Tarawera Sewerage Scheme HAZOP Study

The Tarawera Sewerage Scheme uses a 'trunk main' to convey waste water from the catchment to the Rotorua Waste Water Treatment Plant. This comprises of three 'Transfer Pump Stations' interconnected by approximately 16 Km of welded High Density Polyethylene (HDPE) pipe. Transfer Pump Stations are to be situated at Cliff Road, Stoney Point and adjacent to the Waste Transfer Station.

The design of the trunk main and transfer pumps system was risk assessed using a standard analysis process known as a HAZOP (Hazard and Operability Study). This is the most commonly used method across all process industries worldwide to confirm the safety and integrity of process plant designs.

The HAZOP Process

A HAZOP is carried out by designers, engineers and operators associated with the design. The process is managed and chaired by a qualified HAZOP facilitator. The HAZOP for the Tarawera took place over 2 days and involved the following people:

Name	Initials	Role	Company
Rebecca Randall	RR	Senior Process Engineer (HAZOP Facilitator)	TRILITY
Steve Jamieson	SJ	Project Manager	TIRILITY
Johann van wyk	JVW	Design Manager	Stantec
Will Jacobson	WJ	Technical Lead	Stantec
Ian Stapler	IS	Project Manager	RLC
Steve Harwood	SH	3 Water Operation Manager	RLC
Christine Sparrow	CS	Contract Manager	RLC
Charlie Clague	CL	Civil Design Engineer	Stantec
Simon Todd	ST	Senior Mechanical Engineer	Stantec
Marius Vorster	MV	Senior Civil Engineer	Stantec
Greg Speer	GS	Electrical Lead Engineer	Stantec
Steven Short	SS	Project Manager	Stantec
Ken McLeod	KM	Contract Manager	Fulton Hogan
Richard Cottrell	RC	Operations Manager	RLC

Over a period of the study, each component of the design (pipes, valves, pump, controls etc) were individually assessed against a standard set of prompt guide-words as shown below.

Guidewords	Deviations
HAZOP Continuous process guidewords (node by node)	
Flow	high, low, none, reverse, misdirected, other than
Level	high, low, empty
Pressure	high, low
Temperature	high, low
Composition	change in concentration, 2 phase, reactions
Impurities	gaseous, liquids, solids
Testing	equipment, product
Instruments	sufficient, too many, correct location
Materials of construction	
Plant items	operable, maintainable
HAZOP Overview guidewords (use only as needed)	
Toxicity	
Fire, explosion	
Electrical	Area classification, isolation, earthing
Safety equipment	Personal, fire detection, firefighting, means of escape, location
Services required	Air, nitrogen, water, others
Breakdown	Power, air, steam, water, computer, comms etc
Effluent	gaseous, liquid, solid
Noise	Sources, problem, control measures
Commissioning	
Start-up/shutdown	Isolation, purging
Quality, reliability, efficiency	
Simplicity	

Each part of component of the design is analysed by the group against each of the guide-words in turn and in the order shown above. Once that component has been analysed against each guide-word, the entire process is repeated for the next design component. For example, a pump would be examined for causes of High Flow, Low Flow, No flow, Misdirected Flow (ie going the wrong way), 'other than' flow, followed by High Level, Low Level, Empty Level and so on through the entire list.

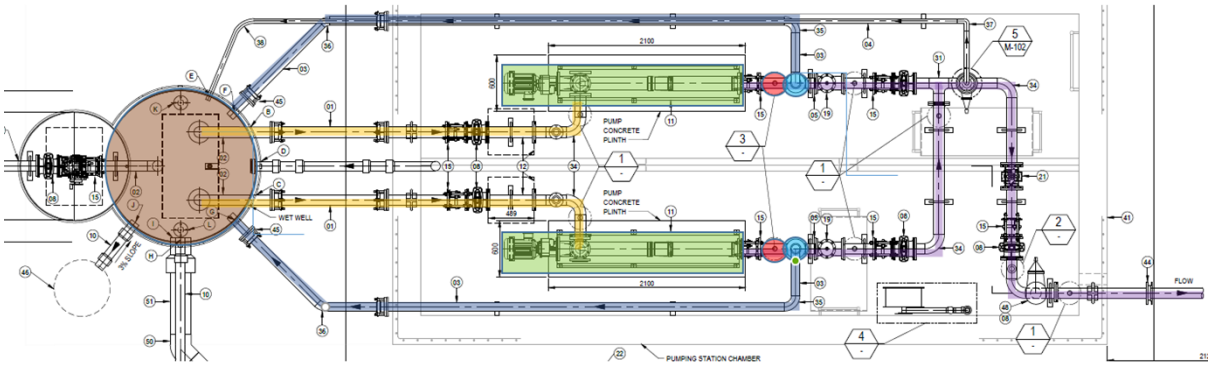
As each guide-word is considered, the team look for scenarios where a high flow, low flow etc. Could occur. These situations are then considered against the integrity of the design and if an issue is identified the design is changed to address it.

The following table summarises the analysis relating to the pipe passing the Green Lake.

Guideword	Deviation	Causes	Consequences	Controls/safeguards	Action
Flow	misdirected	Power failure to pump stations	Waste Water overflow	Fail close network provides minimum 1 day of storage.	Appropriately sized Uninterruptable Power Supply (UPS) required at pump station to provide power to close isolating valves and send alarm to control room.
Flow	misdirected	Damage to pipe	Leakage of waste water from open pipe	Control system monitoring pressure downstream of pumps. A drop in pressure during normal pumping operation indicates a significant leak in the network. A drop in pressure outside of normal range when pumps are not running indicates possibility of a small leak. See Note 1 for pressure transmitter details.	If pressure is abnormally low during pump operation, the pumps will stop and an alarm will be sent to the control room If pressure is abnormally low while pumps are not running an alarm will be sent to the control room.
Pressure	high	Pumps over pressurise the network	Pipe failure or pump failure (dead headed pumps).	Pressure monitoring will shut down the pump if the high pressure has occurred. Additional protection provided by inclusion of burst discs to relieve overpressure in the discharge pipe. Burst discs will divert flow back to the wet well (preventing flow into the trunk main). Burst discs are to have rupture sensors fitted to trip pumps off if disc burst detected.	Ensure the mechanical diversion is upstream of the check valve See Note 2 for mechanical diversion details.
Materials of construction	correct location	Earthquake or other cause of damage	Pipe failure	PE pipe is elastic and can withstand movement. HDPE pipe welds completed by competent trained workers with QA undertaken for all joints.	Weld tests and test results required for all HDPE welds.

Supporting Notes (Addressing clarification questions from Rotokākahi Board of Control, Warena Morgan, 11th August 2023)

The notes below refer to the following diagram for clarity. The diagram shows the equipment layout of the Waste Transfer Station pump station (which pumps waste water past Lake Rotokākahi). The other two pump stations (Cliff Road and Stoney Point) all have the same features and equipment as this one.



Waste water from the Stoney Point pump station is delivered into the pump station 'Wet Well' (brown circle) at the left hand side of the diagram. One of the two pumps (shown in green) pull waste water from the wet well (via the orange pipes) and pump it to the outlet pipe (shown in purple). The pipeline passing Lake Rotokākahi is a continuation of the purple pipe exiting the diagram at the bottom right. Note that each pump station has two pumps to provide duty and standby redundancy.

Note 1: Pressure Transmitter Details

A pressure transmitter is installed within the discharge pipe (purple) of each pump. These are represented by red circles. A seperate transmitter is provied for each pump as shown. These transmitters sense the discharge pressure of the duty pump and are used to detect misdirected flow issues (as per row 2 of the HAZOP table) and High Pressure issues (as per row 3 of the HAZOP table).

Note 2: Mechanical Diversion System Details

In most cases a high pressure in the pump discharge will be detected by the pressure transmitter and the actions in row 3 of the HAZOP table will be performed by the control system.

A 'mechanical diversion system' has been added to each pump to provide a second layer of protection for high pressures. The mechanical system comprises of a burst disc (indicated by the blue circle) and a discharge pipe (dark blue). Burst discs are common in the process industry to protect pipes from overpressure. They are precision engineered metal plates that burst when subjected to a pre-set limit pressure. If a high pressure occurs in the discharge of a Tarawera pump, the disc will rupture and the pressure (and waste water flow) will be diverted along the dark blue pipe and back into the Wet Well. Each burst disc is fitted with a sensor to detect if it has burst. When a burst is detected by the control system, the associated pump will stop and the actions of row 3 of the HAZOP table will be performed. Burst discs cannot be repaired and must be replaced with new ones.

Note 3: Quality Compliance Records

Test results demonstrating quality compliance will be supplied to the Rotokākahi Board of Control

Note 4: PE Pipe Specification

WE can confirm that all trunk main pipe (including that being installed past Lake Rotokākahi) is PE 100.