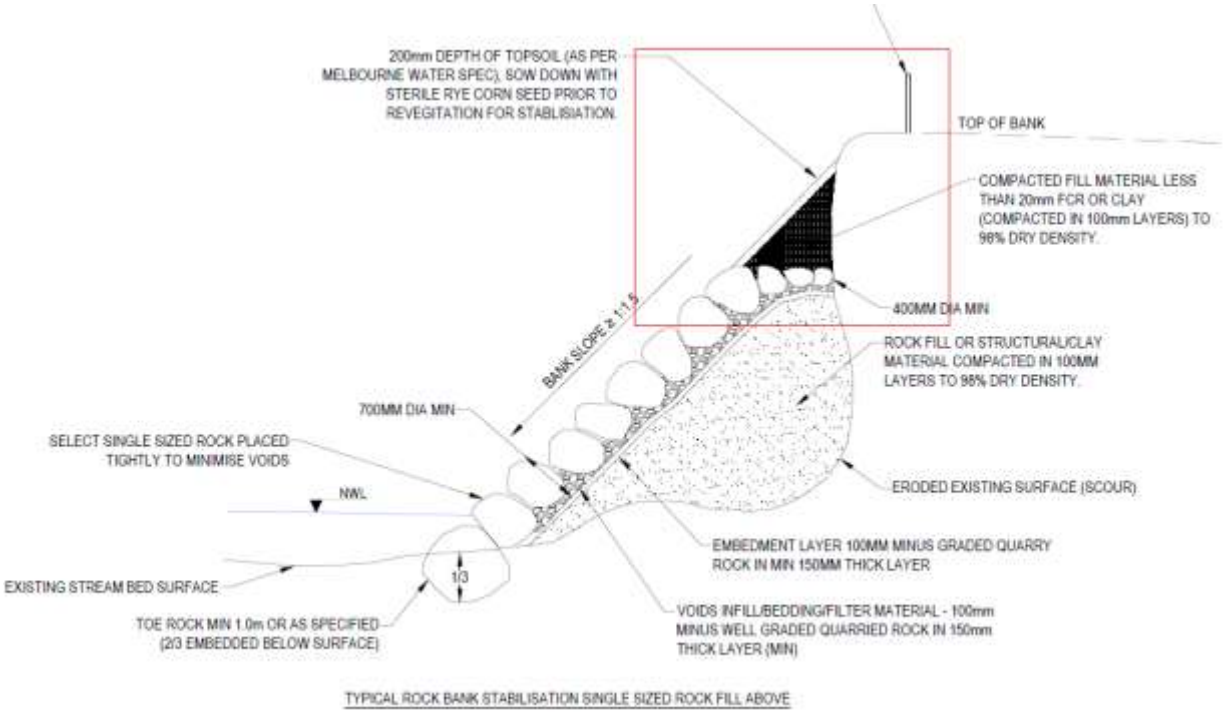

Figure 4 Excerpt from *7251_08_102 Bank Stabilisation for Embankment greater than or equal to 1 in 1.5 (Standard)* showing steep slope and large single-sized rocks with graded rock infill (Melbourne Water, 2018)

Stage 3: Installation guidelines and updated standard drawings

In Stage 3, the following documents were developed based on the findings from the previous stages:

- MW Waterway Bank Protection Rockwork Installation Guideline.
- MW Grade Control Structure Installation Guideline.
- Updated MW Waterway Bank Protection Rockwork Standard Drawing.
- Updated MW Rock Grade Control Structure Standard Drawing.

The examples below have been included to demonstrate the type of content available in the developed documents.

Figure 5 shows an excerpt from the updated MW WBPR Standard Drawing, which demonstrates the preferred option to achieve desired bank slope. The accompanying guideline includes the following associated description in the *Bank preparation* section:

"Where waterway bank faces are steep and site constraints are minimal, it is best practice to batter the bank to a design grade before placing rock. This will provide significant savings in the quantity of rock required and avoid rock protruding into the channel (refer Section A (Option 1) in MW Waterway Bank Protection Rockwork Standard Drawing).

In instances where banks are excessively high and steep, or assets are close to the bank edge, bank battering can become problematic. In these instances, other site preparations or WBPR designs may be required." (Melbourne Water, 2026).

The above documents have been made available on the Melbourne Water website for use and reference by external parties. It is noted that the updated standard drawings are not intended to replace site specific engineering design, but rather as a guide to common design features and rules-of-thumb.

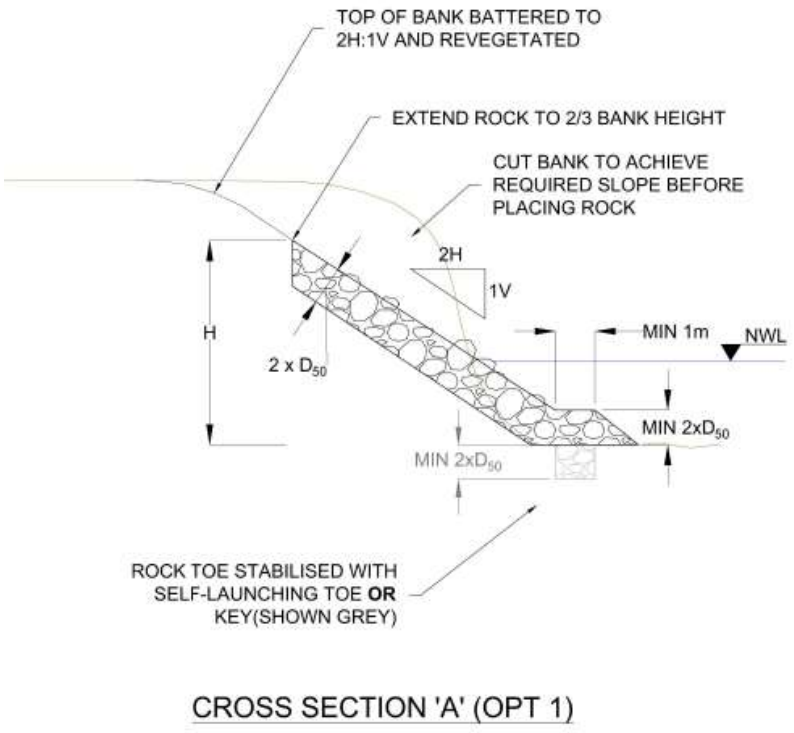

Figure 5 Excerpt from updated MW WBPR Standard Drawing showing best-practice option for achieving desired bank slope (Melbourne Water, 2026).

Summary and conclusions

Knowledge of proper installation techniques for waterway bank protection rockwork (rock beaching) and grade control structures (rock chutes) in Victoria has historically been held predominately by experienced field staff and contractors, despite this knowledge being essential to the success and longevity of waterway rockwork installation. This project aimed to capture, consolidate and formalise that practical expertise to ensure Melbourne Water's rock installations align with industry best-practice and deliver strong geomorphic and environmental outcomes. Project outputs included a review of current practice at Melbourne Water, updated standard drawings for grade control structures and waterway bank protection rockwork, and installation guidelines that represent the first known attempt to document installation techniques for waterway rockwork in Victoria.

Acknowledgements

The project team would like to acknowledge Melbourne Water for funding the project, and the Melbourne Water staff and industry experts (MW and CMAs) who generously provided their time, knowledge and expertise.

References

DEECA. (2024). *Technical Guidelines for Waterway Management*. Retrieved from https://www.water.vic.gov.au/waterways/technical-guidelines-for-waterway-management

Keller, R. J. (2003). *Guidelines for the Design of Rock Chutes using CHUTE*. Retrieved from https://toolkit.ewater.org.au/Tools/CHUTE/documentation

Keller, R. J. (2005). *Guidelines for the Design of River Bank Stability and Protection using RIP-RAP*. Retrieved from https://toolkit.ewater.org.au/Tools/DownloadDocumentation.aspx?id=1000145

Massachusetts Department of Environmental Protection. (accessed 13 May 2025). *Riprap*. Retrieved from https://megamanual.geosyntec.com/npsmanual/riprap.aspx.

Ministry for the Environment, NZ. (2024). *New Zealand Fish Passage Guidelines*. Retrieved from https://niwa.co.nz/freshwater/fish-passage-home/new-zealand-fish-passage-guidelines .

Melbourne Water. (2018). *7251_08_101 Bank Stabilisation for Embankment less than 1 in 1.5 (Standard)*. Retrieved from https://www.melbournewater.com.au/media/eyJtZWRpYSI6IjQ2NSJ9/downloads

Melbourne Water. (2018). *7251_08_104 Rock Chute (Standard)*. Retrieved from https://www.melbournewater.com.au/media/eyJtZWRpYSI6IjQ2OCJ9/downloads

Melbourne Water. (2026). *Grade Control Structure Installation Guide*. Retrieved from https://www.melbournewater.com.au/media/eyJtZWRpYSI6IjMxMjA2In0%253D/downloads

Melbourne Water. (2026). *7251_08_101 Waterway Bank Protection Rockwork Standard Drawing*. Retrieved from https://www.melbournewater.com.au/media/eyJtZWRpYSI6IjMxMTk2In0%253D/downloads

Melbourne Water. (2026). *7251_08_104 Grade Control Structure Standard Drawing*. Retrieved from https://www.melbournewater.com.au/media/eyJtZWRpYSI6IjMxMjAxIn0%253D/downloads

Melbourne Water. (2026). Waterway Bank Protection Rockwork Installation Guide. Retrieved from https://www.melbournewater.com.au/media/eyJtZWRpYSI6IjMxMjExIn0%253D/downloads

O'Connor, J. Stuart, I. & Jones, M. (2017). *Guidelines for the design, approval and construction of fishways*. Retrieved from https://www.ari.vic.gov.au/__data/assets/pdf_file/0025/123397/ARI-Technical-Report-274-Guidelines-for-the-design-approval-and-construction-of-fishways.pdf