

**HAZARD AND OPERABILITY STUDY (HAZOP)
REPORT
FOR
COFFS HARBOUR CITY COUNCIL**

**PROPOSED CHLORINE STORAGE
AND CHLORINATION PLANT
SECTION OF
WATER TREATMENT PLANT FOR
WATER FROM KARANGI DAM**

LOCATED AT 140 UPPER ORARA ROAD, KARANGI

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Whamcorp Pty Ltd

**On the authority of: Stephen Sawtell
General Manager,
Coffs Harbour City Council
Authorised: 18 June 2008**

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GLOSSARY AND ABBREVIATIONS

AQM	Aquatec-Maxcon Pty Ltd
CHCC	Coffs Harbour City Council
CIA	Coffs Infrastructure Alliance
CNF	CNF and Associates Pty Ltd
FDS	Functional description specification
GHD	GHD Group
JHG	John Holland Group
P&ID	Process and instrumentation diagram
SCADA	Supervisory control and data acquisition system
SCBA	Self-contained breathing apparatus

SUMMARY OF MAIN FINDINGS AND RECOMMENDATIONS

Coffs Harbour City Council proposes to construct a water treatment plant for water supplied from Karangi Dam.

The conditions of consent for the approval of the development application included a HAZOP for the proposed chlorination plant and associated alarm system chaired by an independent person approved by the Director –General.

A quantitative risk assessment of the whole proposed water treatment plant was previously undertaken

Whamcorp Pty Ltd was retained to provide the independent chairman and its principal consultant was approved by the Director-General

The prime objective of this HAZOP was to systematically examine the proposed design and identify potential problems before construction so that necessary changes or other actions can be identified and implemented.

The recommendations of this HAZOP do not include any major changes, but primarily relate to minor improvements in layout, clarification of design intent and items to be included in operating and other instructions

SCOPE OF REPORT

The approval in 2007 by the Minister for Planning, File No S06/00885, included the following condition:

“Hazards and Risk

2.10 Prior to the commencement of construction of the project (except for construction of those works that are outside the scope of the hazard studies), the Proponent shall submit for the approval of the Director-General, the following pre-construction studies:

- a) a Hazard and Operability Study for the proposed chlorination plant and associated alarm system chaired by an independent qualified person approved by the Director-General. The study shall be carried out in accordance with the Department’s Hazardous Industry Planning Advisory Paper No. 8 – HAZOP Guidelines (DUAP, 1995). The study report shall be accompanied by an implementation program for all recommendations made in the report. If the Proponent intends to defer the implementation of a recommendation, justification shall be included.
- b) a Final Hazard Analysis for the proposed chlorination plant prepared in accordance with the Department’s Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis (DoP, 1992). If the final design is unchanged from the design at the project approval stage, the Proponent may request in writing an exemption from this condition from the Director-General.”

This study is in compliance with that requirement and covers the chlorination plant and associated alarm system of the proposed water treatment plant.

The scope includes the plant and equipment shown in P&ID “Chlorine dosing system” Drawing No WTP-P-289-01-D, dated 19/12/2008. Included are the storage of chlorine in the “chlorine drum room” and the chlorination of water in the “chlorine dosing room”

DESCRIPTION OF THE FACILITY

A P&ID of the plant is shown on drawing No. WTP-P-289-01 at page 18 The main plant items include:

- 929 kg chlorine drums (two full and two “empty”)
- Two chlorinators (piped in parallel)

This is the chlorine storage and chlorination section of a proposed water treatment plant for water supplied from Karangi Dam

HAZOP TEAM MEMBERS

The HAZOP team was chosen to represent all relevant areas of expertise from design through commissioning to operation. The team consisted of the following:

- Peter Hunt Whamcorp - Chemical Engineer/Safety Specialist (Chair)
- Mike Chapman GHD - Process Engineer/Process Designer
- Mark Aitken AQM (Aquatec Maxcon - Mechanical Contractor) - Water Specialist (Mechanical Engineer) (part time)
- Nathan Oliver JHG (John Holland Group) - Electrical Engineer - Commissioning Engineer
- George Frougas JHG (John Holland Group) - Chemical Engineer - Commissioning Manager
- Glenn O'Grady CHCC - Manager, Infrastructure (part time)
- Simon Thorn CHCC - Manager, Coffs Water
- Hubert Murray CHCC - Process Engineer, Coffs Water
- Peter Buckingham CHCC - Electrical Superintendent, Coffs Water
- Les Potter CHCC - Coffs Water, Head Operator
- Mark Knight CNF - Electrical Engineer, site project engineer (part time)
- Mark Cousins AQM - Mechanical Engineer, site project engineer
- Phil Woodford CNF - Mechanical Engineer, Design Interface Manager (minutes)

HAZOP METHODOLOGY

Selected lines and plant items in the P&ID were examined (HAZOPed) in turn, starting from Chlorine in the full drums. Prior to examining each line in turn, handling of drums and layout etc (normally addressed after all lines) were addressed at the request of several team members. These areas were reviewed later.

Recording in the minute sheets was generally by exception; i.e. only those key items likely to pose a significant consequence were recorded.

Guide words such as HIGH FLOW, as listed below and used in the minute sheets (pages 19 to 28) were applied in turn, from a set of guide word "cards: in a PowerPoint presentation projected onto a wall.

For each guide word, the likely cause/s were entered in the fourth column and credible consequences in the fifth column. The sixth column was provided to record existing design or operational safeguards. Where the consequences were likely to present a potentially hazardous situation or loss (e.g. financial and time), possible changes to the system to eliminate or minimise the consequences were considered and a recommendation made.

For simple cases the recommended change was entered in the seventh column. Where several options were presented or further evaluation was considered necessary, the recommendations were minuted accordingly. The initials of the person responsible were entered in the eighth column

GUIDE WORDS

INTRODUCTORY GUIDE WORDS

HAZOP

- PURPOSE
 - REVIEW DESIGN / PROCEDURES
 - IDENTIFY HAZARDS / OBSTACLES TO OPERABILITY
 - DEVIATIONS FROM DESIGN INTENT
- METHOD
 - FIRM P&ID / ELD (line by line & overview)
 - OUTLINE PROCEDURES (operating; commissioning; maintenance; emergency)
 -

NEW DRAWING

DESCRIBE PURPOSE OF PLANT SHOWN

BROAD OUTLINE OF OPERATION

NEW LINE

- PURPOSE OF LINE & ASSOCIATED EQUIPMENT
- NORMAL OPERATING CONDITION
- NORMAL METHOD OF OPERATION
- DESCRIBE EQUIPMENT, VALVES , INSTRUMENTS
- GENERAL **BROAD** DESCRIPTION

LINE BY LINE GUIDE WORDS:

FLOW

- HIGH
- LOW
- REVERSE
- LEAK
- 2 PHASE
- ZERO / STOPPED

LEVEL

- HIGH
- LOW
- EMPTY
- OVERFLOW

TEMPERATURE

- LOW
- HIGH

PRESSURE

- HIGH
- LOW
- VACUUM
- PRESSURE / VACUUM RELIEF

QUALITY

- CONCENTRATION
- IMPURITIES
- CROSS CONTAMINATION
- SIDE REACTIONS
- INSPECTION & TESTING

CONTROL

- RESPONSE SPEED
- SENSOR & DISPLAY LOCATION
- INTERLOCKS

TIMING

- START TOO EARLY; LATE
- STOP TOO EARLY; LATE
- DURATION
- SEQUENCE

PROTECTION

- RESPONSE SPEED
- INDEPENDENCE OF CONTROL
- TESTING

PLANT ITEMS

- OPERABLE
- MAINTAINABLE

(ISOLATION; PURGING; DRYING;
COOLING; WARMING)

(LINE COMPLETE)

OVERALL DRAWING GUIDE WORDS

MATERIALS OF CONSTRUCTION

- ABNORMAL CONDITIONS
(chilling, exposure to fire)
- CORROSION
- EROSION

SERVICES

(needed & consequence of failure)

- AIR (factory, instrument, other)
- NITROGEN (inert gas)
- WATER (process, hot, other)
- STEAM (pressure, quality)
- POWER
- OTHER (exhaust, suppression, fuel)
- CIP

COMMISSIONING & STARTUP

- STATUTORY APPROVALS
- TRAINING
- SUPERVISION
- COMPLIANCE CHECKING
- SEQUENCE OF STEPS

SHUTDOWN

- ISOLATION
- PURGING
- SEQUENCE

BREAKDOWN

- LOSS OF SERVICES
- "FAIL-SAFE" RESPONSE
- EMERGENCY PROCEDURES

ELECTRICAL SAFETY AND IGNITION SOURCES

- Flammability Issues
 - AREA CLASSIFICATION
 - ELECTROSTATIC DISCHARGE
 - BONDING
 - EARTHING
- Equipment protection
 - IP Code requirements

FIRE & EXPLOSION (also toxic cloud)

- PREVENTION
- DETECTION
- PROTECTION
- CONTROL
- REMOTE ISOLATION

TOXICITY

- ACUTE
- LONG TERM
- VENTILATION

(Irritation, sensitisation)

ENVIRONMENTAL CONTROL

- DISCHARGES:
 - GASEOUS
 - LIQUID
 - SOLID
- NOISE
- ODOUR
- MONITORING

ACCESS

- OPERATION
- MAINTENANCE
- ESCAPE
- EMERGENCY RESPONSE
- INTERLOCKED ACCESS

TESTING

- RAW MATERIALS
- PRODUCTS
- IN-PROCESS
- EQUIPMENT
- ALARMS & TRIPS

SAFETY EQUIPMENT

- PERSONAL PROTECTIVE EQUIPMENT
- SAFETY SHOWERS/EYE WASH
- BREATHING APPARATUS
- FIRE FIGHTING

OUTPUT

- SOURCES OF UNRELIABILITY
- BOTTLENECKS

EFFICIENCY
(material losses)

- TO AIR
- TO DRAIN
- TO FLOOR
- TO OTHER PROCESS STREAM
- LOSS OF CONVERSION

(DRAWING FINISHED)

OVERALL PLANT GUIDE WORDS

PLANT LAYOUT

- ACCESS
- IMPACT ON PERSONNEL:
 - BY MOVING EQUIPMENT
 - BY MOVING / SPILLED PRODUCT
 - BY FALLING OBJECTS (covers, parts)
 - BY TOPPLING / OVERTURNING OBJECTS
- FALLS FROM HEIGHTS

PRODUCT &c HANDLING

- EXCESSIVE WEIGHT
- AWKWARD POSITION
- AWKWARD OBJECT
- REPETITIVE

MACHINE GUARDING

- PHYSICAL BARRIER/FENCE
- OPTOELECTRONIC &c
- INTERLOCKS

(lack; removal; interlock bypass)

PLANT OVERVIEW

The HAZOP was conducted on the P&ID and other drawings, without written operating and other procedures. Reference was made to practices at other, similar installations where appropriate to determine elements to be specifically included in procedures.

ANALYSIS OF MAIN FINDINGS

The main findings were evaluated by using the following methodology.

The outcome of each deviation was evaluated to verify if the consequence would pose a hazardous condition to the plant, or those within and outside the site. Conditions likely to cause frequent loss of continuous chlorination of the water supply were also included.

If a hazardous or loss scenario was considered credible, the analysis was continued to develop a safeguard to eliminate or minimise the possibility. Where the possibility still existed (although reduced), additional alarms and trip systems were recommended.

The study results are detailed in the minute sheets on pages 19 to 28

ACTION ARISING FROM THE HAZOP

The recommendations, modified by the outcomes of the subsequent detailed analyses as outlined above have all been incorporated into the design as shown on the revised P&ID No. WTP-P-289-01-Rev 0 at Appendix C.

The implementation of the changes as a result of the HAZOP has not raised any actions which may be considered potentially hazardous to plant personnel, the public or the environment.

The pre-commissioning and commissioning checklists and test procedures will be prepared to ensure that the final recommendations of the HAZOP are verified at every appropriate stage.

An implementation plan for the changes is being prepared and will accompany this report

APPENDICES

- A Original P&ID, Drawing No WTP-P-289-01 Rev D
- B HAZOP Minutes
- C Amended P&ID, Drawing No WTP-P-289-01 Rev 0
- D HAZOP Implementation Plan

A ***Original P&ID***

B HAZOP Minutes

System: Chlorine Dosing Line 1 - Chlorine Drum Delivery Line 2 - Layout Line 3 - Chlorine Drum No. 1 to Chlorinator No.1 Line 4 - Service Water Line Line 5 - Interconnections Line 6 - Overall	Date: Tuesday 6th May 2008	Present Peter Hunt (Facilitator) Hubert Murray (Process Engineer - Coffs Water) Glenn O'Grady (Manager, Major Works) - p/t George Frougas (Commissioning Manager) Simon Thorn (Water Operations Manager) Nathan Oliver (Commissioning Engineer) Mark Aitken (Water Industry Specialist) - p/t Mark Cousins (Mechanical Engineer) Mike Chapman (Process Engineer/Process Designer) Mark Knight (Electrical Engineer) - p/t Peter Buckingham (Electrical Superintendent - Water) Phil Woodford (Minutes) Les Potter (Senior Operator)	
	Time: 9am to 2.30pm		
	Location: WTP Meeting Room, Karangi		
Drawings: WTP-P-289-01-D P&ID marked up WTP-A-289-01-B WTP-C-289-01A (partially superseded)			

Item No. (1)	Line No. (2)	GUIDE WORD / DEVIATION (3)	POSSIBLE CAUSES (4)	CONSEQUENCES (5)	EXISTING SAFEGUARDS (6)	ACTION REQUIRED (7)	BY (8)	ACTION TAKEN & STATUS
1	1	Product and Handling	Drums and cylinders are delivered out of hours and are left unattended overnight until an operator reports for duty. Empty drums and cylinders are left outside awaiting collection, again, unattended for a number of hours	Vandals could roll cylinders around site or remove them from site, possibly causing harm or damage, also possibly damage drums	Nil	CHCC to prepare procedure for the receipt of chlorine drums and cylinders based on operator to be present to receive deliveries of drums.	GO'G	
2	1	Safety Eqpt - PPE	Persons on site unknown to CHCC	Country Energy staff will be onsite without CHCC being aware of this	N/A	CHCC to prepare procedure for Country Energy coming on site to read meters	GO'G	
3	1	Product and Handling	Existing procedure has some operational issues	Drums, either full or empty could be left unattended on site, for a number of hours at a time	Existing procedure is used at Red Hill	Drum Changeover procedure to be written	GO'G	
4	1	Services	N/A	N/A	N/A	Show the following items on the SCADA a) Flow switch on the safety shower b) Ventilation fan c) Room heaters	MC	

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5	1	Shutdown - Isolation	N/A	N/A	N/A	Show on the SCADA system, the following inputs which initiate a Chlorine gas shutdown: a) Handswitch b) 12VDC failure c) Compressed air failure d) Chlorguard alarm	MC	
6	2	Control - Interlocks	P&ID layout is not intuitive	Confusion may arise in rushed situations	N/A	Mirror reverse P&ID so that chlorine flow is from left to right. Additionally, this will reflect the arrangement on site.	MK	
7	2	Layout	During normal unloading involve shunting the gas drum up to the internal wall	Drums might be pushed through the dividing wall, thereby damaging equipment in the Chlorinator Room	Nil	Architect's drawing and mech layout to show 900mm between full drums and south (internal) wall - see also Item 12	MC	
8	2	Layout	Layout needs to be revised to suit outcomes from HAZOP	Operational and maintenance restrictions	Nil	Upgrade mechanical layout drawing	MC	
9	2	Services	Ventilation could be improved	Increased exposure of operator to minor leaks during drum changeover	Ventilation is placed in west wall of Chlorine Building	Place low level exhaust on the east wall to blow air away from the operator	CM	
10	2	Services	N/A	N/A	Switch proposed but not included in FDS	Update FDS to show that a manual switch can turn on the mechanical ventilation when required	CM	
11	2	Layout	N/A	N/A	Nil	Remote ventilation switch (HS3) to be mounted externally between Door 2 & Door 3 Doors to open out 180 degrees with holdback. D02 to open to north	MK	

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12	2	Layout	Lines from drums may obstruct access	N/A	Gas lines to run overhead from drums to Chlorinator Room	Gas lines to run at a low level from drums to chlorinators with an aluminium stepover which won't create a trip hazard	MK	
13	2	Layout	Vision of drum room may be restricted	Operator may enter the room in unfavourable circumstances to gain a better view of any problem	Smaller window	Window in internal wall to be 1200mm wide and 900mm high.	CM	
14	2	Materials of Construction - Corrosion	Electrical panel and components become corroded	Potential for electrical faults due to corroded items	DB rating is standard, metal enclosure	DB has to be rated to the appropriate IP rating as per the Code and to be constructed from plastic or other suitable non-corrosive material	MK	
15	2	Layout	Gas detectors not located in the optimum position	Possible delay in gas alarms operating	Two chlorine detectors are to be provided to each room	Chlorine detectors to be located away from a stagnant corner being a) Drum room below window	MK	
16	2	Layout	Natural light is always best to work in	Risk of accidents increases	Obtuse light will fill room via ventilation grilles	Add skylights (2) to roof of Chlorinator Room with external security mesh	CM	
17	2	Layout	Code nominates that radiant heaters not be used even though they pose no threat and most people use them	Exposed electrical elements could become corroded	Nil	Heaters to be IR type	MK	
18	2	Layout	Staff may trip when rushing to the safety shower	Trip hazard	General yard maintenance	Hardstand between Doors 2 & 3 and up to safety shower (whole length of building) to be replaced by concrete	CM	
19	2	Layout	Staff may trip when rushing to the safety shower	Trip hazard	General yard maintenance	Link up new footpath along western side of Chlorine building with footpath along the front of the Chemical Bund area	CM	

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20	2	Layout	Unauthorised entry	Possible security breach by vandals	Perimeter fence and standard solid core doors	Double doors for drum entry to be solid construction for both durability and security. Reed switches and manual hold back devices to be fitted.	CM	
21	2	Layout	SCBA unit not readily available	Time to reach a breathing set is too long and the unit would be out of sight	SCBA set was planned to be located in the Control Building	SCBA set is to be located at least 10m away, in a locked box on the outside of the DAFF building, at the NE corner of the former CO2 Room. SCBA to be provided by CHCC	GO'G	
22	2	Layout	Emergency services staff may not be familiar with the site	Potential delay in responding to a site emergency	Nil	Emergency Services to be given a tour of the site at completion of the project	GO'G	
23	2	Layout	Emergency services staff may not be familiar with the site	Potential delay in responding to a site emergency	Nil	Emergency Response Plan to be prepared and submitted to the NSWFB	PH	
24	2	Layout	Pendant may fail to operate during a lifting of a chlorine drum	Corrosion of electrical items	Pendant stored inside the building	Pendant and hoist mechanism to be rated for outdoor use	CM	
25	2	Layout	Hose down water may pool in Drum Room	Corrosion of equipment may occur	N/A	Ensure all footpaths and hardstand areas fall away from the building to ensure that the building does not flood	CM	
26	3	Low flow	Valve on interconnecting header between Gas Train 1 & 2 is normally closed	Operator would need to attend site to instigate a manual changeover if one of the chlorinators failed	N/A	Operating Procedure is to show that the changeover valve 289-V-26 is normally open. Reject Siemens alternative which has only one line going through wall from the Drum Room, and hence minimise redundancy	GO'G	
27	3	Low flow	Valve on interconnecting header between Gas Train 1 & 2 is normally closed	Operator would need to attend site to instigate a manual changeover if one of the chlorinators failed	N/A	P&ID is to show that the changeover valve 289-V-26 is normally open	MC	

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28	3	Toxity - Ventilation	Vent gases may re-enter building	Operators may be exposed to minor gas leaks	Nil	PRVs discharge line to exit on the eastern wall, at least 1.5m from any opening into the building. Add Note 6 to the P&ID to reflect this.	MC	
29	3	Toxity - Ventilation	Vent gases may re-enter building	Operators may be exposed to minor gas leaks	Nil	Fit a chain barrier at either end of the eastern side the Chlorine Building with signs which discourage people moving or congregating in this area where the PRVs discharge	MC	
30	3	Toxity - Acute	A partially full drum may be sent back to Orica	Refilling staff may overfill drum inadvertently	Drums sit on weigh scales	Verify that the FDS allows for when a drum with a non-empty duty drum changes over, then a non-critical alarm is raised	CM	
31	3	Electrical Safety	Earth fault	Possible risk of electrocution	Insulation	Verify that the heaters on the vacuum changeover device are 24VDC (preferably) or ELV	MK	
32	3	Shutdown - Isolation	N/A	N/A	N/A	The gas detection system shall be leased and will be from Orica	GO'G	
33	3	Toxic cloud - detection	Location has not been decided	Windsock may not be immediately apparent during an emergency to assist in determining wind direction	N/A	Windsock to be located on a standard, lowerable flagpole, positioned just north of the Chlorine Building	CM	

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34	3	Shutdown - Purging	Some residual gas may remain in vented lines	Operator may be exposed to minor leaks	Normal venting to atmosphere	Add a tee connection to each half of the header to allow the line to be purged with either ambient air or (preferably) a hired nitrogen bottle. Have a regulator available and add this to the SOP. With the ejectors operating, isolate the gas drums and open the connection to the purge.	MC	
35	3	Services	Lack of hosedown facilities will make it difficult to keep the building clean and to respond to small fires	A small fire from combustible materials may threaten the drums	Two hydrants are located on site	Add a hose point, external to the building, next to the safety shower	MC	
36	3	Access - Emergency response	An open door may hide signage	Possible confusion may arise during an emergency	Signage is mounted on one side of entry doors	Signage to be mounted both sides of doors since they open 180 degrees	MC	
37	3	Pressure	Pressure gauges may not be located in an optimum position	Operator may have difficulty in determining what problems are present in an emergency	Pressure gauges are provided	Relocate pressure indicators 289-PI-09 & 10 to inside the building	MC	
38	3	Controls	N/A	N/A	N/A	Ensure the Chlorinator package vendor understands that the motorised valves which are to be supplied shall conform to Note 5 on the P&ID, relating to the fitting of limit switches, etc.	MC	
39	3	Low temperature	Low ambient temperatures	Insufficient gas vapouring drum will result in underdosing of chlorine	GPOs will be provided to the building	Ensure that there are two GPOs in the Chlorinator Room but none in the Drum Room. This will allow a heater to be fitted to the Chlorinator Room if necessary.	MK	

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40	3	Reverse flow	PLC controls may open the gas flow even if water flow is not established	Reverse flow may occur	Flow switch is proposed as part of the control system	Ensure the FDS shows that the gas discharge valve from the Chlorinators only opens when the Flow Switch 289-FS-04 is made	NO	
41	3	Reverse flow	Valve 289-V-29 may be left open	Reverse flow may occur	Reliance on manual closing of valve	Modify P&ID to show that cross-over valve 289-V-29 is kept closed and locked	MC	
42	3	Reverse flow	Valve on a dosing lance may be left closed	Dosing may not occur	Reliance on manual opening of valve	Valves at dosing lance to be marked normally open and locked on the P&ID	MC	
43	3	Controls	N/A	N/A	N/A	Re-draft NRV 289-V-16 on the P&ID	MK	
44	3	Controls	N/A	N/A	N/A	Re-draft P&ID to show "Eductor" not "Ejector"	MK	
45	3	Operation	N/A	N/A	N/A	Re-draft the P&ID to show a handswitch (i.e. waterproof pendant) on the crane	MK	
46	4	Redundancy	Blockage in the rotameter or splitting of the rotameter tube	Service water flow may be significantly affected	Ongoing maintenance	Amend P&ID to show: a) A locked closed, 40mm bypass around the rotameter and its associated valves & NRV b) Remove the needle valve which is upstream of the rotameter c) Install a ball valve upstream of the rotameter d) Install a diaphragm valve downstream of the rotameter e) Leave the non-return valve further downstream, as indicated f) Install a ball valve downstream of the NRV	MC	

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47	4	Maintainable	Pressure gauges may fail	Loss of indication, possible leakage point	Ongoing maintenance	Pressure gauge 289-PI-03 & 05 to be changed to a diaphragm type pressure gauge	MK	
48	4	Maintainable	Pressure gauges may fail	Loss of indication, possible leakage point	Ongoing maintenance	Agree the need for pressure gauges across the site to all be diaphragm type	MK	
49	3	Materials of Construction - Corrosion	Hose may fail	Possible leakage point	Ongoing maintenance	Advise the team as to the material of the flexible hose which is installed immediately downstream of the regulator/vacuum changeover valve in each gas train (Note PVC hose would be suitable).	MC	
50	3	Maintainable	Hose may fail	Possible leakage point	Ongoing maintenance	Provide spare of the flexible hose which is installed immediately downstream of the regulator/vacuum changeover valve in each gas train	MC	
51	6	Materials of Construction - Corrosion	Exhaust system may corrode and fail	Ventilation of the building will be impaired	Ongoing maintenance	Exhaust fan and ducting is to be PVC to resist corrosion. Motors and electrics are to have an IP rating to suit Code requirements.	CM	
52	6	Materials of Construction - Corrosion	Cable ladder may corrode and fail	Increased maintenance cost	Ongoing maintenance	Use fibreglass unistrut cable ladder to adequately resist corrosion	MK	
53	6	Shutdown - Isolation	Gas leak may result in gas concentrations in the building	Exposed electrical elements could become corroded	Ongoing maintenance	Update FDS to indicate that when the gas alarm goes off, the heaters shut off.	CM	
54	1	Product and Handling	Road radiuses may be too tight	Delivery vehicle may get struck on site	Layout is prepared for truck deliveries	Turning circles to be checked to verify that the chlorine delivery truck (semi with a dog trailer) can adequately negotiate the site	CM	

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55	1	Product and Handling	Cross fall on roadway may be too steep	Forklift may lose load	Kerb in front of stores have been removed	Check the side slope of the roadway in front of the Chlorine building is adequate for a forklift	CM	
56	6	Commissioning and Start-ups - Statutory Approvals	N/A	N/A	N/A	Submit DoP and WorkCover approvals	PH	
57	1	Product and Handling	Some features of the site may restrict delivery	Delivery vehicle may get struck on site, or necessary equipment may be lacking	Existing driveway layout	Schedule in an Orica pre-delivery inspection	GO'G	
58	4	Services	Service trough was proposed which would drain to ground outside the Building	Proposed trough is not needed	N/A	Delete trough from eastern end of Chlorinator Room	CM	
59	6	Services	A small fire may break out	Fire may threaten the drum store	No locations currently determined	Determine the number and location of the fire extinguishers for the site	CM	
60	6	Services	A fire may occur on site	A delay may arise in fighting a fire	Fire service to bring their own fog nozzle to site	Provide a fog nozzle for fire fighting	GO'G	
61	6	Services	A fire or gas leak may occur on site	A delay may arise in fighting a fire	Two hydrants are located on site	Verify that the hydrant point is within 60 metres of all points in the Chlorine Building	CM	
62	6	Commissioning and Start-ups - Statutory Approvals	A fire may occur on site	A delay may arise in fighting a fire or responding to an emergency	Fire service normal response	Resolve emergency response access out of hours	GO'G	
63	3	Maintainable	N/A	N/A	N/A	Ensure there is a spare gel cap for the residual chlorine analyser	MK	

Item No. (1)	Line No. (2)	GUIDE WORD / DEVIATION (3)	POSSIBLE CAUSES (4)	CONSEQUENCES (5)	EXISTING SAFEGUARDS (6)	ACTION REQUIRED (7)	BY (8)	ACTION TAKEN & STATUS
64	4	Start-up	After a power failure, the plant may re-start on the diesel generator	Reverse flow of gas may occur	Nil	Ensure the FDS for the Generator Re-start nominates that the Treated Service Water Pump starts first	CM	
65	1	Product and Handling	Mis-handling may result in a drum falling and striking the ground	Potential for a gas leak	Operator experience	Prepare a procedure for handling 70kg cylinders (both chlorine & air for the Chlogard units)	GO'G	
66	1	Product and Handling	N/A	N/A	N/A	Add the two G-size air cylinders to the overall layout	CM	
67	1	Product and Handling	Mis-handling may result in a drum falling and striking the ground	Potential for a gas leak	Operator experience	Provide a support/stand for the regulator for use whenever the drums are changed over	MK	

C Amended P&ID, Drawing No WTP-DWG-P-289-01 Rev 0

D HAZOP Implementation Plan