Watercare
An Auckland Council Organisation

Engineering Standards Framework

Risk Based Construction Monitoring

Version. 1

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0.5	Working draft	David Ward	20/06/2017
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The latest version of this document takes effect on the date of release on all new work and supersedes all prior versions or formats of this document.

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Definitions

ITP	Inspection and Test Plan, typically the QA/QC process employed by the contractor to manage quality compliance
Construction Monitoring Engineer	A Developer or Watercare's representative(s) responsible for monitoring construction quality and deliverables. This may be an in-house project engineer, or a consultant. There may be multiple construction monitoring engineers for a single project covering off varying engineering disciplines.
Engineer	Engineer to the Contract
Designer	Design engineer, typically services of a consultant engineering firm, responsible for designing the infrastructure that is constructed under the construction contract. **NB** specific guidance is given by Worksafe with respect to Persons Conducting a Business or Undertaking (PCBUs) with 'upstream' duties under the Health and Safety at Work Act 2015, viz: http://www.worksafe.govt.nz/worksafe/information-guidance/all-guidance-items/position-statements/documents/upstream-pcbus.pdf
Framework	The Risk Based Construction Monitoring Framework described in this document.
Compliance Statement	As described in the Watercare Compliance Statement Policy

1 Introduction

Construction monitoring is a key feature of the quality control process during delivery of physical construction works. Monitoring during construction presents the best opportunity to ensure that the works conform to relevant standards and project particular specifications, and allow early identification to rectify of any non-conforming work.

1.1 Purpose and Scope

The purpose of the Risk Based Construction Monitoring framework is to ensure that monitoring of Watercare's construction projects is conducted using a tailored and structured approach, with an appropriate measure of competence aligned with the specific risk profile agreed for each particular component of the works.

1.2 Applicability

This framework is applicable to all Watercare construction projects.

Also, this framework shall be read in conjunction with the Watercare Compliance Statement Policy, and Engineering Standards Framework.

1.3 ACENZ/IPENZ Construction Monitoring Guidelines

This framework has been developed as an alternative to the existing ACENZ/IPENZ Construction Monitoring guideline as it provides direction regarding the different levels of criticality or complexity associated with construction and how to assess these factors.

The ACENZ/IPENZ guidelines should still used for land development with a uniform low level of criticality.

This Framework provides the designer and Watercare with an opportunity to make an informed and accurate consideration of the criticality of the components of the design, and determine the appropriate level of professional competency required to monitor and validate those components during construction.

2 Risk-based Construction Monitoring Framework

The Risk-based Construction Monitoring Framework assesses the consequence of non-compliance and identifies the most appropriate level of competence to undertake the construction monitoring. Consequently, the main characteristics of the framework are:

- To be inclusive of both traditional design and monitor contracts and design & build contracts,
- To be inclusive of all Watercare assets and processes,
- To provide flexibility,
- To align with national and international recognised measures of competency and professionalism,
- To define accountabilities and responsibilities for all parties throughout the delivery process,
- To ensure efficient use of resources,
- To facilitate lessons learned between designer / contractor and Watercare to ensure well executed works are being delivered to Watercare's customers.

The framework has three components relating to the design, procurement and execution stages of normal project delivery.

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Figure 1 outlines the key elements of the framework.

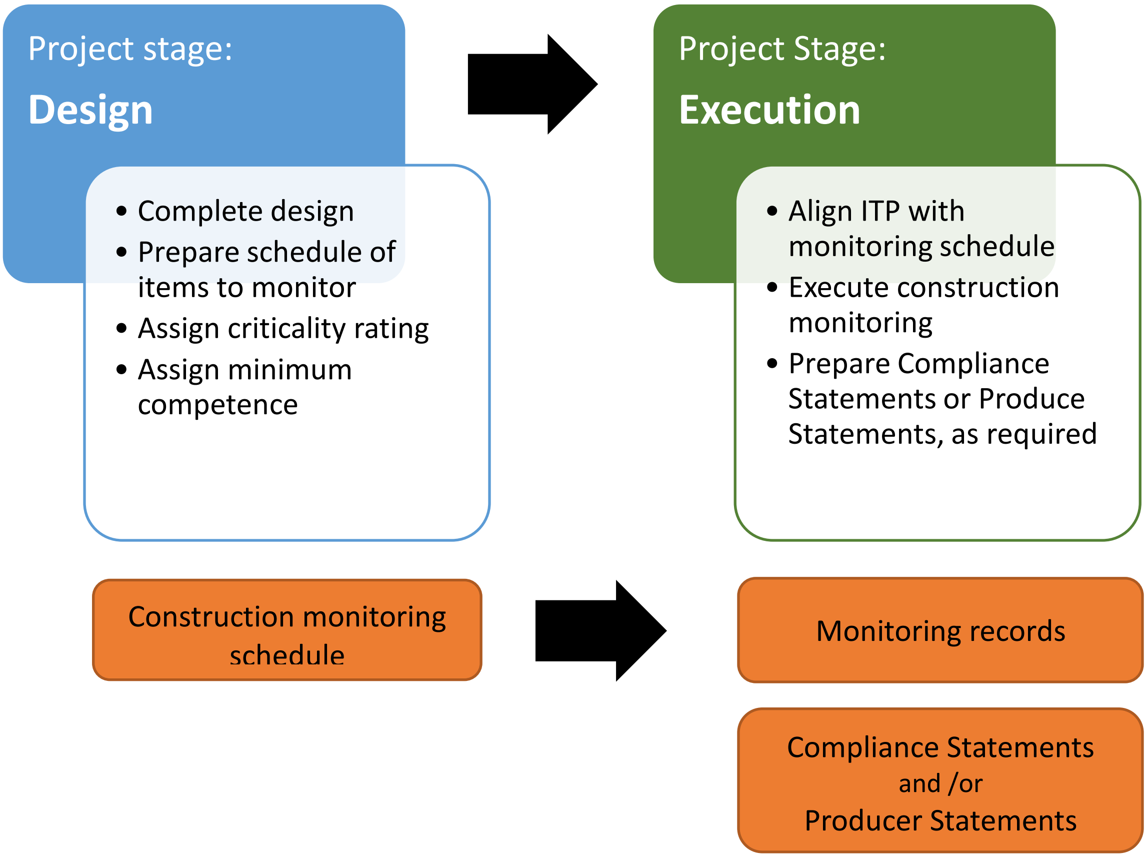

Figure 1; Key Elements of Risk-based Construction Monitoring Framework

The main factors that comprise the framework are:

- **Criticality** – assessing the consequences/impact of the construction not complying with the intended design specification.
- **Competence** – determining what level of competence is required to monitor the construction.
- **Record of execution** – using predefined forms to record the construction monitoring, and making progress payment dependent on issuing of completion certificates.

The framework accommodates traditional procurement, as well as design & build. Construction quality starts at the design stage when standards and tolerances are specified. A key component of the framework is to better integrate the role of the designer and place increased responsibility on them to assess and convey which elements and components of their design require full compliance (minimum tolerance) and any assumptions dependent on site conditions.

The completed construction monitoring schedule will define the minimum level of competence required for checking the various elements. This will allow improved resource planning ahead of construction.

The construction monitoring schedule will be reviewed against the final Contractor's construction methodology and inspection and test plan (ITP) to incorporate any modifications or alternate designs accepted during the works procurement. The construction monitoring schedule and the Contractor's ITP should be aligned, i.e. they should complement each other, but not duplicate each other.

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Execution of the construction monitoring will include completing a series of pre-defined monitoring records to ensure all necessary elements and components are checked. The construction monitoring records provide governance and to not duplicate the contractor's own inspection test plan procedures.

Upon completion of an element or component, the construction monitoring engineer or supervisor will issue a completion certificate. The completion certificate will reference the construction monitoring record(s), and where appropriate and applicable the contractor's inspection test plans. This shall also lead into and form a critical element for the signing of Watercare's Compliance Statement.

3 Design Stage Activities

The framework is to be initiated once the detailed design stage has been completed. If changes are made to the detailed design in later proceedings, the outcome of the framework must be revised.

3.1 Prepare Schedule of Items to Monitor

Upon completion of the design, the designer will be required to produce a construction monitoring schedule. This will comprise a list of items to be monitored, based on the element and component.

To illustrate how the framework is to work the following example has been compiled for the Rosedale Wastewater Treatment Plant's New Primary Sedimentation Tank 7 Pump Station (refer to Appendix B for design drawings).

Table 1; Example Monitoring Schedule

Reference	Element	Component
1.1.1	New PST 7 Pump Station	**Drainage Sump Structure**
1.1.2	New PST 7 Pump Station	**Drainage sump pumps**
1.1.3	New PST 7 Pump Station	**Drainage sump pipework**
1.1.4	New PST 7 Pump Station	**Drainage sump power & ICA**
1.2.1	New PST 7 Pump Station	**Formation**
1.2.2	New PST 7 Pump Station	**Structure**
1.2.3	New PST 7 Pump Station	**Pump plinths**
1.2.4	New PST 7 Pump Station	**Pump installation**
1.2.5	New PST 7 Pump Station	**Pipework & valves**
1.2.6	New PST 7 Pump Station	**Ventilation**
1.2.7	New PST 7 Pump Station	**Access & lifting**
1.2.8	New PST 7 Pump Station	**Utility water & wash basin**
1.2.9	New PST 7 Pump Station	**Pump power & ICA**

For particularly complex elements, it will be necessary to specify a more detailed level of components and break them down to more critical aspects.

Once the schedule is determined the designer will then assess criticality. In some cases, the same component description may have a different criticality, depending on where, or what, it is performing in the process e.g. for a given project not all pipework has the same criticality.

3.2 Assign Criticality Rating

Using a criticality assessment matrix the designer qualitatively assesses the consequence/impact of the construction not complying with the design and specification to determine a criticality rating. The noncompliance consequence/impact uses a series of categories:

- **Complexity:** the use of innovative and/or unproven technologies
- **Safety:** the potential risk to life or risk of injury, including legislative requirements and prosecution
- **Environmental:** risk and impact of a pollution incident, including legislative requirements and prosecution
- **Performance:** deterioration of operational performance of the asset
- **Asset life:** reduction in durability and design life
- **Rectification cost:** impact to the capital works cost and costs perceived by the public.
- **Programme delay:** impact to the capital works programme

A component could have multiple category impacts; the highest criticality recorded for a component defines the overall rating.

Four criticality classes have been defined as: 'Not Applicable (N/A)', 'Low', 'Medium' and 'High'. 'N/A' is for when no monitoring is required and the construction is based on standard details, with no foreseeable consequence from a construction non-compliance with the design.

A qualitative assessment has been chosen, as opposed to a quantitative assessment, to avoid adding further complexity. Adding further detail will also be unnecessary when defining the minimum supervision level.

Figure 3 outlines the criticality assessment matrix.

Criticality Rating	Consequence/Impact of non-compliance with Design					
	Safety	Environmental	Performance	Asset Life	Rectification Cost	Programme Delay
High	Risk to life	Major reportable pollution incident	Inoperable	Remedial work within 5 years	> 10% of works value	> 10%
Medium	Major Injury	Reportable pollution incident	Performance not achieved	Remedial work within 10 yrs	> 5% of works value	> 5%
Low	Minor Injury	Minor impact	Acceptable reduction in performance	Remedial work within 20 yrs	< 5% of works value	< 5%
Not Applicable	None	None	None	None	None	None

Figure 2; Criticality Assessment Matrix

3.3 Assign Minimum Competence

Having determined the criticality rating of any one component, the minimum monitoring competence level is determined.

The basis of the minimum monitoring competence is that a component assessed to be more critical, requires a more competent engineer to monitor the construction and confirm that it complies with the design. The following criteria have been used for assessing competence:

- formal professional or educational qualification;
- relevant experience in a specific practice area; and
- Relevant New Zealand experience.

The use of these criteria is to address the following scenarios:

- a recently qualified chartered engineer will have less competency than a qualified chartered engineer with 10 years' experience.
- an engineer with 15 years' experience in a specific practice area, who is not qualified as a professional engineer, could be more competent than a recently qualified professional engineer.
- a qualified water retaining structures engineer with 10 year's international experience, will have no competence in New Zealand seismic design.

The experience must be relevant to a practice area. This is noted in all international engineering institutes Code of Ethics and procedural constitution. Discipline has therefore been excluded; for example, a civil engineer with 10 years' experience of pumping stations could be more competent to assess the pipework, than a mechanical engineer with no experience of pumping stations.

To provide flexibility regarding a sufficiently large enough pool of suitably qualified engineers, and recognition of various international equivalent accreditations, the matrix allows different qualifications and experience.

The matrix includes provision for allowing recognised international engineering institution qualifications, of equivalent standing, in accordance with the Washington, Sydney and Dublin Accords.

Once the minimum monitoring competence level has been established, for a given component, the construction monitoring schedule can be finalised.

Figure 3 outlines the Monitoring Competence Matrix.

Level	Qualification	Experience in specific practice area (years)		
		> 10	> 5	< 5
		1	2	3
A	Professional (CPEng) with New Zealand experience	H	H	M
B	Professional (CPEng) [1]	H	M	M
C	Practitioner (ETPract) [1]	M	L	N/A
D	Technician (CertETn) [1]	L	L	N/A
E	NZQA Level 3	L	N/A	N/A

Figure 3; Minimum Monitoring Competence Matrix

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3.4 Final Construction Monitoring Schedule

The final construction monitoring schedule assigns a criticality rating and a minimum monitoring competence level to each element and its components.

Once the designer has completed the schedule it can then be approved by Watercare.

In the event the schedule is required to form part of the tender documentation, for procuring an independent construction monitoring engineer, the minimum competence needs to be specified to allow proposed staff to be assessed.

The schedule will need to be prepared in either a database or spreadsheet, to allow the data to be formatted for different outputs. Whilst it will be efficient for the designer to compile the schedule based on 'elements', the output will want to be categorised into 'minimum monitoring competence' in a specific practice area, to plan resources and monitoring records.

An example of a completed construction monitoring schedule for Rosedale Wastewater Treatment Plant new Primary Sedimentation Tank 7 Pump Station is presented in Table 3.

As more construction monitoring schedules are produced for elements, a library will develop to allow automation of the process and define benchmarks.

Design Item Reference	Element	Component	Criticality Rating	Category	Minimum Monitoring Competence in Specific Practice Area
1.1.1	New PST 7 Pump Station	Drainage Sump structure	Low	Asset Life	C2, D2, E1
1.1.2	New PST 7 Pump Station	Drainage Sump pumps	Low	Environmental	C2, D2, E1
1.1.3	New PST 7 Pump Station	Drainage Sump pipework	Low	Environmental	C2, D2, E1
1.1.4	New PST 7 Pump Station	Drainage Sump power & ICA	Low	Environmental	C2, D2, E1
1.2.1	New PST 7 Pump Station	Formation	Medium	Asset Life Rectification Cost	A3, B3, C1
1.2.2	New PST 7 Pump Station	Structure	Medium	Asset Life Rectification Cost	A3, B3, C1
1.2.3	New PST 7 Pump Station	Pump plinths	N/A		C3, D3, E2
1.2.4	New PST 7 Pump Station	Pump installation	Medium	Performance Programme Delay	A3, B3, C1
1.2.5[1]	New PST 7 Pump Station	Pipework & Valves	Medium	Performance Programme Delay	A3, B3, C1
1.2.6	New PST 7 Pump Station	Ventilation	Low	Environmental	C2, D2, E1
1.2.7[1]	New PST 7 Pump Station	Access & Lifting	High	Safety	B1, A2
1.2.8	New PST 7 Pump Station	Utility Water & Wash Basin	Low		C2, D2, E1
1.2.9	New PST 7 Pump Station	Pump power & ICA	Medium	Performance Programme Delay	A3, B3, C1

Figure 4; Example of Final Construction Monitoring Schedule

4 Execution

To support the execution of the construction monitoring, the construction monitoring supervisor or engineer will complete a monitoring record and a completion certificate for each component. This will form an important part of the overall process and without it there is a risk the process will not fulfil the objectives.

4.1 Execute Construction Monitoring

Construction monitoring records are to be filled out by the Monitoring Engineer.

The purpose of the monitoring record is to fulfil the following:

- ensure consistency across projects;
- produce a formal record for accountability and auditing;

- support and inform the completion certificate; and
- provide a means for Watercare to measure and benchmark the performance of contractors and consultants, and
- to inform future tender assessments.

For more simple elements, a single monitoring record may suffice. For more complex elements, with many components, a series of monitoring records will be required. Considering the possible different elements and components, a library of monitoring records will be required.

Based on Rosedale Wastewater Treatment Plant New Primary Sedimentation Tank 7 Pump Station, two example Construction Monitoring Records are presented in figures 5 and 6.

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Construction Monitoring Record

Pumping Station Valve Chamber Pipework

Sheet 1 of 2

Contract Details

Contract Name: Rosedale WWTP 25 Primary Sedimentation

Contract No: DTROS-25-G-T001

Contract Personnel

Project Manager:

Designer:

Construction Inspection Details

Schedule Ref: 1.2.5

Element: New PST 7 Pump Station

Component: Pipework and Valves

Criticality Rating: Medium

Minimum Monitoring Competence: A3, B3, C1

Inspector:

General Check List

No.	Description	Completed (Yes/No)	
1	Thrust blocks fitted to the valve chamber Pipework on the Tee sections & bends		
2	Thrust blocks, if fitted, cover half the Pipework		
3	Are flange adapters tied as necessary to resist thrust		
4	Sufficient space for the removal of adjacent fittings or bolts to allow removal for maintenance		
5	Valve chamber drainage installed and functional		
6	Correct grade of steel used for fittings		
7	Minimum distance between the pipe work and the walls within the chamber		mm
8	Minimum distance between the pipe work flange and the walls within the chamber		mm
9	Isolation valves located at appropriate operational height		
10	Pipework adequatly supported		
11	Adequate clearance to allow the removal of the pins from the reflux valves		
12	Reflux valves horizontally mounted, fitted with a removable top cover, and an external lever weighted arm		
13	Lever weighted arms guarded		
14	Provision of pressure monitoring been provided on each discharge pipe		
15	Pressure monitoring tapping have a valve and male plug installed		
16	Overpumping bauer within the chamber?		

Outstanding Works Record

No.	Description	Date Identified
1		
2		
3		
4		
5		
6		
7		
8		

Figure 5; Example Construction Monitoring Record Sheet 1

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Construction Monitoring Record

Pumping Station Access & Lifting

Sheet 1 of 2

<u>Contract Details</u>

Contract Name: Rosedale WWTP 25 Primary Sedimentation

Contract No: DTROS-25-G-T001

<u>Contract Personnel</u>

Project Manager: ____________

Designer: ____________

<u>Construction Inspection Details</u>

Schedule Ref: 1.2.7

Element: New PST 7 Pump Station

Component: Access & Lifting

Criticality Rating: High

Minimum Monitoring Competence: A2, B1

Inspector: ____________

Lifting Check List

No.	Description	Completed (Yes/No)	
1	Lifting apparatus provided and stored on-site		
2	Number of lifting apparatus provided		
3	Lifting apparatus installed		
4	Lifting apparatus tested		
5	Lifting apparatus Serial Number		
6	Lifting apparatus SWL		Kg
7	Can pumps be lifted out centrally		
8	Can valves be lifted out		

Access Check List

No.	Description	Completed (Yes/No)
9	Need to enter a confined space eliminated	
10	All voids and sumps securely covered	
11	All access covers have adequate vehicle/pedestrian loading rating	
12	Access covers can be safely open and operated	
13	Access has secondary safety net/bar	
14	Steps and platforms comply with specification	
15	Handrailing complies with design	
16	Correct grade of steel used	
17	Access walkways and handrailing fixed to structure appropriately	
18	Access walkway support columns and beams protected from vehicle impact	
19	Toe boards provided on walkways	
20	Walkway floor panels securely fastened and protected from sliding	

Outstanding Works Record

No.	Description	Date Identified
1		
2		
3		
4		

Figure 6; Example Construction Monitoring Record Sheet 2

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4.2 Compliance Statement

The Watercare Compliance Statement Policy is set out separately. The Compliance Statement is a certification of the construction monitoring work complying with the standard requirements and the specific design.

The construction monitoring records are supplied as evidence to the compliance statements. Without completed records the compliance statements are invalid.

5 Quality Control and Quality Assurance

Watercare's construction standards lists a number of minimum quality assurance and checks to be completed. These form the basis for developing the construction monitoring records.

The completed QA / QC records are provided by the contractor. Additional quality controls may be required by the construction monitoring engineer. Table 2 is provided as a template.

Table 2; QC and QA Template

Quality / Control		Measurement	Certification		
			Document supplied	Contractor/ Supervisor	Engineer witness
		Sign-off			

6 Testing

Quality control tests and inspections will be set out in the contractors ITP. The monitoring records will act as a check that those tests have been conducted properly.

7 Framework Competency

Irrespective of the form of contract adopted, it is fundamentally important that construction monitoring is fully integrated with the conditions of contract commercial terms and incentives.
Failure to comprehend this can result in poor behaviours and undermine the framework.

This construction monitoring framework is to be implemented in accordance with the NZS 3910:2013 conditions of contract for building and civil engineering construction, including its suite of supporting contracts e.g. NZS 3916 for Design and Construct.