HEALTH AND SAFETY – FROM PAPERWORK TO PRACTICE

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ABSTRACT

Safety professionals have a range of tools available to them to carry out safety studies. Many of these tools are aimed at the design phase, where safety is a key consideration, and mitigation can most readily implemented at minimum cost. Safety studies during the design phase typically consider the whole life cycle of the asset from construction through to operation, maintenance, and decommissioning / deconstruction of the asset.

This paper describes the challenges of translating the health and safety outcomes of paper-based studies into practical actions that must be carried out during construction, operation and maintenance. The paper draws on a case study from the Christchurch Wastewater Treatment Plant (CWTP), the trickling filters, which shows the value and necessity of undertaking hazard analysis and risk assessment studies throughout the life of a project.

There are various paper based studies that can be used at different stages throughout a project lifecycle to provide information on health and safety. During the design phase HAZOP and Safety in Design are effective methodologies. During construction Permit to Work paperwork combined with Job Safety Task Analysis methodology provides a platform for identifying and managing health and safety risk.

KEYWORDS (ARIAL, 11)

Health and Safety, Hazard, Risk, Operation and Maintenance, Job Safety Task Analysis, JSTA, Safety in Design, SiD

1 INTRODUCTION (ARIAL, 14)

Safety professionals have a range of tools available to them to carry out safety studies. Many of these tools are aimed at the design phase, where safety is a key consideration, and mitigation can most readily implemented at minimum cost. Safety studies during the design phase typically consider the whole life cycle of the asset from construction through to operation, maintenance, and decommissioning / deconstruction.

Commonly used methodologies for design phase safety studies include Hazard Identification (HAZID), Safety in Design (SiD), Hazard and Operability Study (HAZOP), and Risk Assessment, through to more formal Management of Change (MoC) and Layer of Protection Analysis (LoPA). All of these methodologies are paper-based and are undertaken in workshops, interviews or desk-top assessments. The studies typically involve identifying the hazards and assessing the associated risks. Controls are used to reduce the risk score to an acceptable value. The workhorse of health and safety during construction, as well as during operation and maintenance, is the Job Safety Task Analysis (JSTA). This methodology draws together the hazards, mitigation and associated risks from the design phase studies and applies them on a task by task basis to the activities that need to be carried out. Often new hazards are identified, associated with the actions required to carrying out individual tasks. The JSTA usually forms the basis of permit-to-work paperwork. When events do occur, these can be investigated using methodologies such as the Incident Cause Analysis Method (ICAM).

2 TRICKLING FILTER EARTHQUAKE REPAIRS AND MAINTENANCE – A CASE STUDY

2.1 BACKGROUND

2.1.1 PROCESS DESCRIPTION

The CWTP receives untreated wastewater and removes or reduces various contaminants through a series of processing steps, see Figure 1.

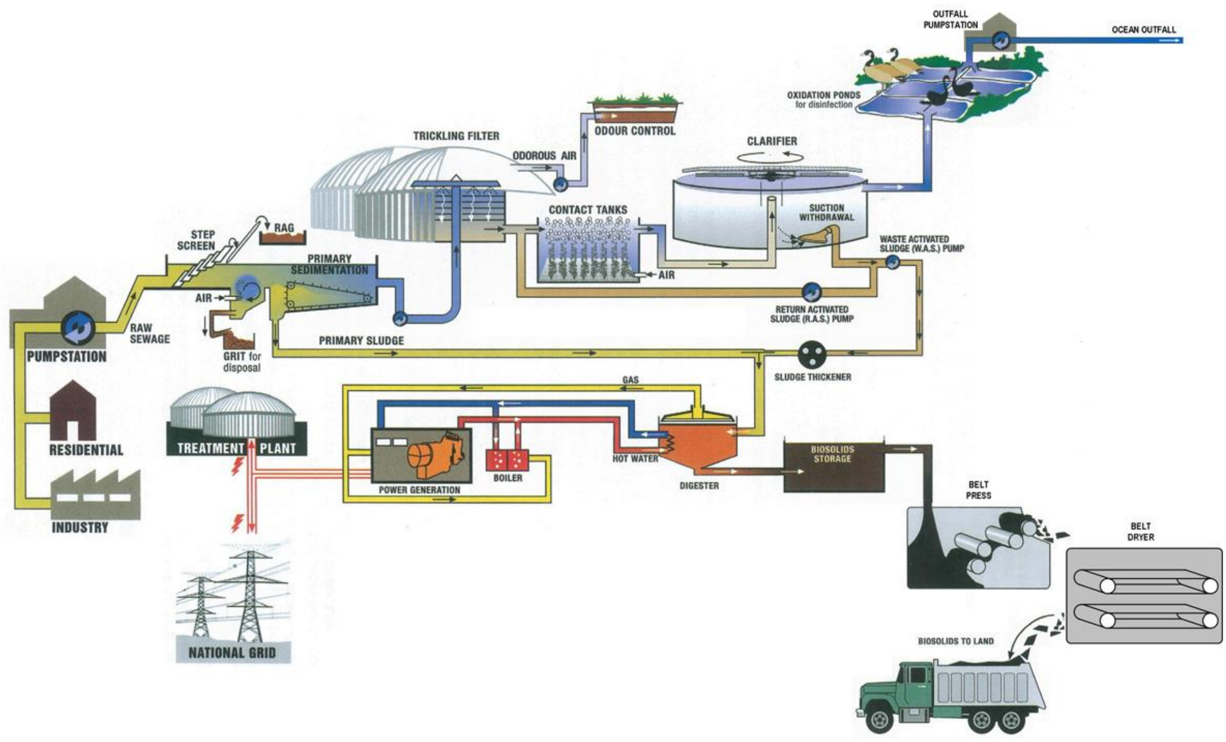

Figure 1: CWTP Process Flow Diagram Showing Key Unit Processes

Initially the wastewater passes through a 3mm gap screen to remove large items. Heavy solids such as sand and grit are then removed in the grit traps. The wastewater then flows into the primary sedimentation tanks, where lighter, organic solids settle more slowly. These solids are removed and are pumped to the solids processing train, where they are digested and biogas produced.

The overflow (primary effluent) from the primary sedimentation tanks is pumped to two trickling filters operating in parallel. These trickling filters are large fixed bed reactors, filled with structured, PVC packing. The primary effluent is sprayed over the top of the packing and trickles down through the packing to the bottom of the trickling filter where it is collected. Microorganisms grow in a biofilm layer on the surface of the packing material which sloughs off periodically. The biomass feeds on the dissolved organic compounds present in the primary effluent.

The treated primary effluent and sloughed biomass pass to the secondary contact tanks. Fine air bubbles encourage further biomass growth and also facilitate biomass agglomeration. These agglomerated biomass solids then settle in the next process, the secondary clarifiers. A portion of the solids from the clarifiers are recycled to the contact tanks (creating a short retention activated sludge process). Waste sludge is pumped to the solids processing train (with the primary settled solids). The clarifier overflow flows to the oxidation ponds for final polishing and disinfection via sunlight, prior to discharge via a 3km long ocean outfall.

2.2 BACKGROUND

The two trickling filters at the CWTP were constructed in 1976 and 1977. They are over 20m diameter and 10m high and were originally open topped vessels (see figure 2). Since this time both trickling filters have undergone several upgrades, including the construction of a top cover to enclose the vessels and protect the packing material for UV damage. The original distribution arms have been were replaced and the central tower upgraded.

The trickling filters are in constant operation and the adverse atmosphere inside the trickling filters limits access for maintenance and repair activities. However, the trickling filters are a critical part of the treatment process at the CWTP, where the secondary treatment takes place. As a result the trickling filters are typically only taken off line, one at a time, once a decade. Furthermore, both trickling filters were damaged during the Christchurch earthquakes of 2010 and 2011. The nature of this damage meant that the trickling filters needed to be taken off line for repairs to be undertaken.

To minimise the disruption to CWTP operations, a combined programme was developed for maintenance and earthquake repairs. General maintenance and repair was undertaken by both CWTP operations staff and earthquake repairs were undertaken by a contractor.

Figure 2: CWTP Trickling Filters

2.3 JOB SAFETY TASK ANALYSIS

2.3.1 JSTA

A JSTA was used to identify hazards to people and plant/equipment for the construction phase activities. A JSTA is a methodology for systematically assessing the individual tasks involved in a project or job. For each task the potential hazards were identified. The consequence and likelihood for each hazard was considered and from this the risk was assessed. Mitigation efforts then focused on the highest risks. Risks to not only people, but also the plant/equipment were considered during the preparation of the JSTA. It was important to consider both the removal and reinstallation of equipment as separate tasks. This resulted in a large number of hazards being identified in the JSTA. Most were assessed as low or very low risk.

A great many individual tasks were identified to carry out the trickling filter repairs and maintenance, which resulted in a large number of hazards being identified in the JSTA. Most were assessed as low or very low risk. The hazards assessed to have medium to high risk to people and plant/equipment are summarised in tables 1 and 2 respectively.

2.3.2 PTW

The JSTA is an important part of the PtW process. At CWTP the PtW is the key pathway for implementing the paperwork during construction and are required prior to commencing any work. The PtW system applies to contractors as well as CWTP Operations for undertaking construction, maintenance and repairs.

Table 1: Medium to High Risk Hazards to Plant/Equipment

Hazards to Plant/Equipment	*Consequence*	*Likelihood **
PVC Media Damage – standing on media	PVC media is damaged as a result of working on media surface	Unlikely as plywood is placed over the media to protect it.
PVC Media Damage – tool dropped from above	PVC media is damaged by falling tools	Possible if tools are dropped
Crane – equipment placed incorrectly	Equipment placed incorrectly resulting damage to the trickling filter of the media	Possible. All lifts to be planned and spotter is in constant communication with crane operator
*In this summary the likelihood presented is following the implementation of controls to eliminate, mitigate, and/or manage the hazard		

Table 2: Medium to High Risk Hazards to People

Hazards to People	***Consequence***	***Likelihood ****
Fall from height – slip while working on the trickling filter roof	Fall from the roof to the floor (over 10 metres) resulting in serious injury or death	Unlikely as fall protection was mandatory (e.g. fall arrestors, scaffolding, etc)
Spain or strain - injury lifting or pulling heavy roof panels	Injury to back or muscles	Unlikely as roof panels designed to be removed. Crane on standby to assist if panels are stuck shut and difficult to open
Falling tools – tool dropped from above	People working below are injured from falling tools	Unlikely as access to upper level is restricted when people are working below
Spain or strain - injury lifting heavy material/equipment	Injury to back or muscles	Unlikely as crane available for heavy lifts and roof panels removed to provide crane access
Falls – falling from scaffold or staircase	Injury such as broken bones	Unlikely as scaffold and staircase designed to minimise falls
Electrocution – temporary lighting installed	Electrocution due to faulty wiring or installation	Unlikely as all electrical wiring is checked and tagged as suitable prior to use
Fall from height - fall into central riser pipe	Fall into central riser pipe resulting in serious injury or death	Unlikely as mesh cover to be installed over riser pipe
Crane injury – hit by crane	Hit by crane as crane operator cannot see inside trickling filter	Unlikely as spotter to be in constant communication with crane operator and all personnel outside trickling filter during lifts
Crushing injury – heavy equipment incorrectly placed	Person crushed by heavy equipment	Possible. Spotter to be in constant communication with crane operator
Suffocation – trickling filter subfloor is a confined space	Low oxygen levels in the subfloor space could lead to suffocation	Use confined space protocols including testing for oxygen levels, constant radio contact, recovery plan, ventilation
Suffocation – degrading biomass inside trickling filter	Low oxygen levels inside the trickling filter could lead to suffocation	Testing for oxygen levels, recovery plan, ventilation
Infection – from contact with biomass or bites from flies/insects	Skin infection, meningitis, leading to sickness or death	Immunisations, personal hygiene such as hand washing and showering
Illness – from contact with biomass	Ill health, vomiting, diarrhea	Personal hygiene such as hand washing and showering. Isolation of trickling filter tagged and tested.
Crushing injury – trench collapse	Trenches down to deep underground pipes could collapse, leading to injury or death	Unlikely as sheet piling used in all deep trenches
***In this summary the likelihood presented is following the implementation of controls to eliminate, mitigate, and/or manage the hazard**		

2.4 SAFETY IN DESIGN

JSTA methodologies are not effective for identifying hazards to the environment. SiD methodology was used to identify and assess the hazards posed to the environment. A SiD workshop was undertaken during the design of the earthquake repair works. The workshop involved both the design team and the operations team. The SiD study included a structured workshop facilitated by an experienced and independent facilitator. A set of standard guidewords were used to test the design with respect to safety. The four phases of asset life were considered, construction, commissioning, operation and decommissioning. Two main hazards to the environment were identified:

- Malodorous discharges to air
- Insufficient wastewater treatment

These were linked, as inadequate wastewater treatment could lead to offensively odorous discharges being released. Each hazard had several possible causes, as shown in Table 3.

Table 3: Medium to High Risk Hazards to Environment

Hazards to Environment	***Consequence***	***Likelihood ****
Malodorous discharges to air – due to incorrectly taking trickling filters off line	Odour complaints from local residents in breach of resource consents resulting in fines.	Possible – this occurred last time the trickling filters were taken off line
Malodorous discharges to air – due to secondary contact tank performing poorly	Odour complaints from local residents in breach of resource consents resulting in fines.	Possible – all secondary contact tanks will need to be in service
Malodorous discharges to air – due to oxidation ponds becoming overloaded	Odour complaints from local residents in breach of resource consents resulting in fines.	Possible – ponds have been overloaded in the past
Inadequate wastewater treatment –due to secondary contact tank performing poorly	Discharges exceeding resource consent conditions resulting in fines	Possible
Inadequate wastewater treatment –due to oxidation ponds becoming overloaded	Discharges exceeding resource consent conditions resulting in fines	Possible
*In this summary the likelihood presented is following the implementation of controls to eliminate, mitigate, and/or manage the hazard		

3 PUTTING THE PAPERWORK INTO PRACTISE

3.1 PLANNING

Planning is a key factor for successfully putting the paperwork into practice. Forward planning prior to taking the tricking filters off line was critical to managing the hazards and the associated risks that had been identified through the JSTA and SiD.

The trickling filters at the CWTP are hydraulically limited, particularly in winter. In Christchurch in winter there is more rainfall and the ground water level is higher. With the earthquake damage to the underground wastewater pipe network, there is significant ingress of water into the wastewater pipework. This results in a higher volume of lower concentration wastewater arriving at the CWTP for treatment and a higher flow through the trickling filters. At these higher flows both trickling filters are required to be in operation.

During the summer months the flow of wastewater through the CWTP is lower. In the driest summer months (December through to March) it is possible to have only one trickling filter in operation and still achieve adequate wastewater treatment. For this reason the trickling filter repairs were scheduled for the summer months of January through to March.

Relying solely on dry summer weather was considered high risk. Christchurch can have significant wet weather events in the middle of summer. In a summer storm event (high rainfall), a single trickling filter would struggle to treat the full wastewater flow. Thus back-up plans were put in place to actively manage the wastewater treatment:

- The operation of the solids contact tanks was changed. Normally this unit process operates in two parallel trains; one for each trickling filter. Instead the solids contact tanks were temporarily reconfigured so that the wastewater flowed through the tanks in series. This facilitated floc formation by making full use of the solid contact tank volume and improved solids settling in the down-stream clarifiers.

- Operating a higher flow through a single trickling filter can increase biomass sloughing and result in a smaller biomass particle being sloughed off. These smaller particles make floc formation problematic (in the solid contact tanks) and as a result be difficult to separate (in the clarifiers). This would result in excessive biomass being carried out to the polishing ponds, adversely affecting the pond performance and resulting in significant malodorous discharges. To mitigate this, flocculent dosing equipment was put on standby and a suitable polymer flocculant was sourced. This flocculent dosing system was used during the project to improve the performance of the solids contact tanks.

- In a high rainfall event, it was likely that some primary effluent from the primary sedimentation tanks would be by-passed around the secondary treatment (trickling filters, secondary contact tanks and clarifiers), and be diverted directly to the polishing ponds. This partially treated wastewater would have higher concentration of contaminants which, in turn, could negatively affect the pond performance and result in significant malodorous discharges. To mitigate this, a chemical dosing system, using hydrogen peroxide, was put on standby. This dosing equipment would be used to dose hydrogen peroxide directly into the bypassed wastewater, increasing the oxygen concentration of the wastewater, and thereby boosting the performance of the ponds. This back-up chemical dosing system was not used during the project.

3.2 CONSTRUCTION

The contractor was engaged under at NZS3910 contract. The contractor was required to prepare a Site Specific Health and Safety Management Plan. This plan provided information on how safety would be managed on the construction site. It included traffic management, people health and safety management, environmental management, and work method statements.

Daily, weekly and monthly site inspections were undertaken to monitor health and safety on the work site. The daily and weekly site inspections were carried out by the contractor, whilst the monthly inspections were carried out by a specialist health and safety practitioner. The purpose of these inspection was to practically identify potential hazards and address these before an incident occurred. The following hazards were identified during construction:

- A power cord on electrical equipment. The necessary testing was carried out.

- Scaffolding that had an out of date “scaff-tag”. The scaffold was reviewed and a new tag issued

- Inadequate fencing around the construction. Additional fencing was installed.

Personnel access to site was carefully managed. The CWTP is an operating wastewater treatment plant, with operations, maintenance staff moving around. Also, maintenance staff were undertaking works in the same space as the contract works. This was managed through regular project meetings and programme updates. At these meetings health and safety was specifically included on the agenda. The interface between the contractor's activities and CWTP maintenance and repair activities was a high risk that needed to be actively managed. These activities were identified during the JSTA, which allowed solution to developed well in advance of the works being undertaken

CWTP site wide weekly toolbox meeting, where activities on site are discussed by operations and maintenance staff. This provided a mechanism for circulating information around CWTP.

3.3 PROGRAMMING WORKS

With the range of people involved in this project, coordinating these inputs was critical to keeping people, plant/equipment and the environment safe. A comprehensive project programme was developed. The programme for the second half of the works is shown in Appendix A. This included the contractor's construction programme and the operations staff maintenance programme. Programming provided a mechanism for clearly demonstrating what activities were being undertaken, when, and by whom. Hazards associated with each achieved were then readily communicated around the project team.

The programme was a live document, particularly while the earthquake damage assessments were being undertaken. During this phase the programme was updated to show activities required to undertake these additional repairs.

4 OUTCOME

JSTA effectively identified hazards to people and the plant/equipment. SiD methodologies identified environmental hazards. SiD methodologies, JSA methodologies and programme planning were invaluable tools for achieving this. Contingency plans are a necessity, especially for events you cannot control, such as the weather.

There was a single incident during the construction phase of this project. This occurred while the preparations were being made to deconstruct the central rotary distribution tower. The trickling filter had been isolated using slide gates. One of these gates had failed to completely close. A wet weather event occurred, subtly changing the hydraulics through the CWTP. Partially treated wastewater flowed back though this incorrectly closed gate valve, backed up the distribution tower and then trickled down onto a worker beneath. Work immediately halted while the situation was remedied and a physical break was put in the feed pipework.

Given that the construction phase of the project duration spanned 18 month, this is a very good outcome.

ACKNOWLEDGEMENTS

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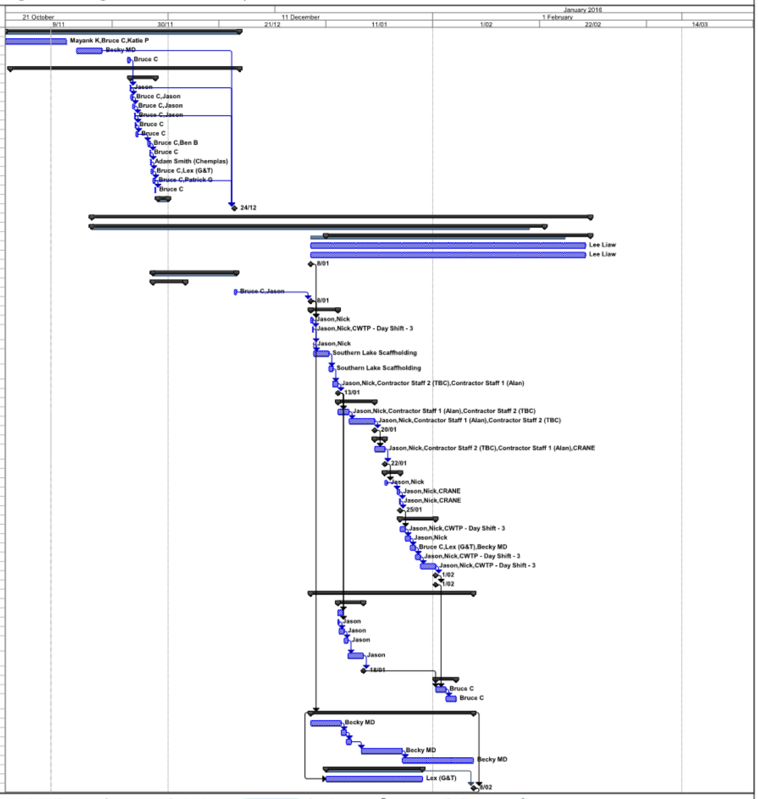
- CWTP Maintenance Team, especially Bruce Cassidy, CWTP Maintenance Team Leader
- CWTP Operations Team
- G&T Construction, especially Lex Thomson, General Manager

APPENDIX A

PROGRAMMES OF WORKS FOR TRICKLING FILTER 2 REPAIRS

Trickling Filter 2 Programme for Offline Repairs

ID	WBS	Task Name	Duration	Start	Finish	Predecessors
1	1	**Preparation Phase**	**34 days**	**Mon 9/11/15**	**Thu 24/12/15**	
2	1.1	Timeline Preparation	10 days	Mon 9/11/15	Fri 20/11/15	
3	1.2	JSA - Job Safety Analysis	5 days	Mon 23/11/15	Fri 27/11/15	
4	1.3	Confirm resources required	0.5 days	Thu 3/12/15	Thu 3/12/15	
5	1.4	**PreShut Meeting with contractors, stake holders etc.**	**33 days**	**Tue 10/11/15**	**Thu 24/12/15**	
9	1.5	**Prepare Materials, Tools and Equipment**	**3 days**	**Thu 3/12/15**	**Tue 8/12/15**	
10	1.5.1	Prepare/procure replacement bearing and seals	0.25 days	Thu 3/12/15	Thu 3/12/15	4
11	1.5.2	Procure rated eye-bolts to secure the bearing	0.25 days	Thu 3/12/15	Thu 3/12/15	10
12	1.5.3	Prepare mesh cover to seal the fall from tower	0.25 days	Fri 4/12/15	Fri 4/12/15	11
13	1.5.4	Prepare plywood cover	0.25 days	Fri 4/12/15	Fri 4/12/15	12
14	1.5.5	Procure fly control spray/equipment	0.25 days	Fri 4/12/15	Fri 4/12/15	13
15	1.5.6	Ensure Gas Detectors working and available	0.25 days	Fri 4/12/15	Fri 4/12/15	14
16	1.5.7	Provision of electrical wiring point	0.25 days	Mon 7/12/15	Mon 7/12/15	15
17	1.5.8	Ensure availability of pumps, leads, pipes to darin flushing chamb	0.25 days	Mon 7/12/15	Mon 7/12/15	16
18	1.5.9	Polymer material and dosing rig available	0.25 days	Mon 7/12/15	Mon 7/12/15	17
19	1.5.10	Prepare for tubes repair or replacement	0.25 days	Mon 7/12/15	Mon 7/12/15	18
20	1.5.11	Arrange fabrication of Apex (Tower top part)	0.25 days	Tue 8/12/15	Tue 8/12/15	19
21	1.5.12	Arrange fabrication of Tie Rod Connections, Plates	0.25 days	Tue 8/12/15	Tue 8/12/15	20
22	1.6	**Preliminary Inspections**	**2 days**	**Wed 9/12/15**	**Thu 10/12/15**	
25	M1	***Milestone - Preparation Phase completed***	***0 days***	***Thu 24/12/15***	***Thu 24/12/15***	***13,3,20,10,24***
26	2	**Shut and Isolate FGR1 (Fixed Growth Reactor1)**	**70 days**	**Thu 26/11/15**	**Wed 2/03/16**	
27	2.1	**Trickling Filter Flushing and Shutdown**	**63 days**	**Thu 26/11/15**	**Mon 22/02/16**	
38	2.2	**Chemically Assisted Sedimentation in Primary Tanks**	**38 days**	**Mon 11/01/16**	**Wed 2/03/16**	
42	2.3	**Operation of Oxidation Ponds**	**38 days**	**Fri 8/01/16**	**Tue 1/03/16**	34
43	2.4	**Operation of Solids Contact Process**	**38 days**	**Fri 8/01/16**	**Tue 1/03/16**	34
44	M2	***Milestone - FGR Process Shut and Isolated***	***0 days***	***Fri 8/01/16***	***Fri 8/01/16***	***34***
45	3	**Prepare Site**	**12.25 days**	**Tue 8/12/15**	**Thu 24/12/15**	
46	3.1	**Crane Setup**	**4.25 days**	**Tue 8/12/15**	**Mon 14/12/15**	
50	3.2	Check all material on site (Ref 1.5)	0.25 days	Thu 24/12/15	Thu 24/12/15	
51	M3	***Milestone - Site ready for commencing Maintenance Works***	***0 days***	***Fri 8/01/16***	***Fri 8/01/16***	***34,49,50***
52	4	**Establish Access**	**3.1 days**	**Fri 8/01/16**	**Wed 13/01/16**	
53	4.1	Slide / Open 4 doors to access FGR1 Arms	0.25 days	Fri 8/01/16	Fri 8/01/16	44,51
54	4.2	Slide / Open Top Cover to access Tower	0.25 days	Fri 8/01/16	Fri 8/01/16	53
55	4.3	Put mesh cover on tower top	0.1 days	Fri 8/01/16	Fri 8/01/16	54
56	4.4	Setup Outer Scaffolding - ring of the tower.	1 day	Fri 8/01/16	Mon 11/01/16	55
57	4.5	Setup Internal Scaffholding - to media level	0.5 days	Mon 11/01/16	Tue 12/01/16	56
58	4.6	Set up Plywood platform and blocks	1 day	Tue 12/01/16	Wed 13/01/16	57
59	M4	***Milestone - Safe Access to FGR1 Established***	***0 days***	***Wed 13/01/16***	***Wed 13/01/16***	***58***
60	5	**Remove Tie Rods from Tower**	**5.5 days**	**Wed 13/01/16**	**Wed 20/01/16**	
61	5.1	Release tension on Tie Rods (6 arms)	2.5 days	Wed 13/01/16	Fri 15/01/16	59
62	5.2	Disassemble tie rods one at a time (42)	3 days	Fri 15/01/16	Wed 20/01/16	61
63	M5	***Milestone - Tie Rods removed***	***0 days***	***Wed 20/01/16***	***Wed 20/01/16***	***62***
64	6	**Remove Arms (6)**	**2 days**	**Wed 20/01/16**	**Fri 22/01/16**	
65	6.1	Unbolt tower flanges (6) by using Crane and lay down on platform	2 days	Wed 20/01/16	Fri 22/01/16	63
66	M6	***Milestone - Arms uncoupled and safely removed***	***0 days***	***Fri 22/01/16***	***Fri 22/01/16***	***65***
67	7	**Remove Tower and safegaurd opening**	**1 day**	**Fri 22/01/16**	**Mon 25/01/16**	
68	7.1	Unbolt the tower	0.4 days	Fri 22/01/16	Fri 22/01/16	66
69	7.2	Lift by Crane and place it outside (space to be defined?)	0.4 days	Mon 25/01/16	Mon 25/01/16	68
70	7.3	Safety Task - Cover Discharge Pipe Hole with Plywood	0.2 days	Mon 25/01/16	Mon 25/01/16	69
71	M7	***Milestone - Tower removed***	***0 days***	***Mon 25/01/16***	***Mon 25/01/16***	***70***
72	8	**Remove & Replace Bearing and Water Seal**	**5 days**	**Mon 25/01/16**	**Mon 1/02/16**	
73	8.1	Remove Water Seal & Bearing	1 day	Mon 25/01/16	Tue 26/01/16	71
74	8.2	Pump out water in flushing chamber / internal pipe	1 day	Tue 26/01/16	Wed 27/01/16	73
75	8.3	Inspect condition of internal pipe for EQ damage	1 day	Wed 27/01/16	Thu 28/01/16	74
76	8.4	Preparation prior to replacing bearing	1 day	Thu 28/01/16	Fri 29/01/16	75
77	8.5	Replace Bearing and Water Seal	1 day	Fri 29/01/16	Mon 1/02/16	76
78	8.6	Check bearing rotation	0 days	Mon 1/02/16	Mon 1/02/16	77
79	M8	***Milestone - Bearing and Water Seal replaced***	***0 days***	***Mon 1/02/16***	***Mon 1/02/16***	***78***
80	9	**Inspections and Repairs**	**22 days?**	**Fri 8/01/16**	**Mon 8/02/16**	
81	9.1	**FGR Tower, Arms and Tie Rod Inspections**	**3 days?**	**Wed 13/01/16**	**Mon 18/01/16**	
82	9.1.1	Inspect Media	1 day?	Wed 13/01/16	Thu 14/01/16	59
83	9.1.2	Inspect condition of tower, does it need paint?	0.5 days	Wed 13/01/16	Wed 13/01/16	59
84	9.1.3	Inspect condition of arms	1 day	Wed 13/01/16	Thu 14/01/16	83
85	9.1.4	Inspect mating surface of tower and central pipework	0.5 days	Thu 14/01/16	Fri 15/01/16	84
86	9.1.5	Inspect Outer Tie Rods and Arm connector joints (6 x 2?)	1 day	Fri 15/01/16	Mon 18/01/16	85
87	9.1.6	Report condition and decision for repairs.	0 days	Mon 18/01/16	Mon 18/01/16	86
88	9.2	**Repairs (subject to condition assessment)**	**4 days**	**Mon 1/02/16**	**Fri 5/02/16**	
89	9.2.1	Tower refurbishment, painting, etc (as required)	2 days	Mon 1/02/16	Wed 3/02/16	79,87
90	9.2.2	Outer Tie Rod and Arm connection repairs (welding or new hook type joint)	2 days	Wed 3/02/16	Fri 5/02/16	89
91	9.3	**EQ Inspections and Repairs**	**22 days**	**Fri 8/01/16**	**Mon 8/02/16**	**51**
92	9.3.1	Waterblast and clean under floor area	4 days	Fri 8/01/16	Wed 13/01/16	
93	9.3.2	Drain Grit from cleanout to concrete pad	1 day	Thu 14/01/16	Thu 14/01/16	92
94	9.3.4	Damage Assessment from Phil W and Ian Billings	1 day	Fri 15/01/16	Fri 15/01/16	93
95	9.3.5	EQ Inspections	6 days	Mon 18/01/16	Mon 25/01/16	94
96	9.3.6	EQ Repairs	10 days	Tue 26/01/16	Mon 8/02/16	95
97	9.4	**Concrete Beam Repairs**	**15 days**	**Mon 11/01/16**	**Fri 29/01/16**	
98	9.4.1	Concrete Beam Repairs	15 days	Mon 11/01/16	Fri 29/01/16	91SS
99	M9	***Milestone - Inspection and Repairs Completed***	***0 days***	***Mon 8/02/16***	***Mon 8/02/16***	***91,97***

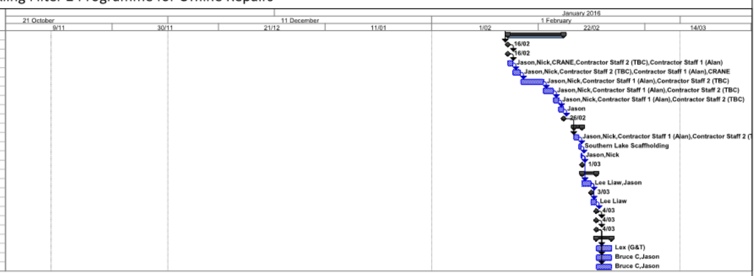


Project: CWTP Asset Management - F
Date: Wed 18/11/15

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Progress | Deadline

Trickling Filter 2 Programme for Offline Repairs

ID	WBS	Task Name	Duration	Start	Finish	Predecessors
100	10	**Re-assemble FGR tower, tie rod and arms**	**9 days**	**Tue 16/02/16**	**Fri 26/02/16**	
101	10.1	Remove cover from pipe opening	0 days	Tue 16/02/16	Tue 16/02/16	99
102	10.2	Remove cover from Tower opening	0 days	Tue 16/02/16	Tue 16/02/16	101
103	10.3	Place Tower	1 day	Tue 16/02/16	Tue 16/02/16	102
104	10.4	Assemble Arms (Connect Flanges)	1.5 days	Wed 17/02/16	Thu 18/02/16	103
105	10.5	Connect Tie rods to Arms	2.5 days	Thu 18/02/16	Mon 22/02/16	104
106	10.6	Remove plywood blocks placed under the arms	2 days	Tue 23/02/16	Wed 24/02/16	105
107	10.7	Inspect tension	1 day	Thu 25/02/16	Thu 25/02/16	106
108	10.8	Check assembly	1 day	Fri 26/02/16	Fri 26/02/16	107
109	M10	***Milestone - FGR Tower, Arms and Tie Rods re-assembled***	***0 days***	***Fri 26/02/16***	***Fri 26/02/16***	***108***
110	11	**Secure Accessway**	**1.75 days**	**Mon 29/02/16**	**Tue 1/03/16**	
111	11.1	remove plywood walkway platform	1 day	Mon 29/02/16	Mon 29/02/16	109
112	11.2	remove scaffholding	0.25 days	Tue 1/03/16	Tue 1/03/16	111
113	11.3	slide back doors and covers	0.5 days	Tue 1/03/16	Tue 1/03/16	112
114	M11	***Milestone - Accessway secured***	***0 days***	***Tue 1/03/16***	***Tue 1/03/16***	***113***
115	12	**Commissioning & Start up of FGR process**	**2.5 days**	**Tue 1/03/16**	**Fri 4/03/16**	
116	12.1	De-isolate FGR	1.5 days	Tue 1/03/16	Thu 3/03/16	113
117	12.2	Stop Dosing of Polymer	0 days	Thu 3/03/16	Thu 3/03/16	116
118	12.3	Start Pumps	1 day	Thu 3/03/16	Fri 4/03/16	116
119	12.4	Monitor temperature COD levels, etc for 2 weeks	0 days	Fri 4/03/16	Fri 4/03/16	118
120	12.5	Checkpoint - all measurements are within limits	0 days	Fri 4/03/16	Fri 4/03/16	119
121	M12	***Milestone - FGR process operational***	***0 days***	***Fri 4/03/16***	***Fri 4/03/16***	***120***
122	13	**Post shut tasklist**	**1 day**	**Fri 4/03/16**	**Mon 7/03/16**	
123	13.1	remove crane	1 day	Fri 4/03/16	Mon 7/03/16	121
124	13.2	debrief session/meetings	1 day	Fri 4/03/16	Mon 7/03/16	121
125	13.3	Post shut report (time, costs, learnings, etc)	1 day	Fri 4/03/16	Mon 7/03/16	121



Project: CWTP Asset Management - F
Date: Wed 18/11/15

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Progress | Deadline

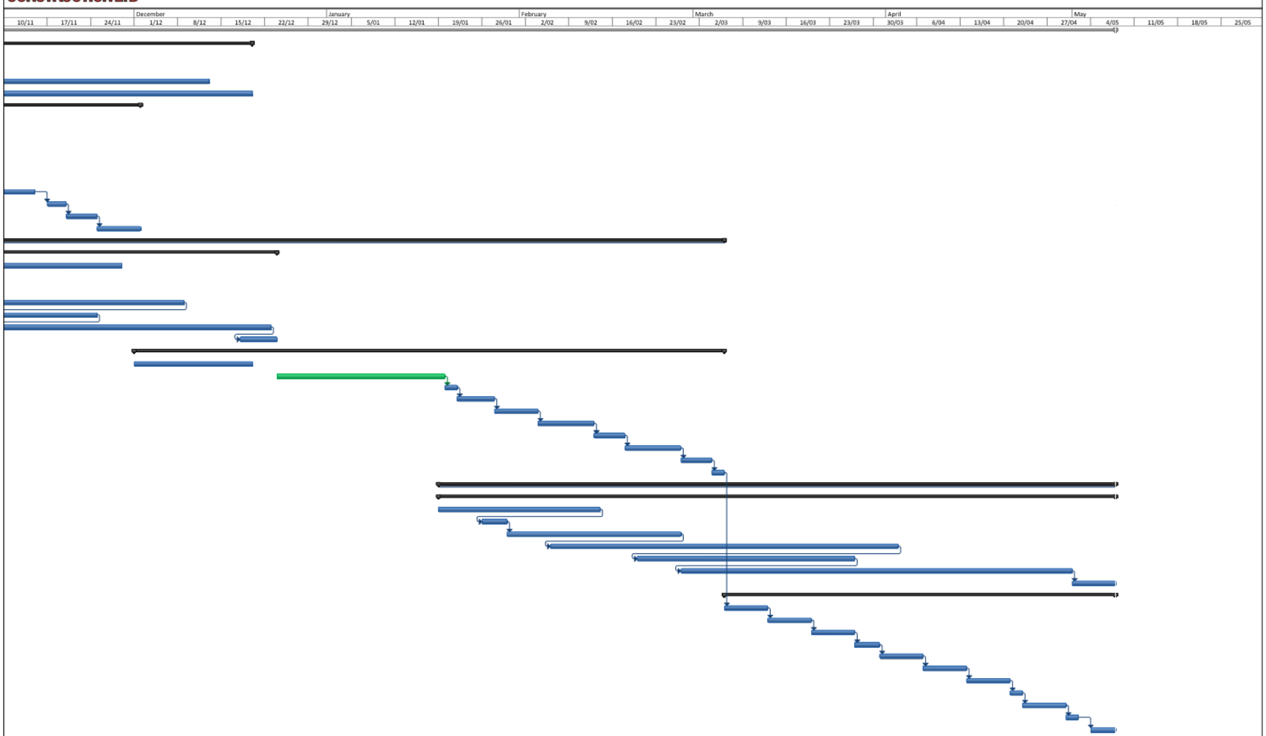
CWTP TRICKLING FILTERS EXTERNAL & PIPEWORK REPAIRS
TENDER PROGRAMME

ID	Task Name	Duration	Start	Finish
0	**CWTP Trickling Filter & pipe repairs**	**224 days**	**Mon 30/06/1**	**Thu 7/05/15**
1	**P&G items**	**125 days**	**Mon 30/06/14**	**Fri 19/12/14**
2	Prepare and submit management plans	20 days	Mon 30/06/14	Fri 25/07/14
3	Order & delivery of GRP ducting	80 days	Mon 30/06/14	Fri 17/10/14
4	Order & delivery of over pumping equipment	120 days	Mon 30/06/14	Fri 12/12/14
5	Order, manufacture & delivery of pipe	70 days	Mon 15/09/14	Fri 19/12/14
6	**Separable Portion 1 - RAS pipe repair**	**76 days**	**Mon 18/08/14**	**Mon 1/12/14**
7	Site establishment	5 days	Mon 18/08/14	Fri 22/08/14
8	Order, manufacture & delivery of slidegates	25 days	Tue 9/09/14	Mon 13/10/14
9	Construct new inlet chamber at SCT headwork's	15 days	Tue 7/10/14	Mon 27/10/14
10	Commission new inlet chamber & isolate 1350 bend	2 days	Tue 28/10/14	Wed 29/10/14
11	Excavate & expose existing 1350 RAS bend	4 days	Thu 30/10/14	Tue 4/11/14
12	Demolition to existing bend	3 days	Wed 5/11/14	Fri 7/11/14
13	Install new bend	5 days	Mon 10/11/14	Fri 14/11/14
14	Install connection to Pump Station B bypass	3 days	Mon 17/11/14	Wed 19/11/14
15	Construct connecting collar	3 days	Thu 20/11/14	Mon 24/11/14
16	Backfill & reinstate	5 days	Tue 25/11/14	Mon 1/12/14
17	**Separable Portion 2 - Trickling Filter 1 repairs**	**109 days**	**Mon 6/10/14**	**Thu 5/03/15**
18	**Concrete work & ducting**	**57 days**	**Mon 6/10/14**	**Tue 23/12/14**
19	Manufacture & delivery of precast plenums	40 days	Mon 6/10/14	Fri 28/11/14
20	Install temporary ducting	3 days	Mon 6/10/14	Wed 8/10/14
21	Demolish existing plenum & duct	20 days	Thu 9/10/14	Wed 5/11/14
22	Construct new concrete band	40 days	Tue 14/10/14	Mon 8/12/14
23	Construct new concrete foundation slab	25 days	Tue 21/10/14	Mon 24/11/14
24	Install new plenum and GRP duct in stages	40 days	Tue 28/10/14	Mon 22/12/14
25	Reinstate lawn areas & paving	4 days	Thu 18/12/14	Tue 23/12/14
26	**Pipe repairs**	**69 days**	**Mon 1/12/14**	**Thu 5/03/15**
27	Install temporary works to pipe trench	15 days	Mon 1/12/14	Fri 19/12/14
28	***Christmas Break***	19 days	Wed 24/12/14	Mon 19/01/15
29	Commission over pumping	2 days	Tue 20/01/15	Wed 21/01/15
30	Excavate and remove damaged pipework	4 days	Thu 22/01/15	Tue 27/01/15
31	Install pipe trench Basecourse	5 days	Wed 28/01/15	Tue 3/02/15
32	Install & connect new PE pipe work	7 days	Wed 4/02/15	Thu 12/02/15
33	Test pipework	3 days	Fri 13/02/15	Tue 17/02/15
34	Backfill & reinstatements to pipe trench	7 days	Wed 18/02/15	Thu 26/02/15
35	Remove temporary works	3 days	Fri 27/02/15	Tue 3/03/15
36	Remove over pumping equipment	2 days	Wed 4/03/15	Thu 5/03/15
37	**Separable Portion 3 - Trickling Filter 2 repairs**	**79 days**	**Mon 19/01/15**	**Thu 7/05/15**
38	**Concrete work & ducting**	**79 days**	**Mon 19/01/15**	**Thu 7/05/15**
39	Manufacture & delivery of precast plenums	20 days	Mon 19/01/15	Fri 13/02/15
40	Install temporary ducting	4 days	Mon 26/01/15	Thu 29/01/15
41	Demolish existing plenum & duct	20 days	Fri 30/01/15	Thu 26/02/15
42	Construct new concrete band	40 days	Fri 6/02/15	Thu 2/04/15
43	Construct new concrete foundation slab	25 days	Fri 20/02/15	Thu 26/03/15
44	Install new plenum and GRP duct in stages	45 days	Fri 27/02/15	Thu 30/04/15
45	Reinstate lawn areas & paving	5 days	Fri 1/05/15	Thu 7/05/15
46	**Pipe repairs**	**45 days**	**Fri 6/03/15**	**Thu 7/05/15**
47	Fabricate & install pump discharge pipework	5 days	Fri 6/03/15	Thu 12/03/15
48	Install pumps, power supplies and controls	5 days	Fri 13/03/15	Thu 19/03/15
49	Install temporary works to pipe trench	5 days	Fri 20/03/15	Thu 26/03/15
50	Commission over pumping	2 days	Fri 27/03/15	Mon 30/03/15
51	Excavate and remove damaged pipework	5 days	Tue 31/03/15	Mon 6/04/15
52	Install pipe trench Basecourse	5 days	Tue 7/04/15	Mon 13/04/15
53	Install & connect new PE pipe work	5 days	Tue 14/04/15	Mon 20/04/15
54	Test pipework	2 days	Tue 21/04/15	Wed 22/04/15
55	Backfill & reinstatements to pipe trench	5 days	Thu 23/04/15	Wed 29/04/15
56	Remove temporary works	2 days	Thu 30/04/15	Fri 1/05/15
57	Remove over pumping equipment	4 days	Mon 4/05/15	Thu 7/05/15

Project: CWTP Trickling Filter & p
Date: Tue 9/09/14

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

CWTP TRICKLING FILTERS EXTERNAL & PIPEWORK REPAIRS
TENDER PROGRAMME



Project: CWTP Trickling Filter & p
Date: Tue 9/09/14

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