AJC JOINT VENTURE

By Hand

The EIA Ordinance Register Office,
Environmental Protection Department
27th floor, Southorn Centre
130 Hennessy Road
Wanchai, Hong Kong

Ref.: AJC/EPD/210012

Date: 13 July 2021

Attn.: Mr. Ronan CHAN

Dear Sir,

RE: CONTRACT NO.: 13/WSD/17
DESIGN, BUILD AND OPERATE FIRST STAGE OF TSEUNG KWAN O DESALINATION PLANT
Submission of Detailed Design Plan for Chlorine and Carbon Dioxide Storage of Desalination Plant

As per Condition 2.12 of both Environmental Permit No. EP-503/2015/A and Further Environmental Permit No. FEP-01/503/2015/A, we would like to submit herewith 4 hard copies and 1 electronic copy of final revised Detailed Design Plan for Chlorine and Carbon Dioxide Storage of Desalination Plant to the Director for approval. The respective table of responses to comments is also attached for your easy reference.

Should you have any enquiry, please do not hesitate to contact our Environmental Monitoring Manager, Brian Kam at 9456 9541.

Thank you for your attention.

Yours faithfully
For and on behalf of AJC Joint Venture

Stephen Yeung
Project Manager

SY/SP/LWWK/BK/pcm

Encl.

c.c.: Binnies Hong Kong Limited – Ms. Christina Ko (By Email)
Binnies Hong Kong Limited – Mr. Roger Wu (By Email)
ANewR Consulting Limited – Mr. Louis Kwan (IEC-Construction) (By Email)
SMEC Asia Limited – Mr. Antony Wong (IEC-Design) (By Email)
Acuity Sustainability Consulting Limited – Jacky Leung (ET) (By Email)

CDX/ER4/2021/L2222

AJC Joint Venture
5/F, Tower A, Manulife Financial Centre,
223-231 Wai Yip Street,
Kwun Tong, Kowloon, Hong Kong

ACUITY SUSTAINABILITY CONSULTING LIMITED

Website: www.acuityhk.com

Unit C, 11/F, Ford Glory Plaza,
Nos. 37-39 Wing Hong Street,
Cheung Sha Wan, Kowloon.

Tel. : (852) 2698 6833
Fax.: (852) 2698 9383

Our Ref. : DPTKO/L202107016
Date : 9th July 2021

By Email

AJC Joint Venture
5/F, Tower A, Manulife Financial Centre,
223-231 Wai Yip Street,
Kwun Tong, Kowloon, Hong Kong
Attn: Mr. Brian Kam (Environmental Monitoring Manager)

Dear Mr. Kam,

Contract No. 13/WSD/17
Design, Build and Operate First Stage of Tseung Kwan O Desalination Plant
Detailed Design Plan for Chlorine and Carbon Dioxide Storage of Desalination Plant

I refer to the updated Detailed Design Plan for Chlorine and Carbon Dioxide Storage of Desalination Plant (Document no. : TKOD1-RPT-A000-JGN003-01) issued on 24th May 2021. Provided that no Chlorine product from the proposed OSCG system will be stored under different operation modes of the desalination plant, please note that we herewith certify the captioned submission in accordance with Condition 2.12 of Further Environmental Permit FEP-01/503/2015/A and Environmental Permit EP-503/2015/A.

Should you have any queries, please do not hesitate to contact the undersigned at 2698 6833.

Yours faithfully,

For and on behalf of
Acuity Sustainability Consulting Limited

Jacky Leung
Environmental Team Leader

SMEC
Member of the Surbana Jurong Group

local people
global experience

Our ref: 7076466/L27637/AB/AW/rw

9 July 2021

Water Supplies Department
6/F Sha Tin Government Offices
1 Sheung Wo Che Road
Sha Tin, NT

By Email & By Post

Attn: Mr Simon LAU (Engineer/Consultants Mgt 8)

Dear Sir

First Stage of Desalination Plant at Tseung Kwan O – Investigation, Design and Construction
Detailed Design Plan for Chlorine and Carbon Dioxide Storage of Desalination Plant
IEC Verification Letter

Reference is made to the *Detailed Design Plan for Chlorine and Carbon Dioxide Storage (Document No.: TKOD1-RPT-A000-JGN0003-04, dated May 2021)* provided by AJC Joint Venture via email on 25 May 2021 which is certified by the Environmental Team (ET) Leader on 9 July 2021 (ET's ref.: DPTKO/L202107016).

We do not have adverse comment on the aforementioned Detailed Design Plan and considered it conforms to the requirements as stipulated in Condition 2.12 of EP-503/2015/A and Condition 2.12 of FEP-01/503/2015/A. We hereby verify the aforementioned Detailed Design Plan for Chlorine and Carbon Dioxide Storage in accordance with Condition 2.12 of EP-503/2015/A and Condition 2.12 of FEP-01/503/2015/A.

Should you have any queries regarding this submission, please do not hesitate to contact the undersigned on tel. 3995 8120 or email to antony.wong@smec.com.

Yours faithfully

Antony WONG
Independent Environmental Checker – Design and Investigation

cc:	BV – Mr Roger WU	(by email)
	IEC (Construction) – Mr Louis KWAN	(by email)
	ET – Mr Jacky LEUNG	(by email)
	AJCJV – Messrs Stephen YEUNG and Brian KAM	(by email)

SMEC ASIA LIMITED
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EPD Comments (email on 8 May 2020)	JV Response
1. Please review and compare the current design and the design submitted in the ERR for the VEP application dated 2017 to confirm that the conclusions of the ERR are still valid from non-fuel gas dangerous goods risk perspective.	There is no change in the design regarding the chemicals or their volumes comparing the current design and that in the ERR for the VEP application dated 2017. Regarding the CO2 locations, the distance from the storage area to both western and northern site boundary has been kept >100m so as to fulfill the EP conditions. Please refer to Appendix B-1 for the storage area location.
2. Please clarify whether the proposed carbon dioxide storage amount is for first stage only or for the ultimate capacity of the desalination plant.	The proposed carbon dioxide storage amount is designed for the ultimate capacity of desalination plant.
3. Please submit the detailed P&ID to demonstrate the compliance of the EP conditions related to carbon dioxide storage tank and road tanker.	Please refer to the attached Appendix B-2 for P&ID of CO2 dosing system and carbon dioxide storage tank, as well as Appendix B-3 for P&ID of road tanker.
4. Please clarify whether there will be synthetic natural gas facilities as proposed in the ERR for VEP application.	There will be no synthetic natural gas facilities at this stage.
5. Appendix C	
(i) Appendix C only discusses the impact by the explosive truck. Please also discuss whether the explosive offloading operation will result in an explosion with overpressure greater than 2 psi in the carbon dioxide storage area.	Appendix C has been revised to include the consequence impact assessment associated with explosive truck and explosive offloading operation as per information from Mines Division of CEDD.
(ii) Please consult Mines Division of CEDD about the maximum capacity per explosive truck from/ to the TKO Area 137 Pier.	The same explosive truck and pier assumptions were adopted in the EIA and the ERR as follows: • Maximum capacity per Mines Division explosive truck from TKO137 pier is 1,750 TNT eqv. kg • Maximum offloading capacity to TKO137 pier is 5,000 TNT eqv. kg The ERR did not change the EIA assumptions on explosive trunk and pier. CEDD (Mines Division) had no comment on the above assumptions during the ERR stage.
(iii) Please provide the reference of the "Blasting Scaling Equation" and confirm that it is applicable for calculating the overpressure generated by the detonation of explosives. Otherwise, please make reference to the approved EIA Reports (e.g. XRL) to calculate the overpressure level.	Appendix C has been revised to aligned with the approaches adopted in the approved EIA Reports (i.e. XRL) to estimate the overpressure levels associated with explosive truck and explosive offloading operation.
6. Figure 1 shows that the OSCG plant is "<100m" from the boundary. Please check. Also, please check the distance between the OSCG plant and the northern boundary of the desalination plant.	The OSCG plant is ">100m" from both the western and northern site boundary as per updated current design. Please refer to Appendix B-1 for detailed location.

EPD Comments (email on 1 December 2020)	**JV Response**
1. Our previous comment about the review of the current design and the design submitted in the ERR dated 2017 is not properly addressed. Apparently, the current design is different from the design in 2017 e.g. the location of the OSCG system but no details of the current OSCG system are provided. Please review and compare the two designs for chlorine and carbon dioxide storage (including OSCG system) in details and confirm that the conclusions of the ERR are still valid.	A review has been added in Appendix C of the revised plan accordingly. The CO_2 storage presented in this plan is designed for the ultimate capacity of the desalination plant (i.e. 270 Mld). The OSCG building (namely R1) as shown in Figure 2 of the plan is designed for the Stage 1 works only (i.e. 135Mld). All the design details of the Stage 2 OSCG system presented in the ERR dated 2017 would remain unchanged. Explanation has been added in Sections 2, 5 and 7 of the revised plan.
2. Appendix B Please explain how the design of the pressure relief valves system can avoid common mode failure.	Explanation has been added in Appendix B-5 of the revised plan. The P&IDs in Appendix B-2 have also been revised.
3. Appendix C The formula quoted in this Appendix refers to human fatality while the concern of 2 psi is about the structural damage. Please refer to the methodology for estimating structural damage in the approved EIA reports to re-calculate the 2 psi effect distance and confirm that the EP condition can be met.	The impact review has been revised and added in Item 2.6 of Appendix A.
EPD Comments (email on 15 April 2021)	**JV Response**
1. Appendix A, Item 2.5 Please clarify whether the explanations in Appendix B-5 are also applicable to carbon dioxide road tanker	Explanations in Appendix B-5 are also applicable to carbon dioxide road tanker. Text has been added in Item 2.5 of Appendix A and title of Appendix B-5 to clarify.
2. Appendix B-7 The presentation in Appendix B-7 is not clear. Please clearly indicate the pipeline alignments of HCl and other chemicals. Please also confirm that the drain system of HCl is separated from the drains of other chemicals to avoid the mixing of incompatible chemicals. We note that there was a chlorine leakage incident from the sump in Tai Po Water Treatment Works in January 2020. Please review the recommendations of this incident (if any) and adopt the measures where applicable.	The presentation in Appendix B-7 has been revised to clearly show the pipeline alignment of HCL and other chemicals. Please be confirmed that the drain system of HCL is separated from the drains of other chemicals as shown in Appendix B-7. The recommendations of the past leak incident have been reviewed and adopted where applicable. Please see Appendix E of the revised Detailed Design Plan for details.

Contract No. 13/WSD/17

First Stage of Tseung Kwan O Desalination Plant

SUBMISSION OF DETAILED DESIGN PLAN FOR CHLORINE AND CARBON DIOXIDE STORAGE OF DESALINATION PLANT

Document No.: TKOD1-RPT-A000-JGN0003-04

Submitted to: Environmental Protection Department

Submitted by: AJC Joint Venture

Date: May 2021

Submission of Detailed Design Plan for Chlorine and Carbon Dioxide Storage of Desalination Plant

TABLE OF CONTENT

APPENDICES

1. Introduction

This submission is prepared and submitted to fulfil Condition 2.12 of Environmental Permit No. FEP-01/503/2015/A.

'No later than 3 months before the commencement of construction of the desalination plant of the Project, 4 hard copies and 1 electronic copy of the Detailed Design Plan for storage of chlorine and carbon dioxide shall be submitted to the Director for approval. The Plan shall show the design requirements/measures as shown in Table 1 of this Permit unless otherwise approved by the Director.

Before submission to the Director, the Detailed Design Plan shall be certified by the ET Leader and verified by the IEC as conforming to the information and recommendations contained in the EIA Report (Register No. AEIAR-192/2015). All design requirements/measures recommended in the approved Detailed Design Plan shall be fully and properly implemented for the Project.'

2. Project Phasing

As assumed in the Environmental Impact Assessment (EIA) Report approved in 2015, the Project would involve 2 stages. Stage 1 works will include the construction of a new desalination plant in Tseung Kwan O (TKO) Area 137 with a capacity of 135 million liter per day (Mld), whilst the Stage 2 works will involve further expansion of the desalination plant to 270Mld in the future.

3. Chlorine Supply

It was assumed in the EIA Report that liquid chlorine would be imported to the desalination plant and stocked on-site in drums which are classified as Potentially Hazardous Installations. Per the latest proposed design, there shall be no on-site chlorine gas storage. Instead, an On-Site Chlorine Generation (OSCG) plant will be constructed to produce chlorine gas on-site to disinfect the process water whereby it provides a secure supply of chlorine and eliminates the risks associated with transportation and storage of liquid chlorine. The overall equation of the electrolysis process for OSCG is as follows: 2 NaCl (sodium chloride) + 2 H_2O (water) = Cl_2 (chlorine gas) + H_2 (hydrogen gas) + 2 NaOH (sodium hydroxide)

4. Carbon Dioxide Storage

Five 96 m^3, vertical liquefied carbon dioxide (CO_2) storage tanks and two dosing systems (1+1) will be provided. The tanks are made of stainless steel to prevent corrosion. The proposed CO_2 storage amount is designed for the ultimate capacity of desalination plant (i.e. 270 Mld).The system includes the following equipment:

<u>Vacuum Insulation Tanks</u>

The inner vessel is made of stainless steel 1.4301. This provides a safe operation due to the much higher design temperature of -196°C. Tank external wall made by carbon steel.

- One duty and one standby vaporizers made of stainless steel;
- 2 automatic vaporizers, nominal capacity 300kg/h each;
- Frame and tubing of our vaporizers are stainless steel; and
- Two condensate trays are installed per unit.

The maximum working pressure is 34bar; the two installed alternating coils are separated with a condense water trap. Examples of this equipment installed is shown below:

Figure 1: Example of CO2 Storage Vessels to be used

5. Building Separation Distances and Design

The separation distance of more than 100m between the CO_2 storage tank area and all the site boundaries (not including hill side) will be maintained under the current design in accordance with the requirements of the Environmental Permit (EP). The CO_2 storage tank area is about 30 m away from the toe of natural slope (**Figure 2** refers). The centre / exhaust points / louvers of the Stage 1 OSCG building and its nearest site boundaries is currently designed to be no less than 100 m. Detailed design of the Stage 2 OSCG system will be carried out at a later Project stage. The reference design of the Stage 2 OSCG system presented in the Environmental Review Report (ERR) (see ***Section 7*** below) is assumed to remain valid. Any future changes of the Stage 2 OSCG design will be submitted to the Environmental Protection Department (EPD) for approval prior to commencement of the Stage 2 construction works.

Besides, the separation distance between the explosives offloading pier at TKO Area 137 and the nearest CO_2 storage tank area is measured more than 300m.

Negative pressures will be maintained in the OSCG and chemical buildings to avoid any accidental gas release.

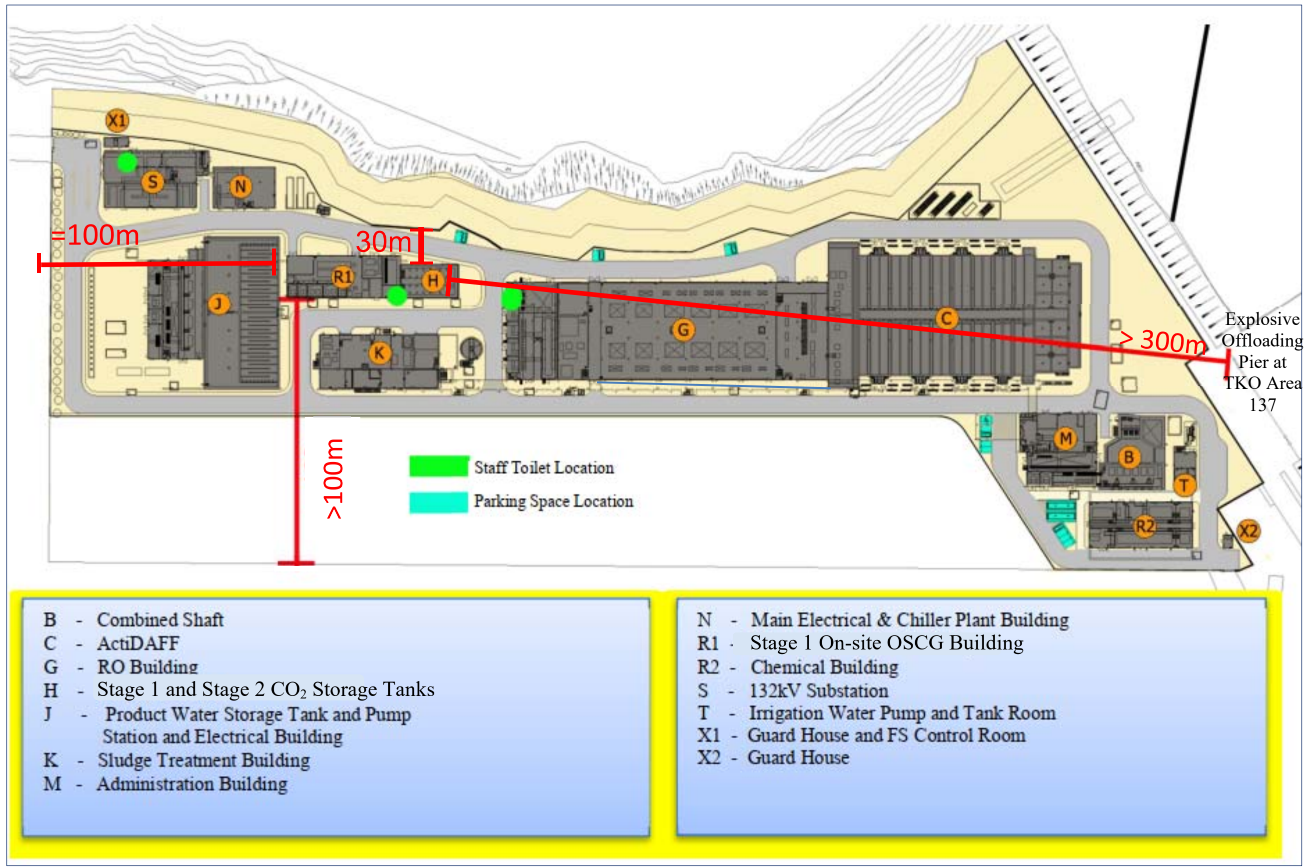


Figure 2: Building Separation Distances

6. Compliance to FEP-01/503/2015/A

List of design requirements / measures for chlorine and carbon dioxide storage as specified in Table 1 of '***Table 1 of FEP-01/503/2015/A***' is reproduced in ***Appendix A***. The actual provisions in the design and upcoming construction is also included therein for easy reference.

7. Comparison with the Reference Design in the Environmental Review Report (ERR)

After the approval of the EIA Report for the Project in 2015, the Project design has been reviewed and several design changes have been identified. An environmental review was carried out in 2017 (after the EIA stage) to address the environmental impacts arising from the proposed design changes and to support the necessary Variation of Environmental Permit (VEP) application. The findings of the environmental review are presented in an Environmental Review Report (ERR), which was accepted by EPD in 2017. A comparison between the current design and the reference design presented in the ERR dated 2017 is provided in ***Appendix C***. Key environmental concerns of the OSCG system and the chemical storage requirements of the Project are explained in detail in the ERR dated 2017. Relevant information is extracted from the ERR in ***Appendix D*** as background information for comparison with the current design.

8. Rectification Measures of Existing OSCG Plant

Problems observed in the existing OSCG plant of Tai Po Water Treatment Works (TPWTW), as well as the design measures of this Project to address or avoid similar problems are presented in ***Appendix E***.

Appendix A:

List of Design Requirements / Measures for Chlorine and Carbon Dioxide Storage vs Actual Provisions

Appendix A: List of design requirements / measures for chlorine and carbon dioxide storage and Actual Provisions

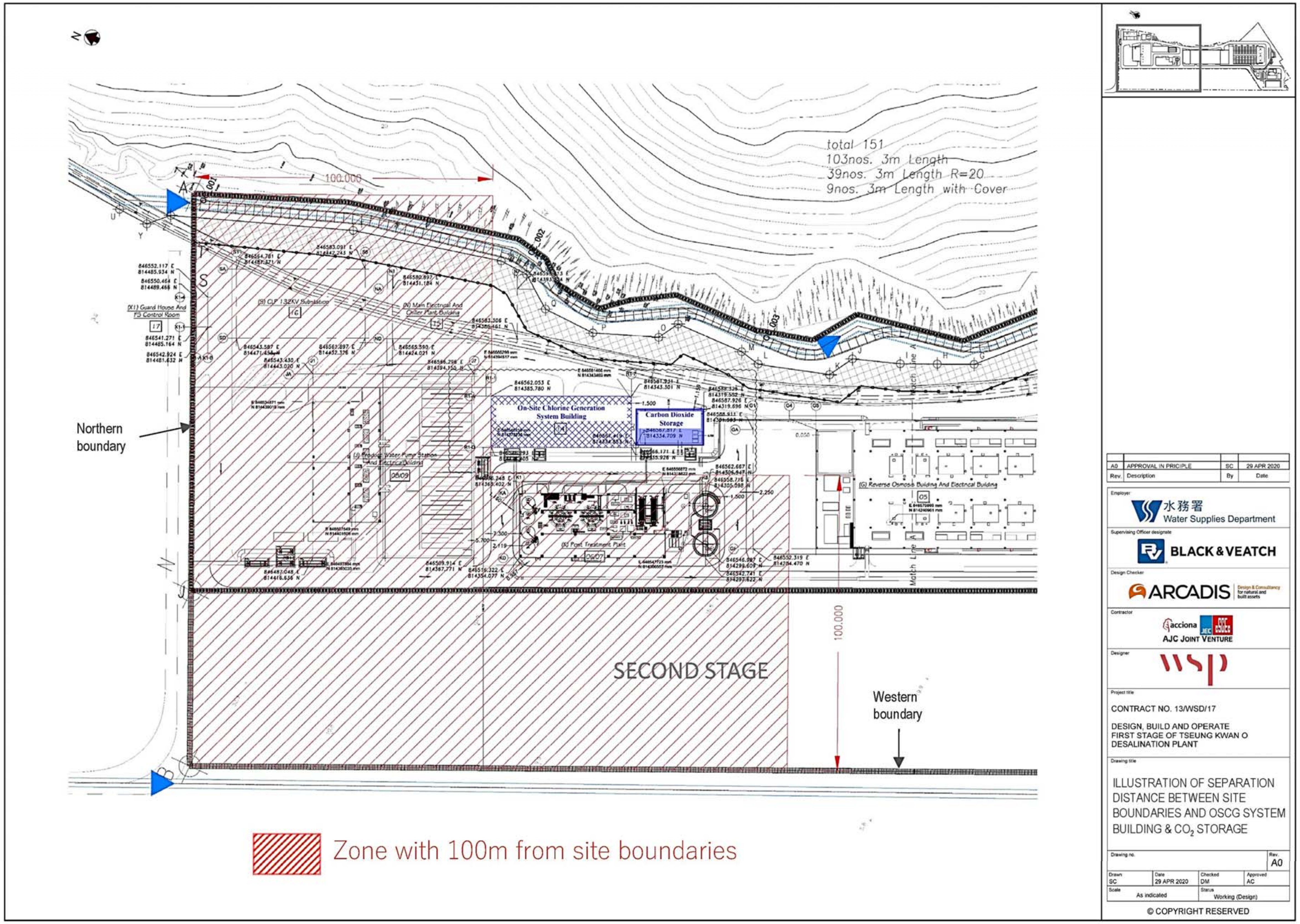
No.	Types of storage	Design requirements/measures	Provisions in the Design
1	**Chlorine store**		
1.1	Chlorine storage quantity in the chlorine store	No more than 37 tonnes in 1-tonne drums	The current design proposes to operate an On-site Chlorine Generation (OSCG) system for use in disinfecting the process water. The use of proposed OSCG system avoids the import of liquid chlorine and need for stocking/ on-site storage of chlorine (i.e. Potential Hazardous Installation) whereby intrinsically eliminating the hazard due to transport (on-site and off-site), use, and storage of liquid chlorine, and thus reducing the risk to human life and the development constraints in the vicinity.
1.2	Volume of chlorine store	Larger than 4200 m^3	
1.3	Design and layout of chlorine store	The chlorine store shall be designed in a way such that the average number of drums ruptured in the worst case scenario during earthquake should be no more than 6.	
1.4	Separation distance between the chlorine store and explosive trucks / TKO Area 137 Pier	The setback distance between the chlorine building and explosive trucks / TKO Area 137 Pier shall provide sufficient clearance **(see remarks below) so that the overpressure resulting from explosion of explosive trucks or the explosives offloading operation that reaches the chlorine building is less than 2 psi.	
1.5	Separation distance between the chlorine store and any one of the site boundary (except for the site boundary adjacent to the Clear Water Bay Country Park)	More than 100m	The Stage 1 OSCG system building is situated at more than 100m away from both northern and western boundaries of the desalination plant. See the illustration in Appendix B-1.
2	**Carbon dioxide store**		
2.1	Maximum number of carbon dioxide storage tank	16 units	5 units
2.2	Type of storage tank	Vacuum insulated, double containment	Vacuum insulated, double containment • The inner vessel is made of stainless steel 1.4301. This provides a safe operation due to the much higher design temperature of -196°C. • Tank external wall made by carbon steel.
2.3	Storage tank capacity	No more than 100 tonnes per tank	Capacity 100 tonnes per tank
2.4	Pressure relief system of carbon dioxide storage tank	1. Pressure protection for the inner vessel shall be provided by 2 sets (1 duty and 1 stand-by) of pressure protection devices. Each set of pressure protection device will be composed of 2 independent pressure relief valves. The pressure relief valves system will be designed to avoid the common mode failure such that the risk of common mode failure is negligible.	Two sets of pressure protection devices will be provided. Each composed of two independent pressure relief valves and designed to avoid common mode failure. See Appendix B-2 for detailed P&IDs of Remineralization CO2 storage tanks and related systems. See Appendix B-5 for further explanation of the pressure relief system.
		2. The pressure protection device on the outer vessel shall be a plate relief device. The plate relief device will be a standard installation in accordance with industrial standards (EN 13458 Part 2 Annex 1).	Confirmed that pressure relief valves to be plate relief valves and will be of EN 13458 Part 2 standard compliant. See Appendix B-5 for further explanation of the pressure relief system.

No.	Types of storage	Design requirements/measures	Provisions in the Design
2.5	Pressure relief system of carbon dioxide road tanker	Pressure protection for the inner vessel shall be provided by 2 sets (1 duty and 1 stand-by) of pressure protection devices. Each set of pressure protection device shall be composed of 2 independent pressure relief valves. The pressure relief valves system shall be designed to avoid the common mode failure such that the risk of common mode failure is negligible.	Two sets of pressure protection devices will be provided. Each composed of two independent pressure relief valves and designed to avoid common mode failure. See Appendix B-3 for the P&ID of CO2 Road Tanker. See Appendix B-5 for further explanation of the pressure relief system.
2.6	Separation distance between the carbon dioxide storage area and explosive trucks / TKO Area 137 Pier	The setback distance between the carbon dioxide storage area and explosive trucks / TKO Area 137 Pier shall provide sufficient clearance**(see remarks below) so that the overpressure resulting from explosion of explosive trucks or the explosives offloading operation that reaches the carbon dioxide storage area is less than 2 psi.	The maximum offloading capacity to the explosive offloading pier at TKO Area 137 is 5,000 kg TNT equivalent explosives. The maximum capacity per Mines Division explosive truck from the explosive offloading pier at TKO Area 137 is 1,750 kg TNT equivalent explosives. According to Section 11.7.17 of the ERR (refers to ***Section 7***), and based on the formula given in the Queensland Explosives Information Bulletin 50 Version 4 (current) Section 12 (the Bulletin 50) and also making reference to Kingery-Bulmash Blast Parameter Calculator on the website of International Ammunition Technical Guidelines, United Nation, the 2 psi overpressure zone for 5,000 kg and 1,750 kg TNT equivalent explosives is within 178 m and 125m from the explosion source respectively. As shown in the current layout in **Figure 2**, the CO_2 storage area is over 300m from the explosive offloading pier, which is greater than the maximum hazard distance or the 2psi overpressure zone of 178m from the explosive source. The CO_2 storage area would have sufficient clearance from the explosive offloading pier under the current design. The current CO_2 storage area would not be impacted by the explosive explosion at the pier. Based on the current plant layout in **Figure 2** and Appendix B-1 and the travel route of the explosive delivery truck provided by Civil Engineering and Development Department (CEDD), the setback distance of the CO_2 storage area is over 125 m from the travel route of the explosive delivery truck. The CO_2 storage area would not be impacted by the road transport of explosives.
2.7	Separation distance between the carbon dioxide storage area and any one of the site boundary (except for the site boundary adjacent to the Clear Water Bay Country Park)	More than 100m	The carbon dioxide storage is situated at more than 100m away from both northern and western boundaries of the desalination plant. See the illustration in Appendix B-1.
2.8	Other safety features of carbon dioxide storage tanks and the facilities	1. Trycock for overfilling alarm and warning shall be provided on carbon dioxide storage tanks.	Trycock valves will be provided for overfilling alarm and warning on CO_2 storage tanks.
		2. High level alarm shall be provided to operating staff at control room for liquid level monitoring and warning.	High level alarm will be provided and connected to main control room.
		3. Fencing shall be provided surrounding the carbon dioxide facilities.	Security fence will be provided around CO2 storage area. See Appendix B-4 for illustration.

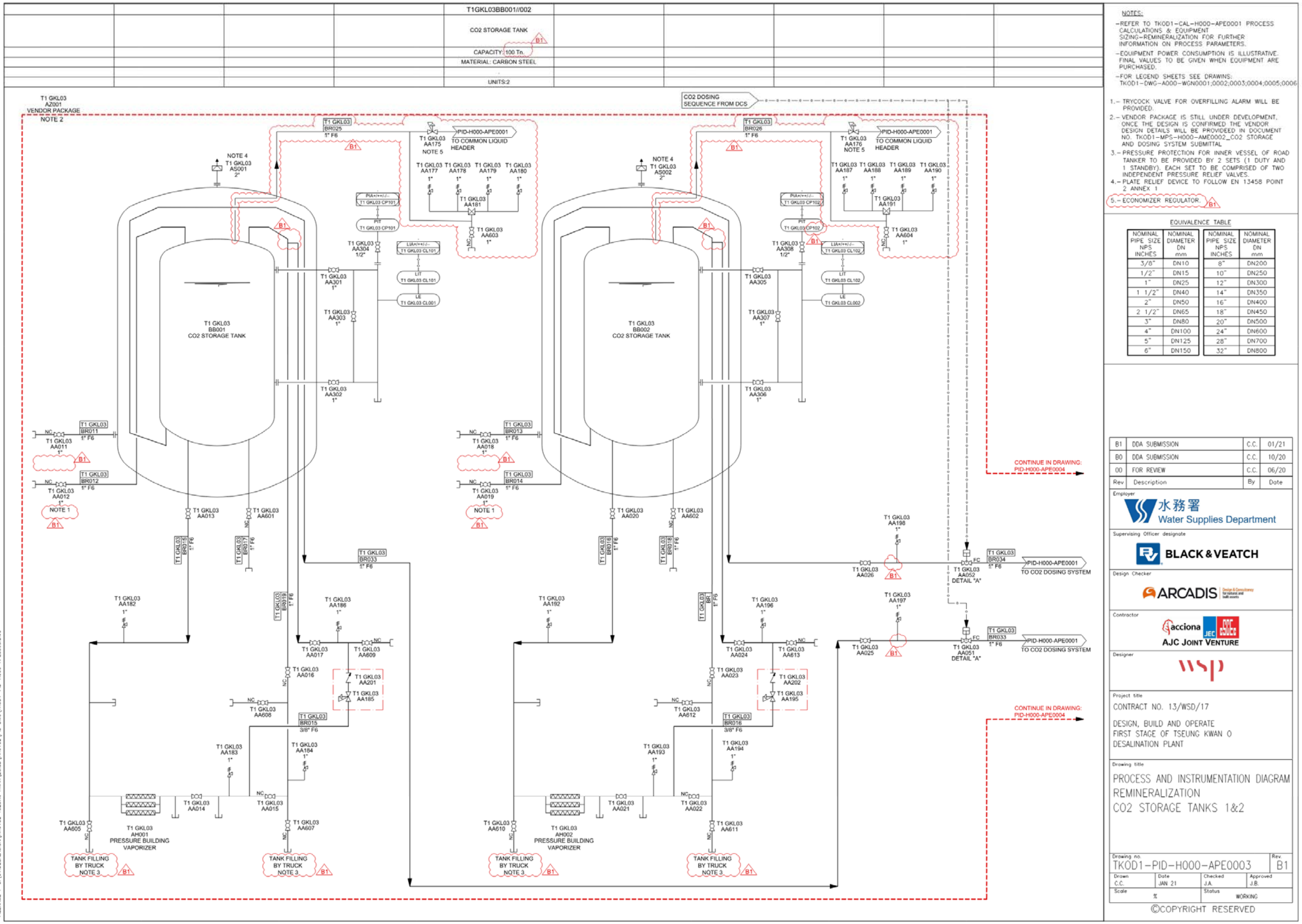
Appendix B:

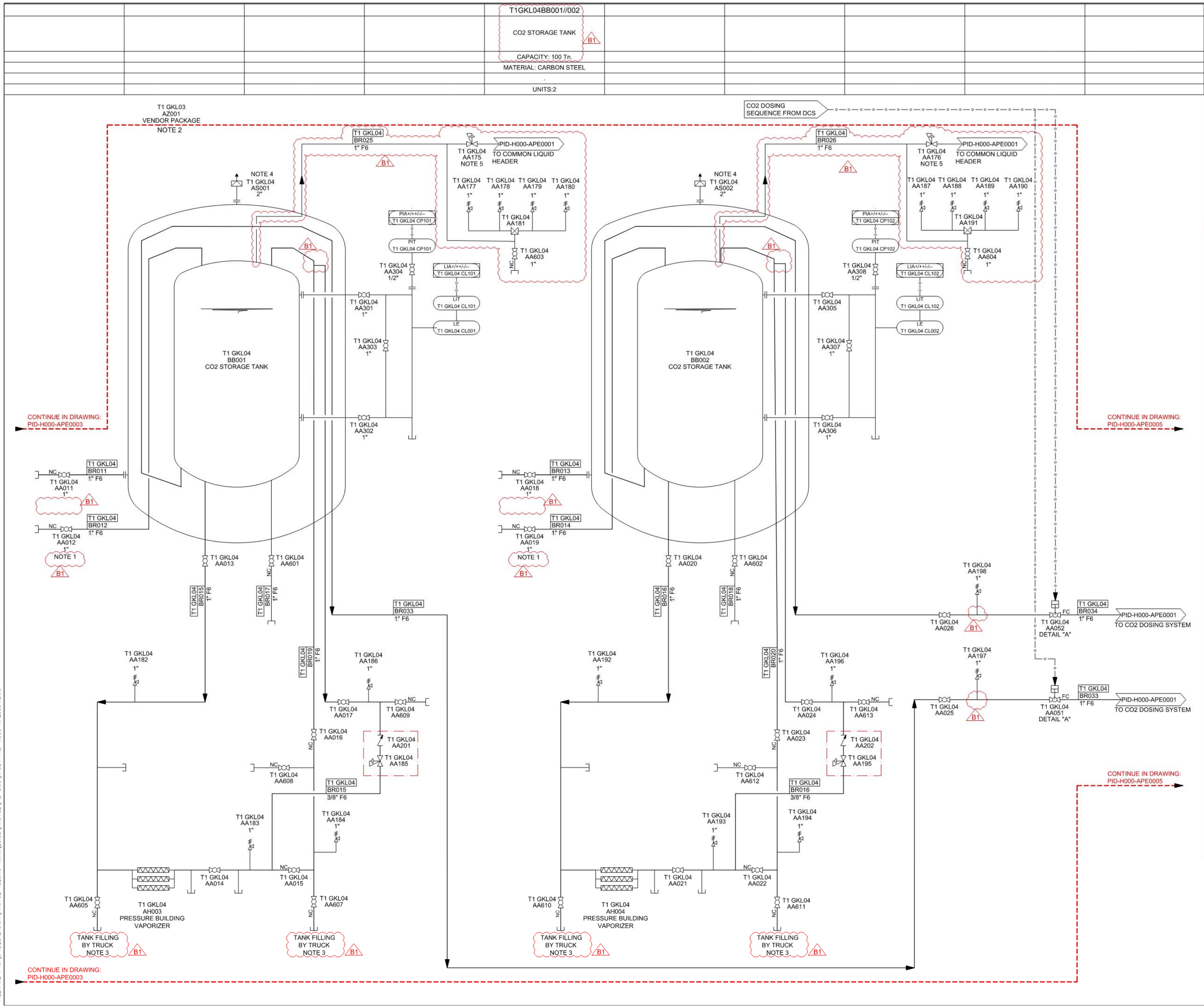
Illustrations with Selected Design Drawings

Appendix B - 1: Separation Distances of On-Site Chlorine Generation System Building and Carbon Dioxide Storage from Site Boundaries



Appendix B - 2: Process & Instrumentation Diagrams (P&IDs) of Remineralisation CO_2 Storage Tanks and Related Systems





NOTES:

- REFER TO TKOD1-CAL-H000-APE0001 PROCESS CALCULATIONS & EQUIPMENT SIZING-REMINERALIZATION FOR FURTHER INFORMATION ON PROCESS PARAMETERS.
- EQUIPMENT POWER CONSUMPTION IS ILLUSTRATIVE. FINAL VALUES TO BE GIVEN WHEN EQUIPMENT ARE PURCHASED.
- FOR LEGEND SHEETS SEE DRAWINS: TKOD1-DWG-A000-WGN0001;0002;0003;0004;0005;0006

1.- TRYCOCK VALVE FOR OVERFILLING ALARM WILL BE PROVIDED.
2.- VENDOR PACKAGE IS STILL UNDER DEVELOPMENT, ONCE THE DESIGN IS CONFIRMED THE VENDOR DESIGN DETAILS WILL BE PROVIDEED IN DOCUMENT NO. TKOD1-MPS-H000-AME0002_CO2 STORAGE AND DOSING SYSTEM SUBMITTAL
3.- PRESSURE PROTECTION FOR INNER VESSEL OF ROAD TANKER TO BE PROVIDED BY 2 SETS (1 DUTY AND 1 STANDBY). EACH SET TO BE COMPRISED OF TWO INDEPENDENT PRESSURE RELIEF VALVES.
4.- PLATE RELIEF DEVICE TO FOLLOW EN 13458 POINT 2 ANNEX 1
5.- ECONOMIZER REGULATOR. B1

EQUIVALENCE TABLE

NOMINAL PIPE SIZE NPS INCHES	NOMINAL DIAMETER DN mm	NOMINAL PIPE SIZE NPS INCHES	NOMINAL DIAMETER DN mm
3/8"	DN10	8"	DN200
1/2"	DN15	10"	DN250
1"	DN25	12"	DN300
1 1/2"	DN40	14"	DN350
2"	DN50	16"	DN400
2 1/2"	DN65	18"	DN450
3"	DN80	20"	DN500
4"	DN100	24"	DN600
5"	DN125	28"	DN700
6"	DN150	32"	DN800

Rev	Description	By	Date
B1	DDA SUBMISSION	C.C.	01/21
B0	DDA SUBMISSION	C.C.	10/20
00	FOR REVIEW	C.C.	06/20

Employer: 水務署 Water Supplies Department

Supervising Officer designate: BLACK & VEATCH

Design Checker: ARCADIS

Contractor: acciona JEC AJC JOINT VENTURE

Designer: wsp

Project title: CONTRACT NO. 13/WSD/17 DESIGN, BUILD AND OPERATE FIRST STAGE OF TSEUNG KWAN O DESALINATION PLANT

Drawing title: PROCESS AND INSTRUMENTATION DIAGRAM REMINERALIZATION CO2 STORAGE TANKS 3&4

Drawing no.: TKOD1-PID-H000-APE0004 Rev.: B1

Drawn	Date	Checked	Approved
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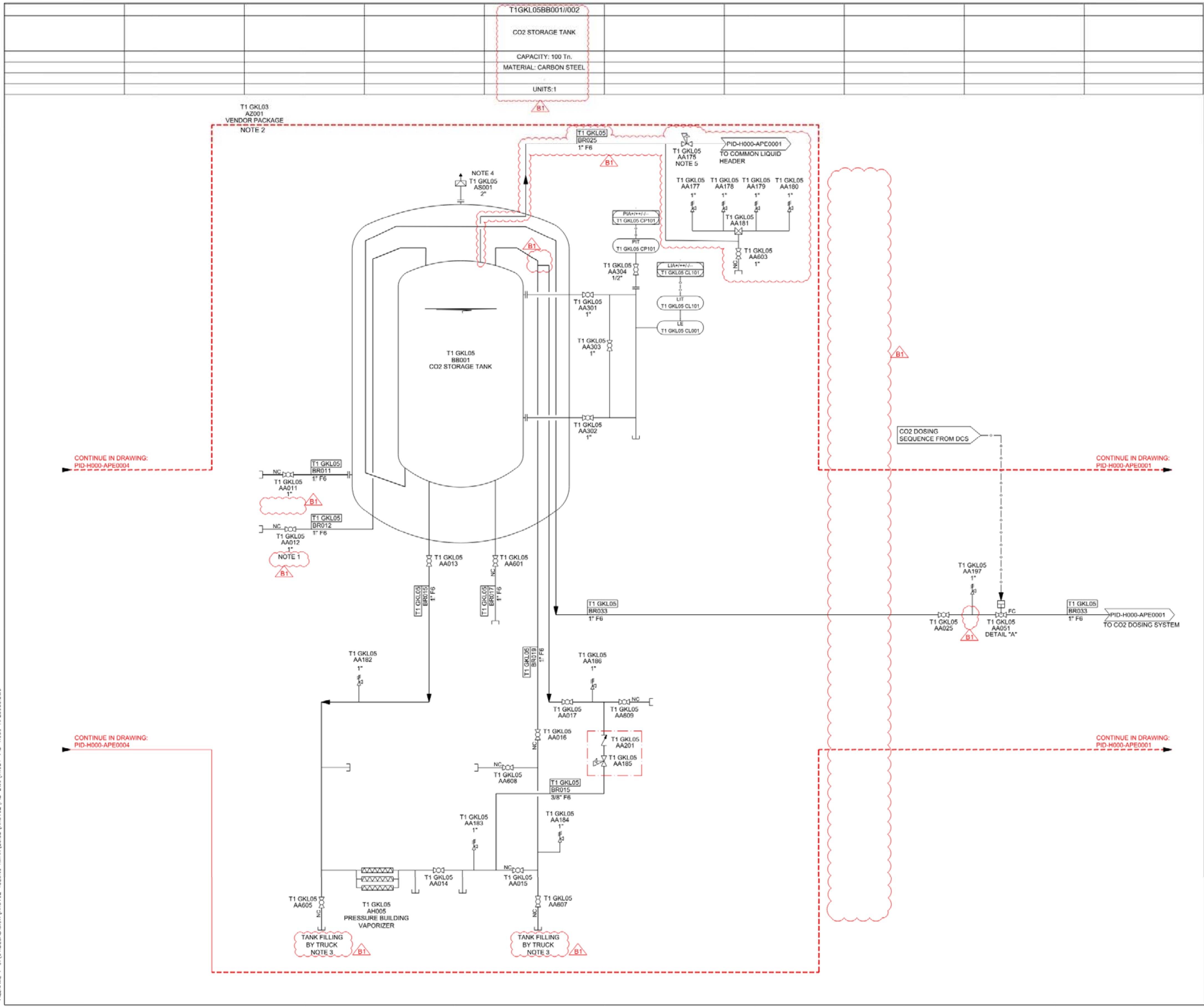
Scale: % Status: WORKING



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- EQUIPMENT POWER CONSUMPTION IS ILLUSTRATIVE. FINAL VALUES TO BE GIVEN WHEN EQUIPMENT ARE PURCHASED.
- FOR LEGEND SHEETS SEE DRAWINS: TKOD1-DWG-A000-WGN0001;0002;0003;0004;0005;0006

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2"	DN50	16"	DN400
2 1/2"	DN65	18"	DN450
3"	DN80	20"	DN500
4"	DN100	24"	DN600
5"	DN125	28"	DN700
6"	DN150	32"	DN800

Rev	Description	By	Date
B1	DDA SUBMISSION	C.C.	01/21
B0	DDA SUBMISSION	C.C.	10/20
00	FOR REVIEW	C.C.	06/20

Employer: 水務署 Water Supplies Department

Supervising Officer designate: BLACK & VEATCH

Design Checker: ARCADIS

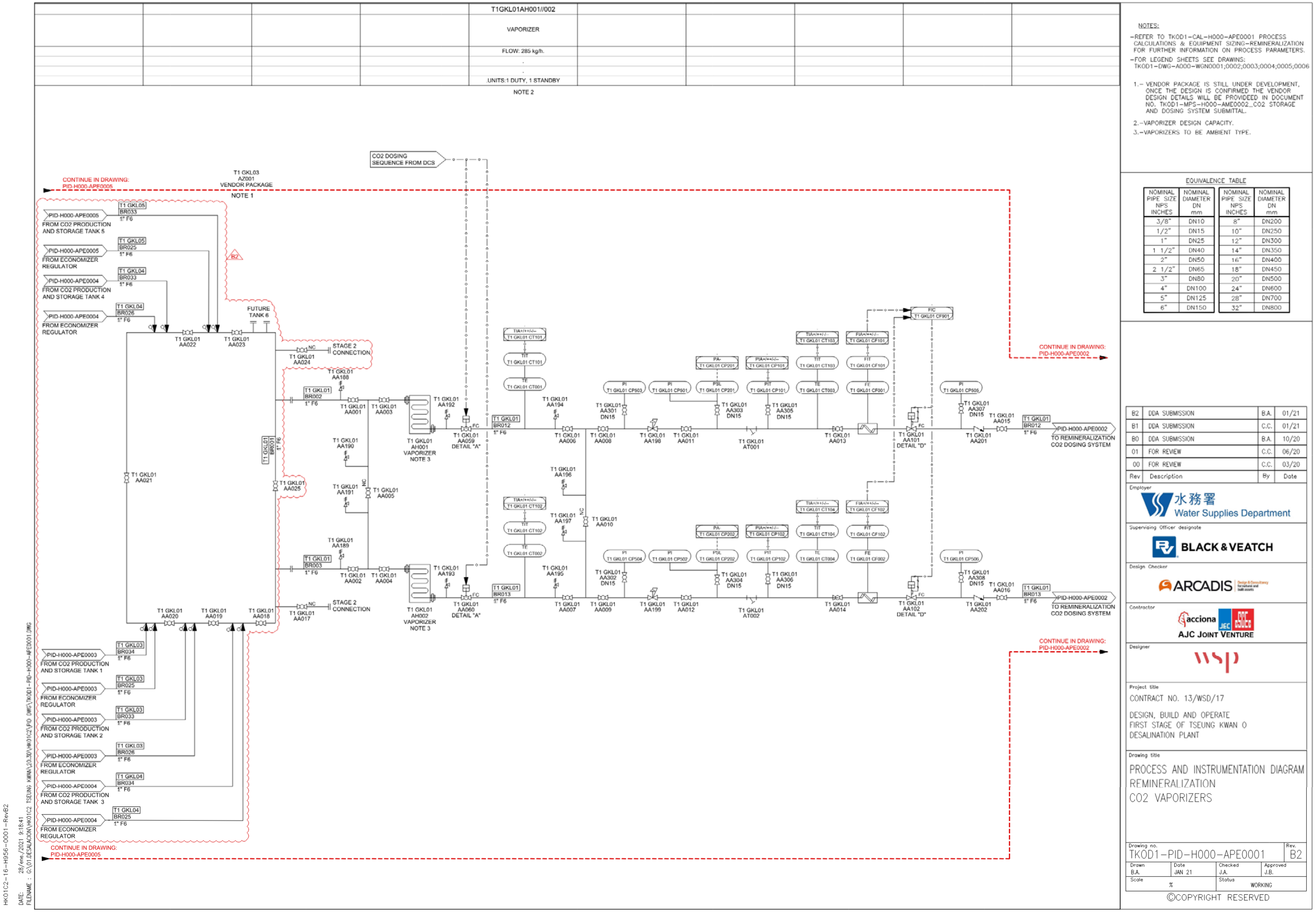
Contractor: AJC JOINT VENTURE

Designer: wsp

Project title
CONTRACT NO. 13/WSD/17
DESIGN, BUILD AND OPERATE
FIRST STAGE OF TSEUNG KWAN O
DESALINATION PLANT

Drawing title
PROCESS AND INSTRUMENTATION DIAGRAM
REMINERALIZATION
CO2 STORAGE TANKS 5&6

Drawing no.			Rev.
TKOD1-PID-H000-APE0005			B1
Drawn: C.C.	Date: JAN 21	Checked: J.A.	Approved: J.B.
Scale: %		Status: WORKING	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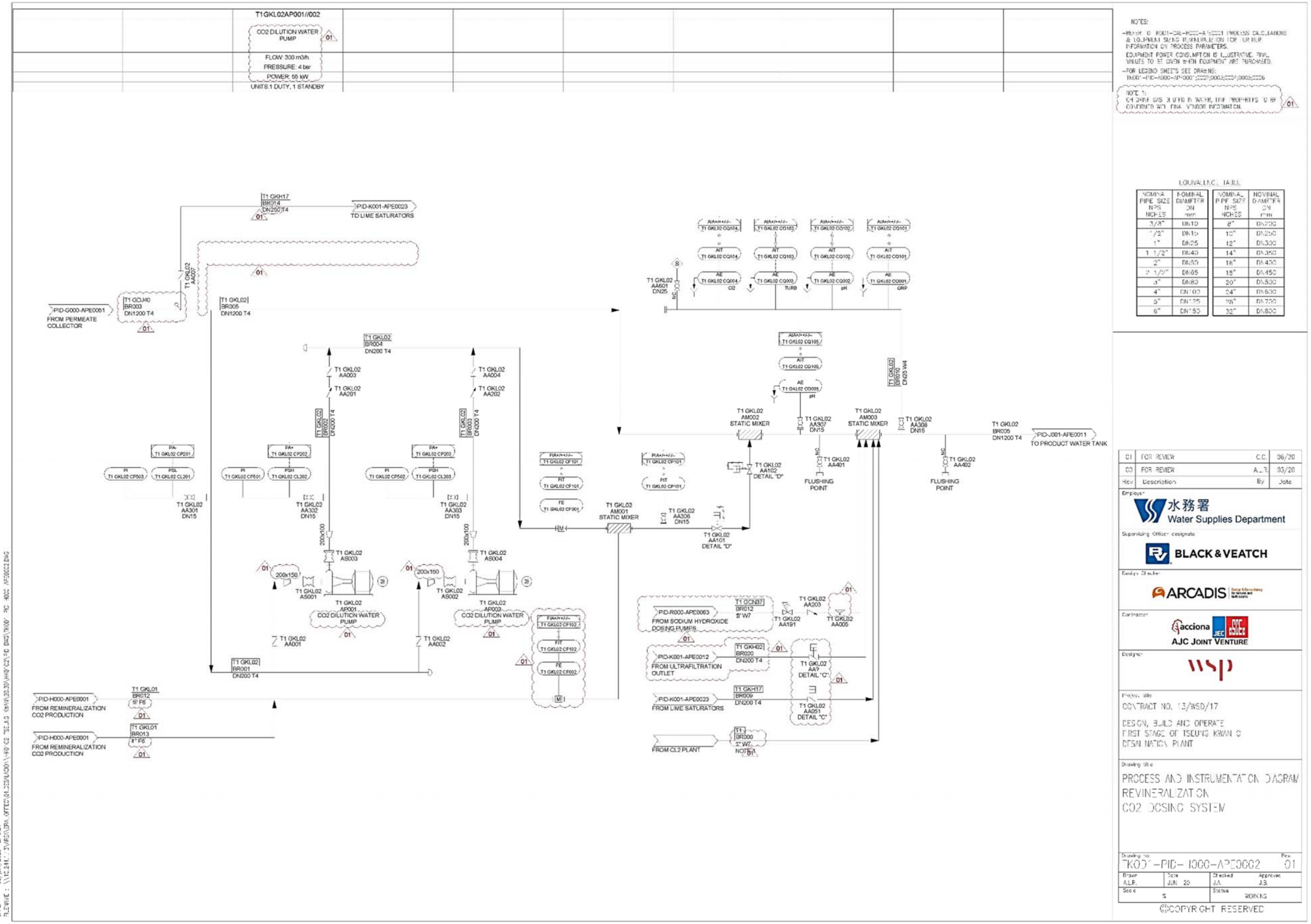
VAPORIZER
FLOW: 285 kg/h.
UNITS:1 DUTY, 1 STANDBY
NOTE 2
CO2 DOSING SEQUENCE FROM DCS
T1 GKL03 AZ001 VENDOR PACKAGE
NOTE 1
CONTINUE IN DRAWING: PID-H000-APE0005
FROM CO2 PRODUCTION AND STORAGE TANK 5
FROM ECONOMIZER REGULATOR
FROM CO2 PRODUCTION AND STORAGE TANK 4
FUTURE TANK 6
STAGE 2 CONNECTION
T1 GKL01 AH001 VAPORIZER NOTE 3
T1 GKL01 AH002 VAPORIZER NOTE 3
TO REMINERALIZATION CO2 DOSING SYSTEM
CONTINUE IN DRAWING: PID-H000-APE0002
FROM CO2 PRODUCTION AND STORAGE TANK 1
FROM CO2 PRODUCTION AND STORAGE TANK 2
FROM CO2 PRODUCTION AND STORAGE TANK 3
NOTES:
-REFER TO TKOD1-CAL-H000-APE0001 PROCESS CALCULATIONS & EQUIPMENT SIZING-REMINERALIZATION FOR FURTHER INFORMATION ON PROCESS PARAMETERS.
-FOR LEGEND SHEETS SEE DRAWINGS: TKOD1-DWG-A000-WGN0001;0002;0003;0004;0005;0006
1.- VENDOR PACKAGE IS STILL UNDER DEVELOPMENT, ONCE THE DESIGN IS CONFIRMED THE VENDOR DESIGN DETAILS WILL BE PROVIDEED IN DOCUMENT NO. TKOD1-MPS-H000-AME0002_CO2 STORAGE AND DOSING SYSTEM SUBMITTAL.
2.-VAPORIZER DESIGN CAPACITY.
3.-VAPORIZERS TO BE AMBIENT TYPE.
EQUIVALENCE TABLE
NOMINAL PIPE SIZE NPS INCHES | NOMINAL DIAMETER DN mm | NOMINAL PIPE SIZE NPS INCHES | NOMINAL DIAMETER DN mm
3/8" | DN10 | 8" | DN200
1/2" | DN15 | 10" | DN250
1" | DN25 | 12" | DN300
1 1/2" | DN40 | 14" | DN350
2" | DN50 | 16" | DN400
2 1/2" | DN65 | 18" | DN450
3" | DN80 | 20" | DN500
4" | DN100 | 24" | DN600
5" | DN125 | 28" | DN700
6" | DN150 | 32" | DN800
B2 DDA SUBMISSION B.A. 01/21
B1 DDA SUBMISSION C.C. 01/21
B0 DDA SUBMISSION B.A. 10/20
01 FOR REVIEW C.C. 06/20
00 FOR REVIEW C.C. 03/20
Rev Description By Date
Employer
水務署 Water Supplies Department
Supervising Officer designate
BLACK & VEATCH
Design Checker
ARCADIS
Contractor
acciona JEC AJC JOINT VENTURE
Designer
wsp
Project title
CONTRACT NO. 13/WSD/17
DESIGN, BUILD AND OPERATE FIRST STAGE OF TSEUNG KWAN O DESALINATION PLANT
Drawing title
PROCESS AND INSTRUMENTATION DIAGRAM
REMINERALIZATION
CO2 VAPORIZERS
Drawing no. TKOD1-PID-H000-APE0001
Rev. B2
Drawn B.A. Date JAN 21 Checked J.A. Approved J.B.
Scale % Status WORKING
©COPYRIGHT RESERVED


T1GKL02AP001/002
CO2 DILUTION WATER PUMP
FLOW: 300 m3/h
PRESSURE: 4 bar
POWER: 55 kW
UNITS:1 DUTY, 1 STANDBY
FROM PERMEATE COLLECTOR
TO LIME SATURATORS
STATIC MIXER
TO PRODUCT WATER TANK
FLUSHING POINT
CO2 DILUTION WATER PUMP
FROM SODIUM HYDROXIDE DOSING PUMPS
FROM ULTRAFILTRATION OUTLET
FROM LIME SATURATORS
FROM CL2 PLANT
FROM REMINERALIZATION CO2 PRODUCTION
水務署
Water Supplies Department
BLACK & VEATCH
ARCADIS
acciona
AJC JOINT VENTURE
wsp
CONTRACT NO. 13/WSD/17
DESIGN, BUILD AND OPERATE
FIRST STAGE OF TSEUNG KWAN O
DESALINATION PLANT
PROCESS AND INSTRUMENTATION DIAGRAM
REMINERALIZATION
CO2 DOSING SYSTEM
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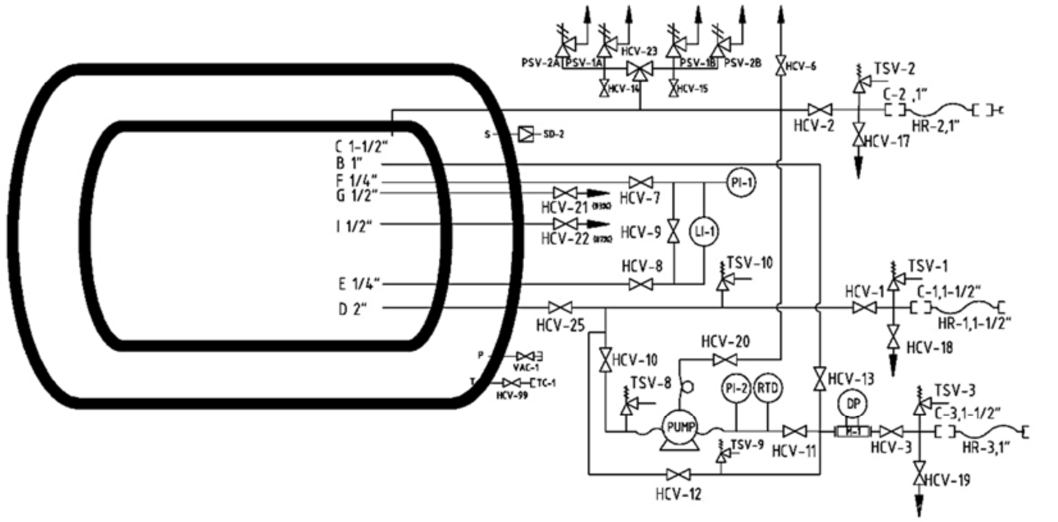
Appendix B - 3: Process & Instrumentation Diagram (P&ID) of CO_2 Road Tanker

代号				
HCV-1	液相充液阀	MECA-INOX #PS4LSWVI050	2"	1
HCV-2	气体回气阀	MECA-INOX #PS4LSWVI025	1"	1
HCV-3	液体出口阀	MECA-INOX #PS4LSWVI025	1"	1
HCV-6	手动排放阀	HEROSE#01321.2533.001	1"	1
HCV-7	气相针型阀	REGO #CMM250A B31.3	1/4"	1
HCV-8	液相针型阀	REGO #CMM250A B31.3	1/4"	1
HCV-9	平衡针型阀	SWAGELOK #B-1RM4-SC11	1/4"	1
HCV-10	泵进液阀	MECA-INOX #PS4LSWVI050	2"	1
HCV-11	泵出口阀	MECA-INOX #PS4LSWVI025	1"	1
HCV-12	压力出液阀	MECA-INOX #PS4LSWVI025	1"	1
HCV-13	回流阀	MECA-INOX #PS4LSWVI025	1"	1
HCV-14,15	排压阀	REGO #CMM250A B31.3	1/4"	2
HCV-17,18,19	排残阀	MECA-INOX #PS4LSWVI015	1/2"	3
HCV-20	泵体回流阀	REGO#C009464DAS PI-MARK	3/8"	1
HCV-21,22	溢满阀	MECA-INOX #PS4LSWVI015	1/2"	2
HCV-23	三通切换阀	BESTOBELL#CJF60SS7CLE1T	DN32	1
HCV-25	液相根部阀	MECA-INOX #PS4LSWVI050	2"	1
HCV-99	规管截止阀	HOKE 4111L2B BRS 1/8MPTX1/8FF	1/8"	1
TC-1	真空规管	HASTINGS 1415671S #DV-6	1/8"	1
VAC-1	抽真空阀	LANSHI #ZK-30/40-1Q(KF40)	1-1/2“	1
TSV-1,2,3	安全阀	REGO #PRV9432T450	1/4"	3
TSV-8,9,10	安全阀	REGO #PRV9432T450	1/4"	3
PSV-1A,B	安全阀	HEROSE #06388.1510.6040 UV	1"	2
PSV-2A,B	安全阀	HEROSE #06388.1510.6040 UV	1"	2
PI-1	储罐压力表	WIKA #233.50 1/4MPT W/ PANNEL	0-4Mpa	1
PI-2	泵出口压力表	WIKA #232.50 1/4MPT W/ PANNEL	0-4Mpa	1
LI-1	液位计	WIKA #712.15 W/PANEL	0-2500MM	1
PUMP	泵	PUMP CO2 R83-316H4BM-0405T1-	TEIKOKU	1
C-1,3	CGA接头	YCLB #CGA-CO-40-001	1-1/2“	2
C-2	CGA接头	YCLB #CGA-CO-25-001	1”	1
M-1	流量计	FLOWCOM 3000 #SWM33.4*	1”	1
DP	压差变送器	ROSEMOUNT 3051CD3A02A2BH2P2		1
RTD	温度传感器	BURNS#200A 10BN035		1

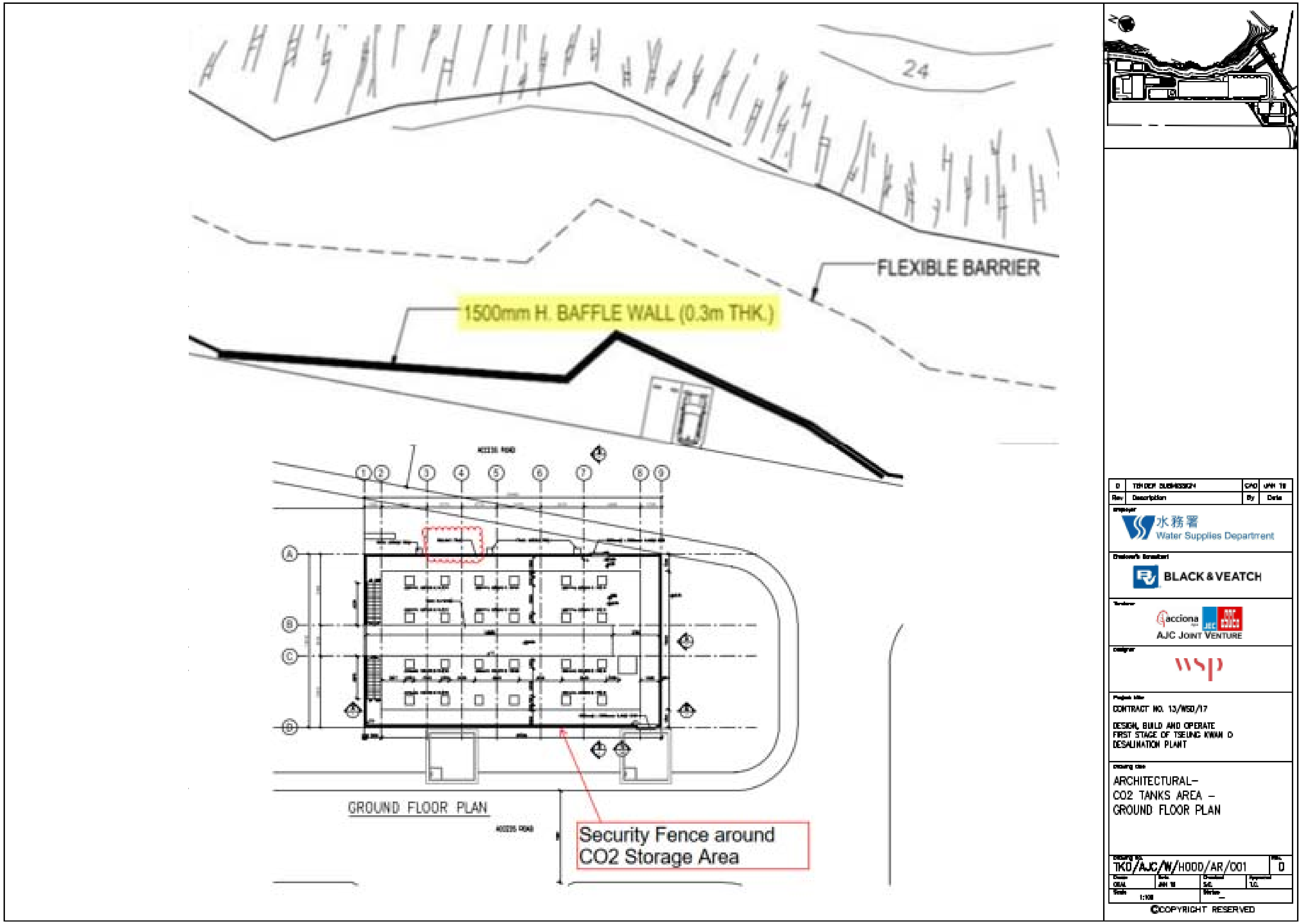
B	VAPOR RETURN
C	VENT
D	BOTTOM FILL
E	LIQUID PHASE
F	GAS PHASE
G	TRYCOCK
I	TRYCOCK
P	PUMPOUT
S	JACKET RELIEF
T	VACUUM GUAGE

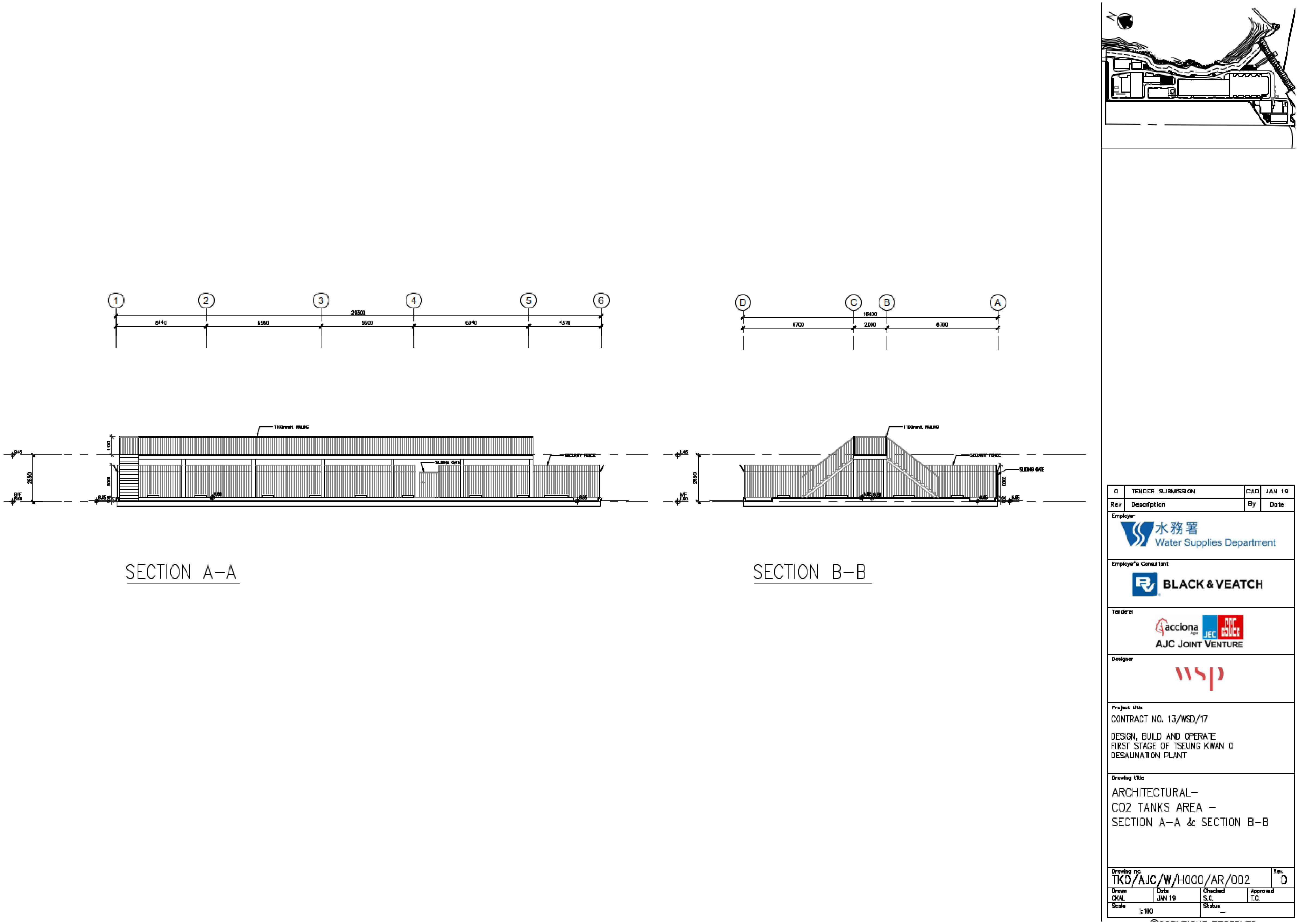


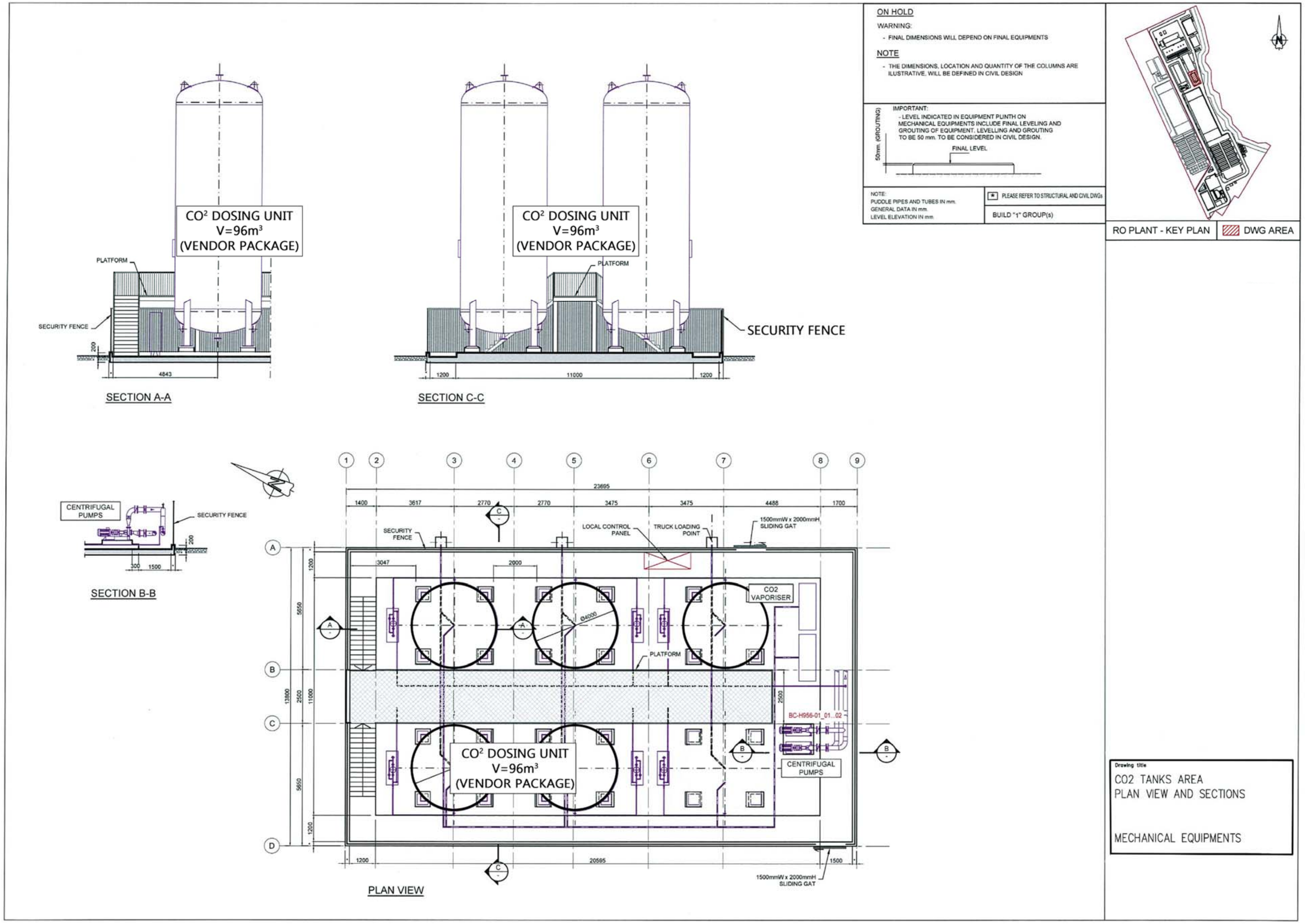
标记	处数	分区	更改文件号	签字	年月日
设计		标准化			
校对					
审核					
工艺		批准			

阶段标记 重量 比例
共 页 第 页
P&ID FOR LCO2 OR
FL3000标准版
版本
FD

Appendix B - 4: Architectural & Sectional Drawings for the CO_2 Tanks Area

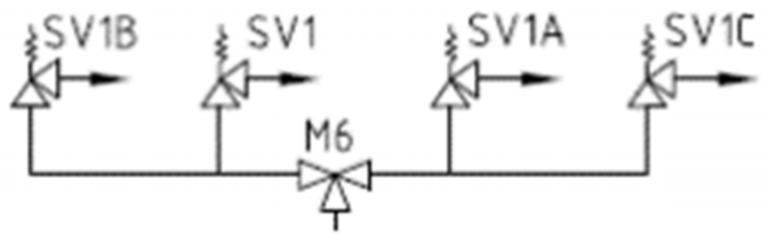



SECTION A–A
SECTION B–B
0
TENDER SUBMISSION
CAD
JAN 19
Rev
Description
By
Date
水務署
Water Supplies Department
BLACK & VEATCH
AJC JOINT VENTURE
CONTRACT NO. 13/WSD/17
DESIGN, BUILD AND OPERATE
FIRST STAGE OF TSEUNG KWAN O
DESALINATION PLANT
ARCHITECTURAL–
CO2 TANKS AREA –
SECTION A–A & SECTION B–B
TKO/AJC/W/H000/AR/002
D
JAN 19
1:100


ON HOLD
WARNING:
- FINAL DIMENSIONS WILL DEPEND ON FINAL EQUIPMENTS
NOTE
- THE DIMENSIONS, LOCATION AND QUANTITY OF THE COLUMNS ARE ILUSTRATIVE, WILL BE DEFINED IN CIVIL DESIGN
IMPORTANT:
- LEVEL INDICATED IN EQUIPMENT PLINTH ON MECHANICAL EQUIPMENTS INCLUDE FINAL LEVELING AND GROUTING OF EQUIPMENT. LEVELLING AND GROUTING TO BE 50 mm. TO BE CONSIDERED IN CIVIL DESIGN.
FINAL LEVEL
50mm. (GROUTING)
RO PLANT - KEY PLAN
DWG AREA
CO² DOSING UNIT
V=96m³
(VENDOR PACKAGE)
PLATFORM
SECURITY FENCE
SECTION A-A
SECTION C-C
CENTRIFUGAL PUMPS
SECTION B-B
LOCAL CONTROL PANEL
TRUCK LOADING POINT
1500mmW x 2000mmH SLIDING GAT
CO2 VAPORISER
PLAN VIEW
Drawing title
CO2 TANKS AREA
PLAN VIEW AND SECTIONS
MECHANICAL EQUIPMENTS

Appendix B - 5: Pressure Relief System of Inner and Outer Vessel of Insulated Tank and Carbon Dioxide Road Tanker

Pressure relief system of the inner vessel is as below:



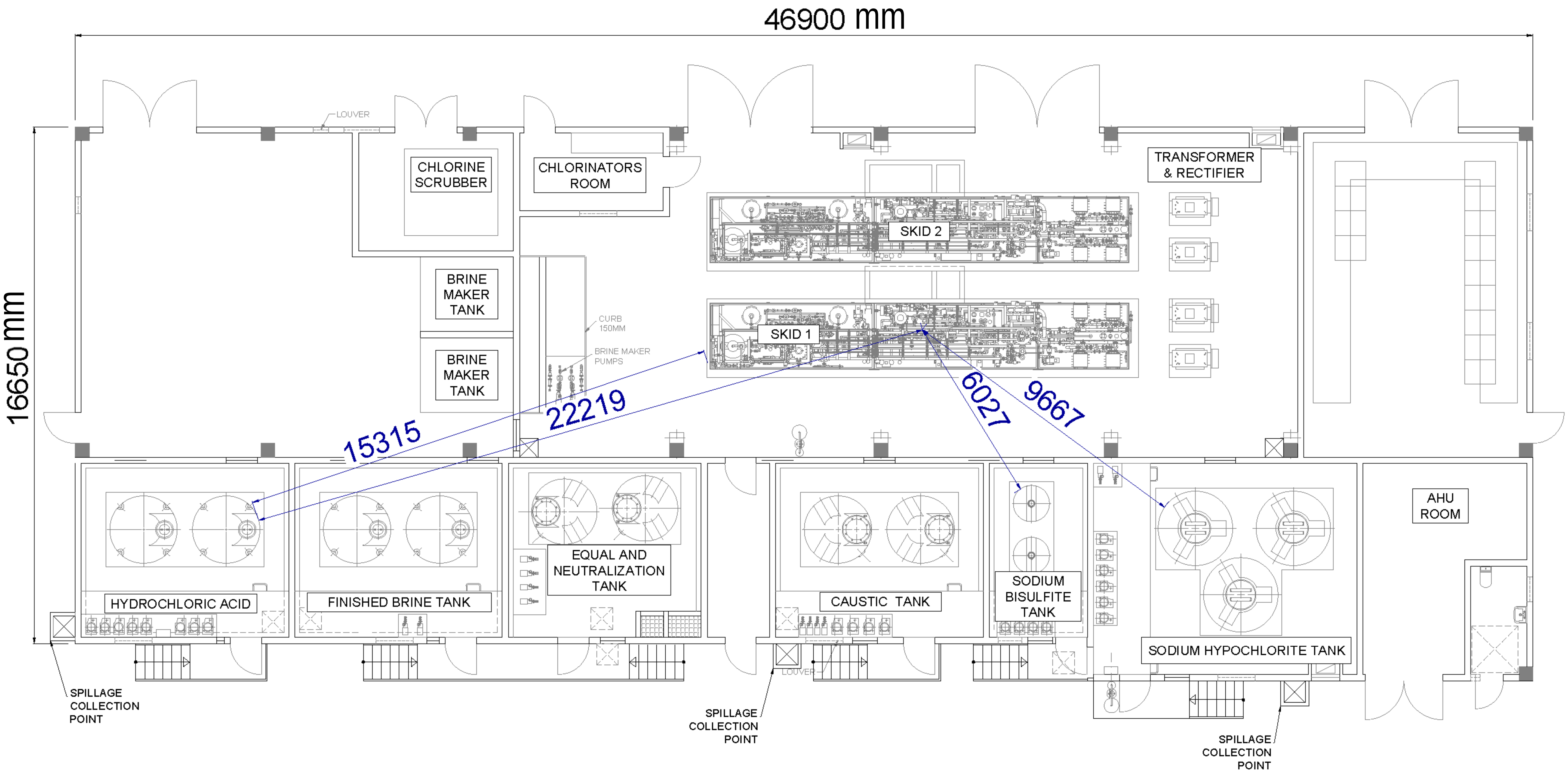
Characteristics :

1. Two sets of relief valves, one duty and one standby. Such design allows annual calibration without interrupting the system.
2. There is a 3-way diverter valve to switch between duty and standby. Design of valve ensure opening at either side (ie. Either to left or right). There will not be accidental closing of both streams.
3. Each side consists of two relief valves in two settings, usually at 22 barg and 24 barg. The two stage design allows double protection. In case pressure rises too quickly that the first stage valve cannot release the pressure, there is the second stage relief valve for protection.

Above designs fulfills the requirement of Table 1 - List of design requirements / measures for chlorine and carbon dioxide storage extracted from Annex 13L of the EIA Report (Register No. AEIAR-192/2015))-Item 2.4.

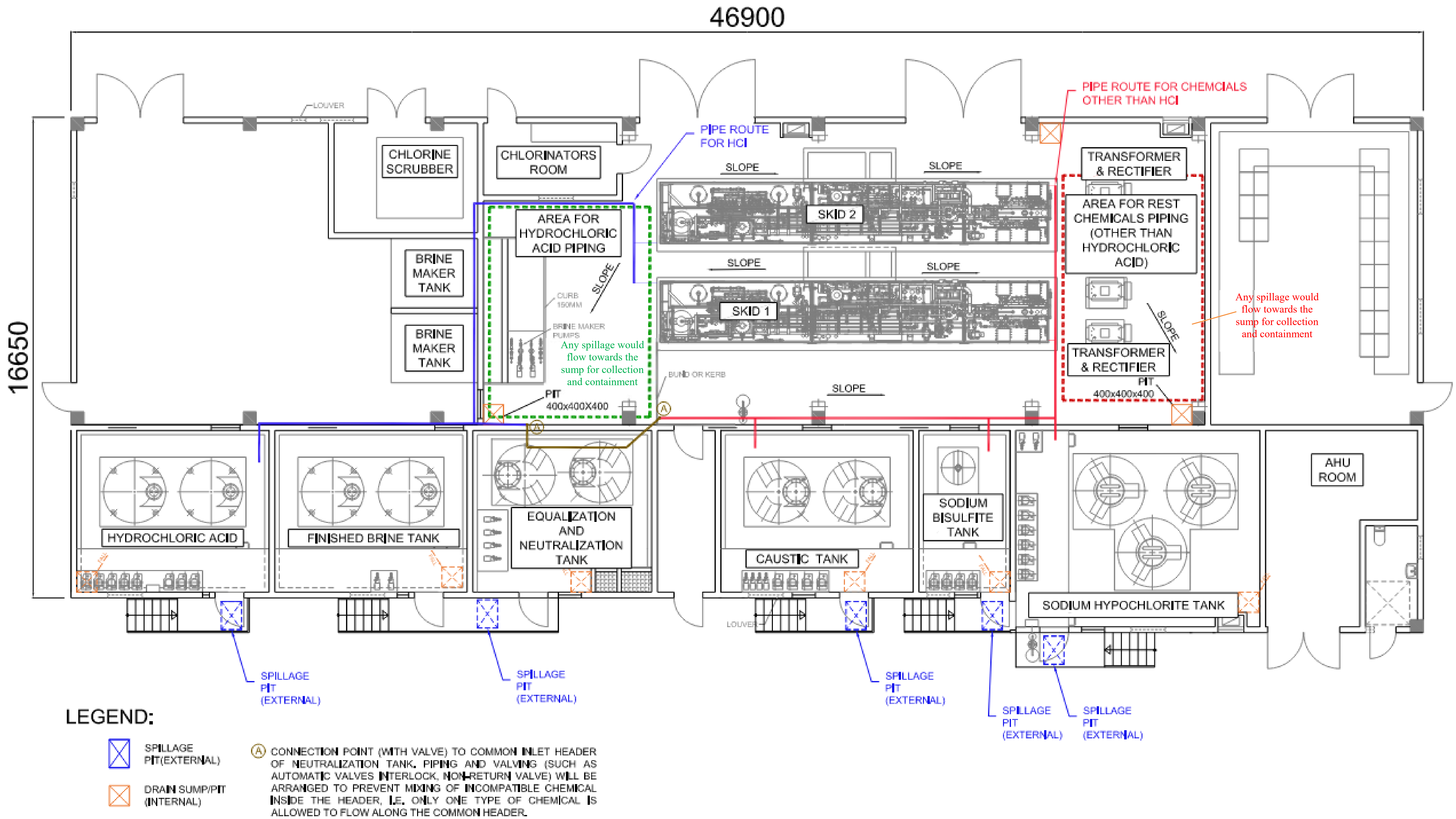
At outer vessel of vacuum insulated tank, there will be a burst disc plate, usually set at 1.0 barg. This is for protection of outer vessel. The design fulfills requirement of Environmental Permit Clause 2.4 part 2.

Appendix B - 6: Layout Inside Stage 1 OSCG Building



OSCG General Plan

Appendix B - 7: General Area for Piping Installation and Drainage Arrangement in Stage 1 OSCG Building



Appendix C:

Comparison of the Current Design and the Reference Design Presented in the Environmental Review Report dated 2017

Appendix C: Comparison of the Current Design and the Reference Design Presented in the Environmental Review Report (ERR) dated 2017

No.	Parameters	Design Assumptions in ERR	Provisions in the Current Design / Hazard Implications
1	**On-site Chlorine Generation**		
1.1	Chlorine generation rate	The ultimate chlorine generation rate (including both Stage 1 and Stage 2 works) is 2250 kg per day. Two OSG systems, each with capacity of 1125 kg per day, will be installed in 2 stages in 2 separate buildings.	No changes to these assumptions are proposed in the current design.
1.2	Ventilation rate	6 air change per hour (ACPH)	No change to the ventilation rate is proposed in the current design.
1.3	Volume of each OSCG building	4000 m^3	<u>Stage 1 OSCG Building</u> **Current Design Value:** 3800 m^3 **Hazard Implications:** In the ERR, the 10-minute average chlorine release rates to atmosphere (due to accidental indoor chlorine release) were generated or computed by the PHAST model with reference to the building volume of 4000 m^3 and the 6 ACPH ventilation rate. In view that the chlorine generation rate of no more than 1125 kg per day in Stage 1 OSCG building and the associated indoor chlorine release rate at source as assumed in the ERR would remain unchanged and with the same ventilation rate of 6 APCH, the chlorine release rates to atmosphere would not be significantly affected by the slight reduction of the building volume. In addition, the separation distance between the Stage 1 OSCG building and the desalination plant boundary has been significantly increased to at least 100 m under the current design (see Items 2.3 and 2.4 below), which is much greater than the maximum hazard distance for chlorine release in Section 11.7.2 of the ERR (49 m). With provision of such a margin of safety distance, the slight reduction of the building volume would not cause any significant implication on the offsite hazard impact and would not change the conclusion of the ERR. <u>Stage 2 OSCG Building</u> No changes to all the ERR assumptions are proposed.
2	**Chlorine Gas**		
2.1	Discharge of chlorine gas to the atmosphere	No vent pipe will be provided for direct discharge to the atmosphere	No change to the discharge arrangement is proposed in the current design.
2.2	Safety measures	- Chlorine detectors - Chlorine scrubber system - Activation of recycle damper when chlorine scrubber is in operation	No changes to the safety measures are proposed in the current design

No.	Parameters	Design Assumptions in ERR	Provisions in the Current Design / Hazard Implications
2.3	Separation distance between the centre of OSCG building and the nearest site boundary	Greater than 30 m	- At least 100m for Stage 1 OSCG building - Greater than 30 m for Stage 2 OSCG building
2.4	Separation distance between the exhaust point / louvers of OSCG buildings and the nearest site boundary	Greater than 30 m	- At least 100m for Stage 1 OSCG building - Greater than 30 m for Stage 2 OSCG building
3	**Hydrogen Release**		
3.1	Discharge of hydrogen gas to the atmosphere	Individual vent pipe will be provided for each generator	No change to the discharge arrangement is proposed in the current design.
3.2	Concentration of hydrogen gas for discharge to the atmosphere	1% of Lower Flammability Limit (LFL) for hydrogen	No change to the hydrogen gas discharge concentration is proposed in the current design.
3.3	Hydrogen explosion due to failure of OSCG units	The hazard distance of hydrogen explosion from the OSCG skid was estimated to be 11m for overpressure of 2 psi. Under the reference design, sufficient separation was provided between the chemical tanks and OSCG units to avoid simultaneous failure of tanks containing incompatible chemicals.	Based on the hazard distance of 11m estimated in the ERR, the OSCG layout of the current design as illustrated in Appendix B-6 would not cause simultaneous damages to hydrochloric acid (HCl) storage compartment and other storage compartments for incompatible chemicals. The changes of the OSCG layout under the current design would not affect the conclusion of the ERR on hydrogen explosion due to failure of OSCG unit.
4	**Sodium Bisulphite ($NaHSO_3$) Assessment**		
4.1	Safety measures to avoid right product delivered into the wrong tank.	Hoses and couplers for transferring of $NaHSO_3$, hydrochloric acid (HCl), ferric chloride ($FeCl_3$), sulphuric acid (H_2SO_4) and citric acid ($C_6H_8O_7$) are different in size to avoid connecting road tankers of incompatible chemicals to corresponding storage tanks.	No change to the safety measure is proposed in the current design.
		Warning signs will be displayed at the inlet of each storage tank to show chemical name and to warn the potential hazards of mixing incompatible chemicals	No change to the safety measure is proposed in the current design.
		$NaHSO_3$, sodium hypchlorite (NaOCl), HCl, $FeCl_3$, H_2SO_4 and $C_6H_8O_7$ will be delivered by road tankers.	No change to the safety measure is proposed in the current design.
		HCl, $FeCl_3$, H_2SO_4 and $C_6H_8O_7$ at chemical building will be stored in double containment tanks.	No change to the safety measure is proposed in the current design.
		HCl, $FeCl_3$, H_2SO_4 and $C_6H_8O_7$ flowing outside of the chemical building will be collected by road side drains	Floor surface gradient will be used for directing any spillage of HCl, $FeCl_3$, H_2SO_4 and $C_6H_8O_7$ towards the sump within the storage compartment and contained inside the chemical

No.	Parameters	Design Assumptions in ERR	Provisions in the Current Design / Hazard Implications
			building for further clean-up and proper disposal. Design of the floor gradient shall take account of the viscosity of the chemicals.
		Perimeter drain will be installed surrounding $NaHSO_3$, HCl and NaOCl storage compartments at OSCG buildings.	Floor surface gradient will be used for directing any spillage of ,$NaHSO_3$, HCl and NaOCl towards the sump within the storage compartments and contained inside the Stage 1 OSCG building for further clean-up and proper disposal. No changes are proposed for the Stage 2 OSCG system. The floor gradient design of the building shall take account of the viscosity of the chemicals.
		Bunds will be provided for all storage compartments	No change to the safety measure is proposed in the current design.
		Double containment will be provided for HCl pipelines in OSCG buildings.	No change to the safety measure is proposed in the current design.
		Alignment of HCl pipeline is away from pipelines for other incompatible chemicals in OSCG building.	No change to the safety measure is proposed in the current design (see Appendix B-7 for piping arrangement of the current design).
		Floor surface gradient will be used for directing spillage of incompatible chemicals to different locations such that HCl will be collected to a separate drain system.	No change to the safety measure is proposed in the current design (see (Appendix B-7 for general drainage arrangement of the current design). The floor surface gradient design shall take account of the viscosity of the relevant chemicals.
		Only one storage tank will be connected to delivery pipeline at any one time to minimize the amount of spillage	No change to the safety measure is proposed in the current design.
		Pipe pressure will be continuously monitored. Pumps will be immediately shut down if irregular pressure drops occur.	No change to the safety measure is proposed in the current design.
		Vibration sensing system will be installed alone pipelines. Pumps will be immediately shut down if excessive vibration is detected to minimize the amount of leakage through damaged pipelines.	No change to the safety measure is proposed in the current design.
4.2	Separation distance between OSCG buildings and chemical building.	380m	**Current Design Value:** About 300 m **Hazard Implications:** The separation distance of 380m in the ERR is mainly to show that it is one of the safety measures for eliminating the operation error namely "right product delivered into the wrong tank". There is no significant risk implication due to the change in the separation distance from 380m to about 300m.
5	**Liquid Carbon Dioxide (CO_2)**		

No.	Parameters	Design Assumptions in ERR	Provisions in the Current Design / Hazard Implications
5.1	Number of CO_2 storage tank	16 units	**Current Design Value:** 5 tanks **Hazard Implications:** The number of CO_2 storage tanks and capacity of each tank are no greater than that assumed in the ERR. The overall CO_2 storage quantity on-site will be reduced. No adverse hazard to life impact would be caused by the reduction of CO_2 storage tank number.
5.2	Type of storage tank	Vacuum insulated	No change to the type of storage tank is proposed.
5.3	Storage tank capacity	100 tonnes per tank	100 tonnes per tank
5.4	Type of vaporizer	Ambient	No change to the type of vaporizer is proposed.
5.5	Transport mode	By road tanker	No change to the transport mode is proposed.
5.6	Safety measures	CO_2 storage in double containment	No change to the safety measure is proposed.
		2. set of pressure relief valves (PRVs) on inner containment. The 2 sets of PRVs are connected by a switchover valve. Each set consists of 2 PRVs.	No change to the safety measure is proposed (see Item 2.4 of Appendix A and Appendix B-5 for details)
		Plate pressure relief device on outer containment (considered on storage tanks only).	No change to the safety measure is proposed. (see Item 2.4 of Appendix A and Appendix B-5 for details)
		Trycock for overfilling alarm and warning	No change to the safety measure is proposed.
		High level alarm to operating staff at control room for liquid level monitoring and warning	No change to the safety measure is proposed.
5.7	Separation distance between CO_2 storage area and the explosive truck during off-site transport	Set back the CO_2 storage with sufficient clearance so that the overpressure resulting from explosion of explosive vehicle during off-site transport that reaches the storage is less than 2 psi.	Sufficient separation distance is provided in the current design (see the relevant impact review in Item 2.6 of Appendix A for details)
5.8	Separation distance between CO_2 storage area and the explosive offloading pier	Set back the CO_2 storage with sufficient clearance so that the overpressure resulting from explosion of explosives at the offloading pier that reaches the storage is less than 2 psi.	Sufficient separation distance is provided in the current design (see the relevant impact review in Item 2.6 of Appendix A for details)
5.9	Separation distance between CO_2 storage area and site boundary	Approximately 100 m	More than 100 m
5.10	Separation distance between CO_2 storage area and toe of natural slope behind	Approximately 30m	Approximately 30m.

No.	Parameters	Design Assumptions in ERR	Provisions in the Current Design / Hazard Implications
5.11	Safety measure to protect the CO_2 storage area from soil debris.	A 1.5m high baffle barrier will be constructed at the road side of the internal access road.	No change to the safety measure is proposed in the current design (see Appendix B-4 for layout of the baffle wall under the current design).

Appendix D:

Extracts from the Environmental Review Report dated 2017

11 Review of Hazard to Life Assessment

11.1 Introduction

11.1.1 This Section presents a review on hazard to life impacts due to changes in design associated with operational phase of the desalination plant as discussed in **Section 2.6** through **Section 2.7**. Hazards are assessed quantitatively to ensure the associated risk is acceptable.

11.2 Legislative Requirements & Evaluation Criteria

11.2.1 The legislation and criteria used for the hazard to life impact assessment in the approved EIA Report have been reviewed and remain valid.

11.3 Proposed Design Changes

11.3.1 This section describes the proposed design changes that would have an implication on the hazard to life impact of the Project.

On-site Generation of Chlorine Gas for Disinfection of Product Water

11.3.2 In the approved EIA Report for the Project, it was assumed that liquid chlorine would be imported to the proposed desalination plant for use in meeting the residual disinfection requirements for potable water. In order to cope with fluctuation in supply due to delay in delivery or other unforeseen events, a stock level of chlorine equivalent to 90-day consumption was assumed to be maintained in the desalination plant. The proposed chlorine storage using 1-tonne chlorine drum is classified as a Potentially Hazardous Installation (PHI) under the Hong Kong Planning Standards and Guidelines (HKPSG) with potential hazards to the surrounding population.

11.3.3 The proposed design change will involve an "on-site chlorine generation" (OSG) system to replace the importation of liquid chlorine to disinfect the potable water. A portion of the chlorine gas generated from the OSG process will be converted to sodium hypochlorite solution for shock chlorination of seawater intake. Hence, no importation of sodium hypochlorite solution for shock chlorination is required under the latest design. In the emergency events that the OSG system is out of operation, sodium hypochlorite solution supplied from other WSD's water treatment works or bulk purchase will be used as a backup to disinfect the process water. In other emergency events, sodium hypochlorite solution generated from the OSG system at TKO desalination plant may be delivered to other WSD's water treatment works (WTW) where there were outages in the OSG systems. The sodium hypochlorite solution will be delivered to and from the desalination plant by road tankers. Chlorine gas produced from the OSG process will be directly dosed into the process water or consumed in the sodium hypochlorite conversion process with no storage requirement. The typical schematic for the production process is depicted in **Appendix 11A** for reference.

11.3.4 Under the ultimate scenario, chlorine generation rate is 2250 kg/day. Two OSG systems, each with capacity of 1125 kg/day, will be installed in 2 stages. Each OSG system will consist of 4 chlorine gas generators including 2 on-duty and 2 stand-by units. At the ultimate stage, a maximum of 1650 kg per day of chlorine gas would be used for the production of sodium hypochlorite solution at 1800 kg per day which is based on 100% sodium hypochlorite content. The sodium hypochlorite solution will be stored in storage tanks at 12.5% wt concentration. The usage rate is 40 m^3 for each shock chlorination dose which will be carried out every 5 days. The total storage quantity is 60 m^3 in 3 x 10 m^3 and 2 x 15 m^3 storage tanks for Stage 1 and Stage 2 respectively. The spare storage capacity is for emergency operation. The storage capacity is smaller than the one proposed in the approved EIA. In the approved EIA report, 90-day storage was provided in accordance with WSD practice. The OSG system will allow sodium hypochlorite be produced on an on-demand basis so that the storage quantity can be reduced.

11.3.5 Hydrochloric acid, sodium hydroxide and sodium bisulphite will be stored in OSG buildings for de-chlorination and neutralization. These chemicals together with sodium hypochlorite will be placed in separate compartments in OSG buildings.

Chlorine Scrubbing System

11.3.6 Emergency chlorine scrubbing system is installed to remove any leaked chlorine in the OSG building. The system is either a wet-type with packed tower/ horizontal type utilising sodium hydroxide as the neutralising agent or a dry-type using alumina oxide substrate as the neutralising agent. The plant and equipment are installed in a separate scrubber room.

11.3.7 On detection of chlorine content at a level of 3 ppm or above in the OSG building, the normal ventilation system will stop / close and the scrubbing system will activate automatically. The air/ chlorine mixture in the affected areas is drawn into the scrubber by the scrubber fan (one duty and one standby) via ducting which may be the same as (or entirely separate from) the ducting provided for the normal ventilation system.

11.3.8 An electrically-operated isolating damper is provided in the scrubber intake for recycling which opens automatically when the scrubber fan starts up. An additional isolating damper is provided to isolate the normal ventilation system when the scrubber system is operating.

11.3.9 The scrubber system is normally set to recycle air back to the OSG building. The treated air may be discharged to atmosphere at roof level when the chlorine concentration is below 3 ppm (in accordance with the FSD requirements DG/TS/llOA, 3rd Revision). This is affected by means of a pair of electrically operated change-over dampers controlled manually from the local control panel. A continuous chlorine monitor is installed at a point downstream of the chlorine scrubber and upstream of the vent/recycle changeover dampers. It has a high level alarm which sounds at both the local control panel and in the main control room when the chlorine concentration exceeds a pre-set level.

11.3.10 Typical setup of a wet-type packed tower chlorine scrubbing system is described in the following paragraphs as an example.

11.3.11 The sodium hydroxide solution is of approximately 12.5% - 15% (w/v) concentration and is held in a solution tank. When the system is in operation, the sodium hydroxide is recirculated by a pump to the distributor to provide adequate irrigation. A mist eliminator is provided upstream of the chlorine scrubber outlet to prevent entrainment of liquid into the treated air in the scrubber before it is discharged to the atmosphere or returned to the OSG building.

11.3.12 The scrubber is provided with the following additional features: a sampling point, a mixer (for preparation the sodium hydroxide solution), a direct reading transparent level gauge, an inspection window and level indication with high and low level alarms and a temperature measurement device for monitoring the temperature of caustic solution during preparation process.

Change of Plant Layout

11.3.13 The site of the desalination plant as proposed in the EIA Report would occupy an area of about 10 hectares (ha) (for the ultimate 270Mld capacity) in TKO Area 137 with individual building heights originally ranging from 2m to 20m above ground level.

11.3.14 The latest Project scheme would involve re-arrangement of building blocks and a more compact plant design to free up land in the north to allow possible need of other developments in the future. However, there is currently no firm development proposal available for this northern area. Any potential developments to be planned in this area are not covered in this ERR and will be subject to separate studies in the future to ensure their acceptability. The design change could have environmental implications in the aspects of hazard to life due to the changes in the locations of hazardous sources.

11.3.15 **Figure 11.1** below shows the revised plant layout for the Project to facilitate understanding of the potential hazard issues of the revised scheme. Major changes in layout relevant to this review are highlighted as follows:

- OSG systems for Stage 1 and Stage 2 will be located in separate OSG buildings.
- Chemical building is moved to the southern portion of the desalination plant at 120m from the TKO Area 137 explosives unloading pier.
- Storage tanks for sodium hypochlorite are moved from south of the plant to OSG buildings at indoor.
- Storage area for liquid carbon dioxide is shifted towards the eastern boundary. The distance between the toe of the slope and the storage area is about 30 m.
- Administration building is located on top of the chemical building. There will be no visitor centre.

Landfill Gas Utilization for Power Generation

11.3.16 Under the latest design, a Synthetic Natural Gas (SNG) power generation system based on landfill gas would be built and operated within the site of the proposed desalination plant. The maximum design capacity of the power generation system will be about 4 MW. SNG will be utilized as the fuel source of the power generation system to meet some of the electricity demand for operation of the desalination plant.

11.4 Review of Background Information

Location

11.4.1 The Project site location of the revised scheme is same as that assumed in the EIA Report, which is at the southeast corner of TKO Area 137. The revised scheme will have a more compact plant design to free up the northern portion of the site for other possible developments in the future.

Layout

11.4.2 Under the revised scheme, the building blocks have been re-arranged. Whilst there are changes to the locations of building blocks according to the latest design and processes, an internal access road is maintained to generally divide the Project site into two portions (i.e. the eastern and western portions respectively), following the general arrangement adopted in the approved EIA Report.

11.4.3 As shown in **Figure 11.1**, the most noticeable change in the layout plan is found near the southern boundary of the Project site. The open space near the southern Project boundary as assumed in the approved EIA Report is replaced with chemical building, solids handling building, electrical room and Dissolved Air Flotation (DAF) building under the revised design. Sectional views for the revised design are shown in **Figure 11.2**.

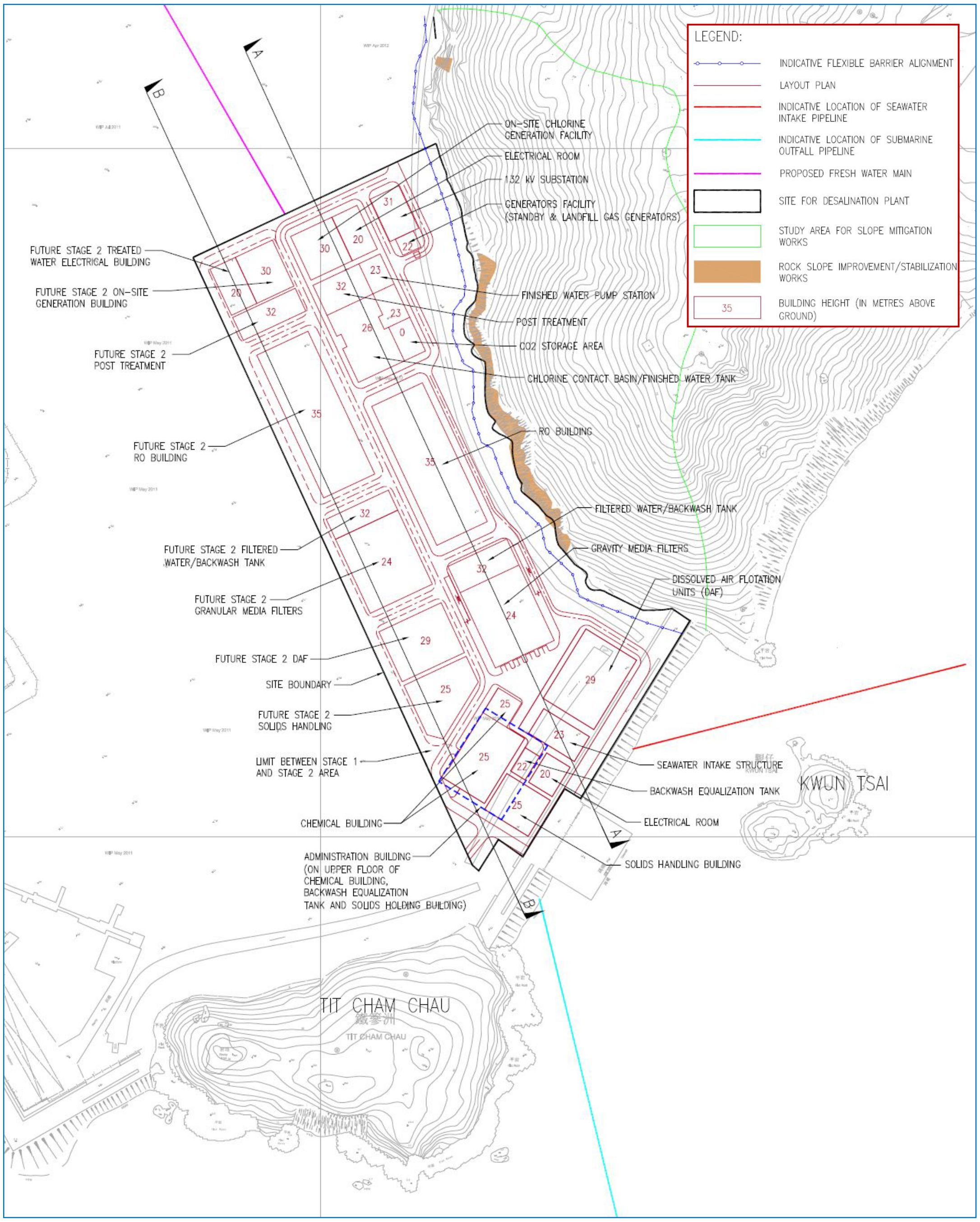


Figure 11.1 Layout Plan for the Proposed Desalination Plant

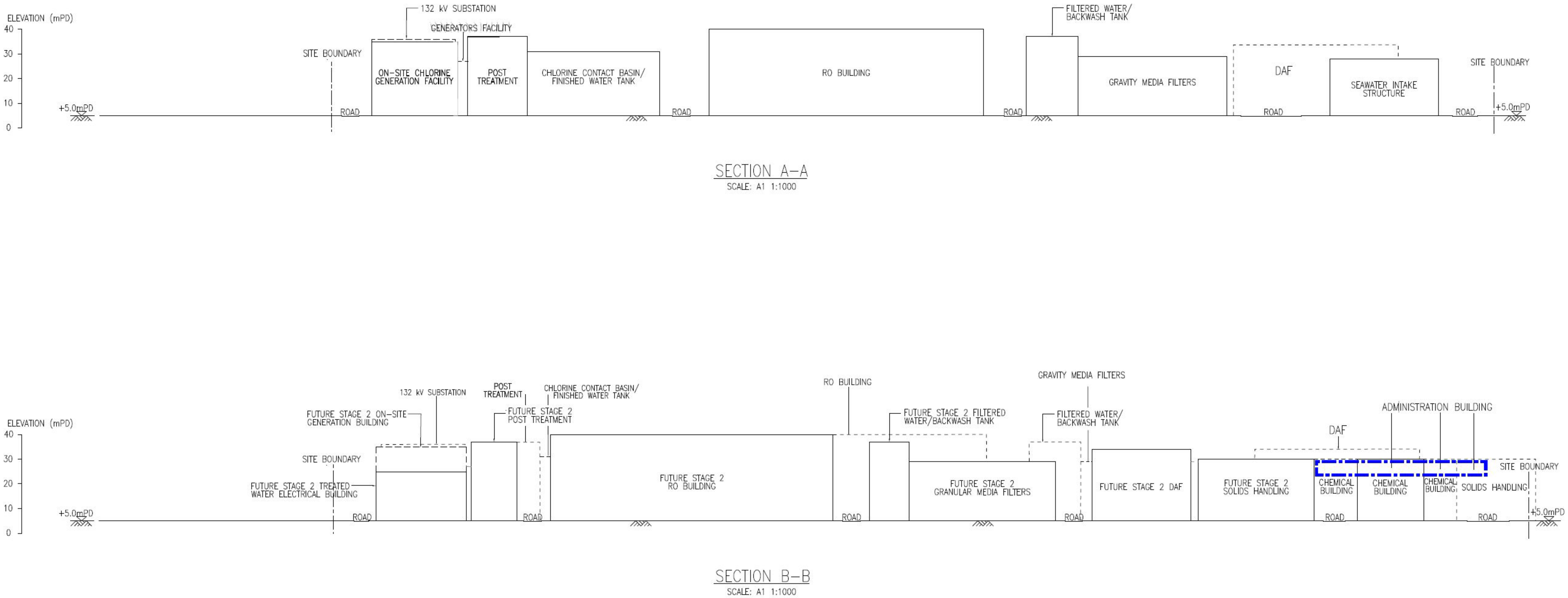


Figure 11.2 Sectional View for the Proposed Desalination Plant

Operation

11.4.4 It is anticipated that the proposed OSG would not lead to significant change in the plant operation and manning schedule. However, the operation and manning schedule are reviewed and accounted for in this ERR.

Population Data

11.4.5 While transport, storage and use of liquid chlorine are no longer required with OSG, the area potentially affected by hazardous sources is significantly reduced. Based on the consequence analysis of this ERR, the study area is reduced to 500m range away from the centre of the desalination plant. **Figure 11.3** shows the current study area and the study area which adopted in the approved EIA for reference. There is no approved change in land use in TKO Area 137. Request has been made to Planning Department for the latest available population data. Two sets of Territorial Population and Employment Data Matrix (TPEDM) are provided including enhanced 2011-based data and 2014-based data in advance copy. Having compared with the 2011-based with adjustment data, which was adopted in the approved EIA, there is no change in the enhanced 2011-based data. However, 2014-based data shows an increase in employment population for Year 2014 by referring to the most relevant Planning Data Zone (namely PDZ 392) although it shows a year by year decreasing trend. The coverage of PDZ 392 is however much larger than the 500m study area. It covers TKO Area 137 within the 500m study area as well as Tseung Kwan O Industrial Estate (TKOIE) to the north and other rural area which are outside the 500m study area. By considering only the area within the 500m study range, population data adopted in the approved EIA is valid by referring to responses of Planning Department to the request on population data update. Therefore, there is no change in population data for this ERR. Adopting conservative approach, the piece of land adjoining the northern boundary of the desalination plant is assumed having population density as TKO Area 137. Population data within the study area is summarized in **Table 11.1**.

Table 11.1 Population Data

Ref no.	Name	Population (Operation, Year 2036)	Remarks
04	TKO Area 137	12	The same as the approved EIA
05	SENT Landfill Extension	129	The same as the approved EIA
06	TKO Area 137	1671	The same as the approved EIA
06b	Free-up open space adjoining the northern boundary of the desalination plant	89	It is estimated from the same population density as TKO Area 137

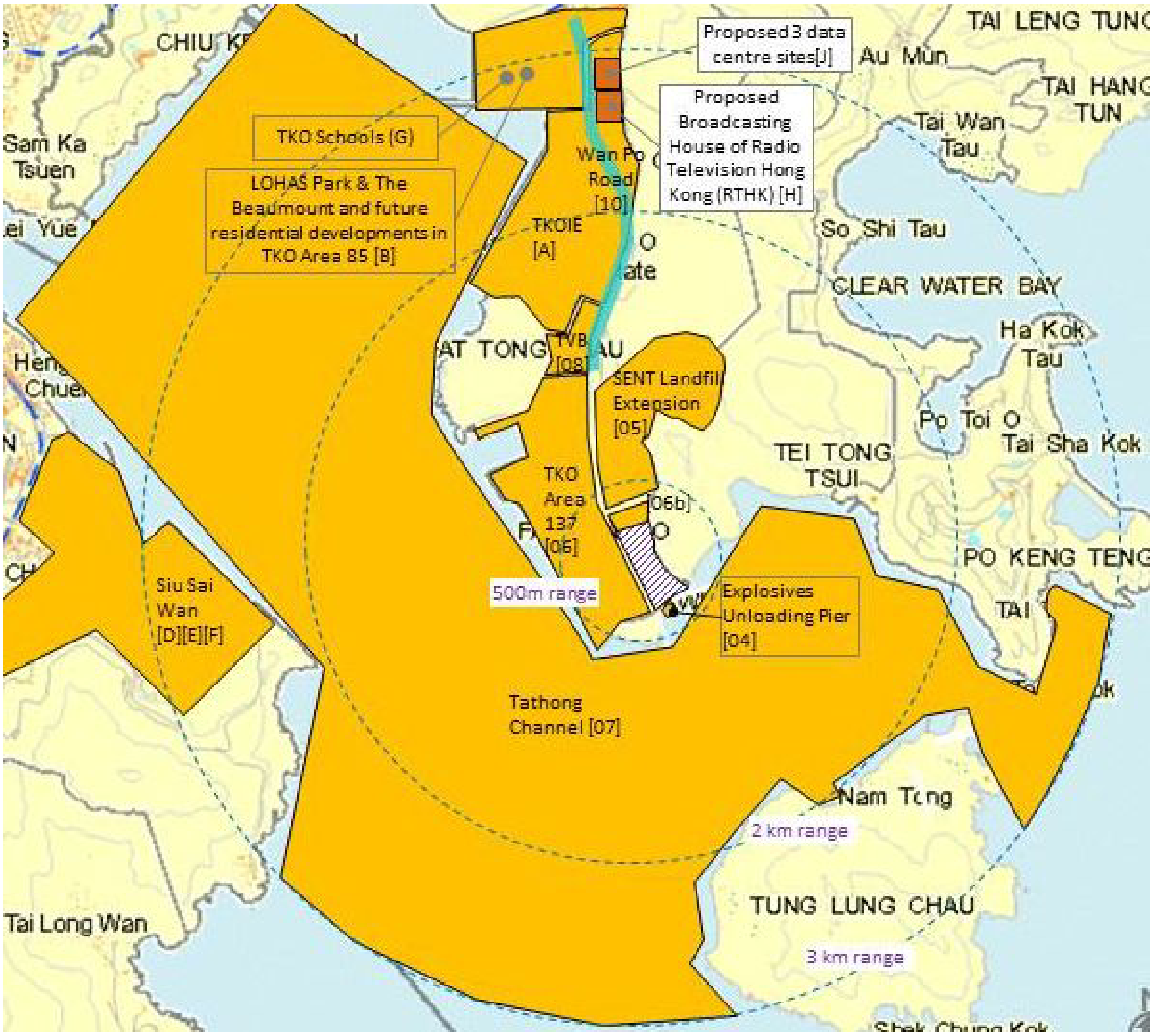


Figure 11.3 500m-Range Study Area and Population Locations

Meteorological Data

11.4.6 Wind data from Kai Tak Weather Station for the past 10 years between 2006 and 2015, as shown in **Table 11.2**, is adopted for consequence and risk analyses.

Table 11.2 Meteorological Data (Kai Tak Weather Station, Year 2006-2015)

		Probability							
		Day				Night			Total
	Wind Speed (m/s)	3	2	4.5	1.5	2	4.5	1.5	
	Atmospheric Stability	B	D	D	F	D	D	F	
Wind Direction	N	0.0068	0.0053	0.0086	0.0055	0.0037	0.0092	0.0205	0.0596
	NE	0.0076	0.0069	0.0131	0.0059	0.0053	0.0138	0.0183	0.0709
	E	0.0308	0.0091	0.1136	0.0056	0.0119	0.1355	0.0293	0.3358
	SE	0.0533	0.0196	0.0589	0.0124	0.0157	0.0378	0.0731	0.2708
	S	0.0125	0.0064	0.0046	0.0040	0.0026	0.0035	0.0263	0.0599
	SW	0.0276	0.0074	0.0095	0.0038	0.0040	0.0079	0.0205	0.0807
	W	0.0139	0.0063	0.0095	0.0054	0.0033	0.0101	0.0206	0.0691
	NW	0.0061	0.0057	0.0096	0.0047	0.0036	0.0087	0.0148	0.0532

		Probability							
		Day				Night			Total
	Wind Speed (m/s)	3	2	4.5	1.5	2	4.5	1.5	
	Atmospheric Stability	B	D	D	F	D	D	F	
	Total	0.1586	0.0667	0.2274	0.0473	0.0501	0.2265	0.2234	1.0000

11.5 Methodology for the Review

11.5.1 The review is conducted following the generic assessment steps listed below:

- Hazard identification and scenario definition;
- Consequence assessment;
- Frequency assessment;
- Risk summation; and
- Risk mitigation as applicable.

11.5.2 The technical scope of the OSG to be covered in the review is defined as follows:

- The ultimate design capacity of the OSG is used for the worst case assessment.
- Offsite risk to the general public is considered by taking into account the future population at operation stage in 2036.

11.6 Hazard Identification

On-site Generation of Chlorine Gas for Disinfection of Product Water

11.6.1 There will not be any storage for the chlorine gas product and the associated hazard. The electrolysis process will be undertaken within cellular modules. Chlorine gas will be consumed following the electrolysis process. Tentative layout inside the OSG building is shown in **Appendix 11B**.

11.6.2 Safety measures will be implemented in the OSG system and the OSG building. Vacuum system will be used for transmission of chlorine gas in the OSG system. Since chlorine gas will not be pressurized, a puncture on piping would not lead to leakage of chlorine. Mechanical ventilation will provide 6 Air Changes Per Hour (ACPH) for the OSG building to maintain a safe environment under the normal operation as well as installation of chlorine gas and hydrogen gas detectors.

11.6.3 The toxic effect of chlorine and the associated hazards have already been well identified in the approved EIA Report. The hazard of chlorine is referred to the approved EIA Report and other previous studies relevant to chlorine. There is no incident record from databases including MHIDAS (Major Hazard Incident Data Service), ARIA and eMARS in relation to the proposed scale of on-site chlorine generation system. Separate searches were carried out using keywords “chlorine”, “sodium hypochlorite” and “electrolysis”. Chlorine and hydrogen release accidents are found for chemical plants or chlorine plants. Since there is no on-site storage of chlorine / hydrogen, chlorine / hydrogen releases would be caused by failures of process vessels, pipeline, joints or valves.

11.6.4 There was a recent incident in Phase 1 of the on-site chlorine generation system during testing and commissioning at Ngau Tam Mei Water Treatment Plant (NTMWTW). According to the QRA for Phase 2 of the on-site chlorine generation system (Quantity Risk Assessment for Provision of Second Unit of On-site Chlorine Generation (OSCG) Plant at Ngau Tam Mei Water Treatment Works, Issue 04, BMT Asia Pacific):

“The caustic ejection pump did not start doing caustic to the hypo tank after the set point was reached. Due to insufficient caustic dosing, chlorine gas was not converted to sodium hypochlorite in the hypo tank. The chlorine scrubber was activated and the normal ventilation was shut down upon detection of 3 ppm chlorine gas by several chlorine leak detectors near the OSCG Phase 1. It was later found out that the chlorine gas might be leaked from the loosen bolts at flanges around the anolyte tank and the chlorine / chlorinated brine line.

The root cause investigation of the chlorine leak is still on-going at the stage when preparing this QRA. The initial findings suggested that the incident was caused by a combination of programme control errors and improper mechanical installations. It is believed that such errors are only more probable during the testing and commissioning period and the likelihood can be much reduced during the operation of the OSCG."

11.6.5 In spite of occurring during testing / commissioning stage, this flange leak scenario is further assessed. To minimize human error in operation, operation staff of the desalination plant will be familiarized operating conditions with comprehensive training and clear operating procedures through the following actions,

- Provide 40-hour initial training (i.e. 16 hr classroom + 24 hr hands-on) and 8-hour annual refresher training for all operation and maintenance staff (including management, supervisor and front line staff) on the fundamentals of OSG technology, the standard operating procedures and the maintenance program;
- Prepare detailed O&M manual;
- Develop standard operating procedures;
- Conduct regular internal audits on O&M records, e.g. every 6 months;
- Perform monthly drills to ensure the proper function of the ventilation system for the OSG building and the chlorine scrubbing system.
- Incorporate Permits to Works system when maintenance works are carried out into the standard operating procedures.

- Direct Chlorine Discharge to the Atmosphere

11.6.6 The release scenario of chlorine gas direct to the surrounding is not considered credible while the OSG system does not have direct connection to vent pipe for the chlorine gas product.

- Continuous Indoor Chlorine Release

11.6.7 A leakage or rupture on pipelines would lead to indoor chlorine release. As generators will be connected to a common header for chlorine dosing, the worst case release from the common header is considered. This is referred as "failure of chlorine pipeline" scenario in which the leak size is further divided into (1) small leak with 3mm hole diameter, (2) large leak with 25mm hole diameter and (3) full bore rupture for the pipe with 50mm diameter. Another identified leak scenario is "failure of flange joint" in which the leak size is divided into (1) leak from 1 segment between 2 consecutive bolts with 13mm equivalent hole diameter and (2) leak from circumference with equivalent hole diameter of 25mm. The leak sizes are based on 4-bolt flanges and gasket thickness of 3.2mm.

11.6.8 Under normal operation, chlorine pipeline is under negative pressure. Chlorine would not leak from holes at flange joints or along chlorine pipeline when the negative pressure can be maintained. The release pressure is relatively low, which is generated by the evolution of chlorine from the electrolysis process. In order to obtain release rates for various hole sizes, the release pressure is estimated from the discharge model of PHAST 6.7 for the rupture scenario in which the release rate is assumed the same as the chlorine generation rate. According to the design capacity of the OSG system, the chlorine generation rate is 1125 kg per day per system, which is equivalent to a chlorine release rate of 0.013 kg/s at source. The release pressure is then applied to the rest of leak sizes. Release rates for 3mm leak, 13mm leak, 25mm leak and full bore rupture are 6.65E-05 kg/s, 1.25E-03 kg/s, 4.62E-03 kg/s and 1.3E-02 kg/s respectively. According to 4000 m^3 for the volume of OSG building and 6 ACPH ventilation rate, 10-minute average release rates to atmosphere for the OSG system are estimated to be 0.02 g/s, 0.46 g/s, 1.7g/s and 5 g/s for 3mm leak, 13mm leak, 25mm leak and full bore rupture.

11.6.9 The hazard is referred to Chlorine Gas hazard and is further assessed.

Hydrogen Gas By-products from On-site Generation of Chlorine Gas

11.6.10 Hydrogen gas is flammable, colourless and odourless with density 13 times lighter than air. When it is ignited, flash fire or explosion may be resulted. Considering physical properties of hydrogen, potential accumulation of hydrogen at indoor is possible although well ventilated operating environment and gas detectors will be provided. Moreover, hydrogen gas is odourless and colourless and the production scale is small, leakage of the gas might not be immediately detected. Because of the buoyancy of hydrogen gas, escaped gas tends to accumulate in the highest and draft-free areas such as under the ceiling and overhangs or in congested area. Lower Flammability Limit (LFL) and Upper Flammability Limit (UFL) for hydrogen are 4E+04 ppm and 7.5E+05 ppm respectively. Hydrogen can be ignited when the concentration in air is within LFL and UFL with the presence of ignition sources.

11.6.11 There will not be any storage for the hydrogen gas by-product. Hydrogen gas releases would be caused by failures of pipeline, joints or valves. Hydrogen gas will be diluted below LFL and discharged to the atmosphere ensuring that the concentration level will not lead to a hazardous environment.

- External Release Through Vent Pipe

11.6.12 Under normal operation, hydrogen gas by-product is diluted to 1% of LFL before discharging to the atmosphere without causing fire hazard. If the on-duty air blower fails, the stand-by air blower will start and the generator will trip. Risk of fire hazard for the discharging hydrogen would occur when there is insufficient fresh air for dilution and the generator continues operation. As each generator has individual 150 mm diameter vent pipe for hydrogen, the maximum release rate in the external release scenario is assumed equal to hydrogen generation rate for a generator. Referring to the chemical equation for the electrolysis process, the ratio of generation rate for chlorine gas to hydrogen gas molecules is 1. Corresponding to chlorine gas generation rate of 6.5 g/s per generator, hydrogen gas generation rate is 0.18 g/s per generator.

- Indoor Release

11.6.13 Failure of pipelines from electrolysers containing hydrogen-caustic solution mixture or vent pipe for hydrogen within the OSG building would lead to indoor release of hydrogen. When mechanical ventilation is turned off or ventilation relies on natural convection, hydrogen concentration could go up faster than in a room with forced ventilation. Change in indoor hydrogen concentration with time is depicted in **Figure 11.4** under different ventilation conditions. The hydrogen concentration levels off at approximately 330 ppm for ventilation rate of 6 ACPH under normal operation condition. According to the hydrogen generation rate for each system, maximum 0.108 kg of hydrogen is discharged to the OSG building in a continuous release for 10 minutes. It is estimated that the mass of hydrogen cumulated indoor would be 0.108 kg under the well ventilated and diluted condition for even longer release duration.

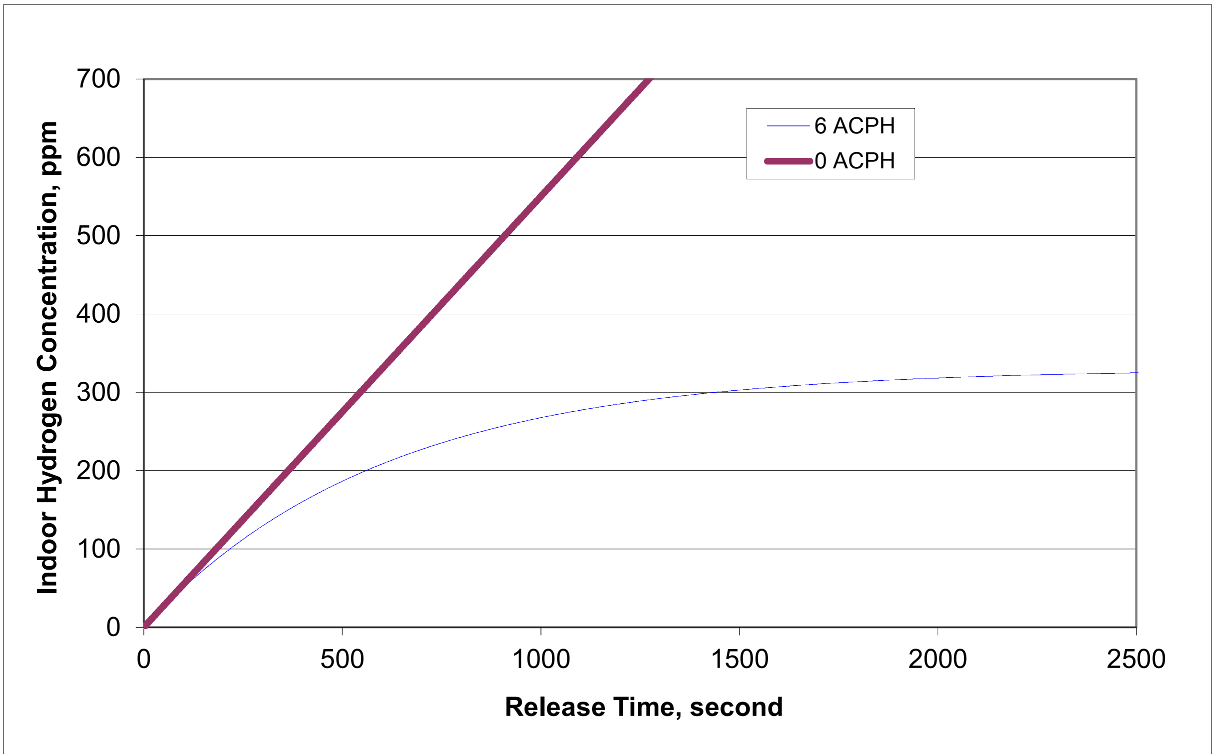


Figure 11.4 Changes in Indoor Hydrogen Concentration under Different Ventilation Conditions

11.6.14 The above calculation shows that it is crucial to maintain a well ventilated environment for the safe on-site chlorine generation operation. The use of blower and forced ventilation system are 2 main safeguard measures for the safety operation. Moreover, hydrogen detectors will be installed to monitor indoor hydrogen concentration. They would be triggered at concentration much lower than the LFL, at 10% and 25% of LFL for first and second alarm levels respectively, resulting in shutdown of chlorine generators and limiting the indoor quantity of hydrogen. However, hydrogen may aggregate at local spots when hydrogen gas is inadequately diluted, such as blower failure, and leakage occurs.

11.6.15 Hazardous would be localized explosion due to congested volume being filled up with hydrogen. The hazard is referred to Hydrogen Gas hazard and is further assessed.

Sodium Hydroxide Solution By-products from On-site Generation of Chlorine Gas

11.6.16 Sodium hydroxide (NaOH) is one of the dangerous goods to be used in the desalination plant. The hazard of NaOH has already been assessed in the approved EIA Report. The assessment results indicate that the chemical will not lead to hazard to life issue. Therefore, the impact of NaOH is not further assessed.

Use and Storage of Sodium Bisulphite Solution

11.6.17 38% wt sodium bisulphite ($NaHSO_3$) is one of the dangerous goods to be used in the OSG process for dechlorination. It evolves sulphur dioxide when it is mixed with incompatible chemicals. The aforementioned incident databases have also been searched for accidents involving sodium bisulphite using keywords “sodium bisulphite” or “sodium bisulfite”. Accident records relating to mixing of incompatible chemicals during refilling process which is relevant to the operation of the desalination plant are summarized in **Appendix 11H**.

11.6.18 38% wt sodium bisulphite ($NaHSO_3$) solution will be stored at OSG buildings together with 32% wt hydrochloric acid (HCl). Considering 90-day storage, storage quantities for sodium bisulphite and hydrochloric acid are 2 m^3 for each chemical, in 1 m^3 storage tanks, in each

OSG building. Sodium bisulphite is incompatible with hydrochloric acid. When chemical reaction take place, sulphur dioxide gas is evolved, referring to the following chemical equation,

$NaHSO_3 + HCl \rightarrow H_2O + NaCl + SO_2$

11.6.19 Although aircraft crash is not considered a credible external event with the occurrence frequency less than 10^{-9} per year by referring to the approved EIA (Section 13.2.9), other external events such as earthquakes and explosives transport may damage to pipelines, storage tanks and partition walls causing simultaneous failure of containments for incompatible chemicals. The following preventive measures will be implemented to avoid accidental mixing of incompatible chemicals in this simultaneous failure scenario,

- Chemicals will be stored in separate compartments, in which bund wall is designed to contain entire storage quantity in case of tank failure, to prevent from mixing of spillage. Bunds will be constructed with linings such that chemicals would not leak from bunds through cracks.
- Double containment will be provided for HCl pipelines in OSG buildings.
- Alignment of HCl pipeline is away from pipelines for other incompatible chemicals in OSG building referring to **Appendix 11C**.
- Floor surface gradient will be used for directing spillage of incompatible chemicals to different locations such that HCl will be collected to a separate drain system.
- Separate drain system for HCl will be provided to collect spillage from pipelines inside OSG building and outside storage compartment, by referring to indicative diagrams as shown in **Appendix 11C**.
- Only one storage tank will be connected to delivery pipeline at any one time to minimize the amount of spillage.
- Pipe pressure will be continuously monitored. Pumps will be immediately shut down if irregular pressure drops occur.
- Vibration sensing system will be installed along pipelines. Pumps will be immediately shut down if excessive vibration is detected to minimize the amount of leakage through damaged pipelines.

11.6.20 However, accidental mixing in loading operation with other dangerous goods including 10% wt hydrochloric acid, hydrochloric acid content in ferric chloride, sulphuric acid and citric acid may be possible. The mechanism for the mixing of incompatible chemicals scenario is similar to the one for sodium hypochlorite in the approved EIA. The methodology for the assessment of sodium hypochlorite in the approved EIA is adopted for accidental mixing of sodium bisulphite with incompatible chemicals. Chemical reactions with sulphuric acid and citric acid refer to the following chemical equations,

$2\ NaHSO_3 + H_2SO_4 \text{ -> } \rightarrow 2\ H_2O + Na_2SO_4 + 2\ SO_2$

$3\ NaHSO_3 + C_6H_8O_7 + \rightarrow 3\ H_2O + Na_3C_6H_5O_7 + 3\ SO_2$

11.6.21 Assumptions are made to estimate the quantity of sulphur dioxide gas evolved from the reaction. The transfer rate from road tankers to storage tanks is taken 10 l/s. Storage tanks are not empty but 50% full of remaining chemical solution. The amount of chemical in a road tanker involving in the mixing depends on the size of storage tank being filled up or the size of the road tanker if the tank size is bigger than the road tanker. The amount of sulphur dioxide evolving from chemical reaction depends on the number of molecules in sodium bisulphite solution and the reacting acid content. It is governed by the smaller number available for the 2 chemicals. Scenarios for accidental mixing are described in details as follows,

- Scenario 1A / 1B – wrong product (32% wt HCl) is delivered and unloaded to the right tank (38% wt $NaHSO_3$ tank) at OSG building for Phase 1 / Phase 2, due to human error by supplier.

11.6.22 The reaction is limited by the available sodium bisulphite in the storage tank. The release rate of sulphur dioxide and the mixing duration are 6.5 kg/s and 24 seconds respectively.

Table 11.3 Mixing Rate and Duration for Scenario 1A / 1B

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	32% HCl	0.5 (note 1)	1.16	5092	102	25
Storage Tank	38% $NaHSO_3$	0.5	1.33	**2428**		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 1 m^3 are assumed. 2 storage tanks at each OSG building.*

- Scenario 2A / 2B – wrong product (38% wt $NaHSO_3$) is delivered and unloaded to the right tank (32% wt HCl tank) at OSG building for Phase 1 / Phase 2, due to human error by supplier.

11.6.23 The reaction is limited by the available sodium bisulphite from the road tanker. The release rate of sulphur dioxide and the mixing duration are 3.1 kg/s and 50 seconds respectively.

Table 11.4 Mixing Rate and Duration for Scenario 2A / 2B

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	38% $NaHSO_3$	0.5 (note 1)	1.33	**2428**	49	50
Storage Tank	32% HCl	0.5	1.16	5092		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 1 m^3 are assumed. 2 storage tanks at each OSG building.*

- Scenario 3A / 3B – wrong product ($FeCl_3$ with 5% wt HCl content) is delivered and unloaded to the right tank (38% wt $NaHSO_3$ tank) at OSG building for Phase 1 / Phase 2, due to human error by supplier.

11.6.24 The reaction is limited by the available hydrochloric acid in ferric chloride from the road tanker. The release rate of sulphur dioxide and the mixing duration are 1.2 kg/s and 50 seconds respectively.

Table 11.5 Mixing Rate and Duration for Scenario 3A / 3B

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	$FeCl_3$ (5% HCl)	0.5 (note 1)	1.37	**940**	19	50
Storage Tank	38% $NaHSO_3$	0.5	1.33	2428		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 1 m^3 are assumed. 2 storage tanks at each OSG building.*

- Scenario 4 – wrong product (38% wt $NaHSO_3$) is delivered and unloaded to the right tank ($FeCl_3$ tank with 5% wt HCl content) at chemical building, due to human error by supplier.

11.6.25 The reaction is limited by the available sodium bisulphite from the road tanker. The release rate of sulphur dioxide and the mixing duration are 3.1 kg/s and 2500 seconds respectively.

Table 11.6 Mixing Rate and Duration for Scenario 4

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	38% $NaHSO_3$	25 (note 1)	1.33	**121420 (#)**	49	2500
Storage Tank	$FeCl_3$ (5% HCl)	126	1.37	236790		

Note 1: Road tanker's quantity for reaction is limited by its capacity.
** Road tanker capacity 25 m^3 and storage tank size 252 m^3 are assumed. 8 storage tanks at chemical building*

- Scenario 5A / 5B – wrong product (10% HCl) is delivered and unloaded to the right tank (38% wt $NaHSO_3$ tank) at OSG building for Phase 1 / Phase 2, due to human error by supplier.

11.6.26 The reaction is limited by the available hydrochloric acid from the road tanker. The release rate of sulphur dioxide and the mixing duration are 1.8 kg/s and 50 seconds respectively.

Table 11.7 Mixing Rate and Duration for Scenario 5A / 5B

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	10% HCl	0.5 (note 1)	1	**1372**	27	50
Storage Tank	38% $NaHSO_3$	0.5	1.33	2428		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 1 m^3 are assumed. 2 storage tanks at each OSG building.*

- Scenario 6 – wrong product (38% wt $NaHSO_3$) is delivered and unloaded to the right tank (10% HCl tank) at chemical building, due to human error by supplier.

11.6.27 The reaction is limited by the available hydrochloric acid in the storage tank. The release rate of sulphur dioxide and the mixing duration are 3.1 kg/s and 1130 seconds respectively.

Table 11.8 Mixing Rate and Duration for Scenario 6

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	38% $NaHSO_3$	20 (note 1)	1.33	97136	49	1130
Storage Tank	10% HCl	20	1	**54870**		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 40 m^3 are assumed. 2 storage tanks at chemical building.*

- Scenario 7A / 7B – wrong product (98% H_2SO_4) is delivered and unloaded to the right tank (38% wt $NaHSO_3$ tank) at OSG building for Phase 1 / Phase 2, due to human error by supplier.

11.6.28 The reaction is limited by the available sodium bisulphite in the storage tank. The release rate of sulphur dioxide and the mixing duration are 23.6 kg/s and 7 seconds respectively.

Table 11.9 Mixing Rate and Duration for Scenario 7A / 7B

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	98% H_2SO_4	0.5 (note 1)	1.84	9200	368 ($NaHSO_3$)	7
Storage Tank	38% $NaHSO_3$	0.5	1.33	**2428**		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 1 m^3 are assumed. 2 storage tanks at each OSG building.*

- Scenario 8 – wrong product (38% wt $NaHSO_3$) is delivered and unloaded to the right tank (98% H_2SO_4 tank) at chemical building, due to human error by supplier.

11.6.29 The reaction is limited by the available sodium bisulphite in the road tanker. The release rate of sulphur dioxide and the mixing duration are 3.1 kg/s and 2500 seconds respectively.

Table 11.10 Mixing Rate and Duration for Scenario 8

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	38% $NaHSO_3$	25 (note 1)	1.33	**121420** (#)	49 ($NaHSO_3$)	2500
Storage Tank	98% H_2SO_4	69	1.84	1269600		

Note 1: Road tanker's quantity for reaction is limited by its capacity.
** Road tanker capacity 25 m^3 and storage tank size 138 m^3 are assumed. 10 storage tanks at chemical building.*
 # The molar ratio in the chemical reaction is 2:1 (sodium bisulphite : sulphuric acid).

- Scenario 9A / 9B – wrong product (50% $C_6H_8O_7$) is delivered and unloaded to the right tank (38% wt $NaHSO_3$ tank) at OSG building for Phase 1 / Phase 2, due to human error by supplier.

11.6.30 The reaction is limited by the available sodium bisulphite in the storage tank. The release rate of sulphur dioxide and the mixing duration are 6.2 kg/s and 25 seconds respectively.

Table 11.11 Mixing Rate and Duration for Scenario 9A / 9B

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	50% $C_6H_8O_7$	0.5 (note 1)	1.24	1615	97 ($NaHSO_3$)	25
Storage Tank	38% $NaHSO_3$	0.5	1.33	**2428 (#)**		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 1 m^3 are assumed. 2 storage tanks at each OSG building.*
 # The molar ratio in the chemical reaction is 3:1 (sodium bisulphite : citric acid).

- Scenario 10 – wrong product (38% wt $NaHSO_3$) is delivered and unloaded to the right tank (50% $C_6H_8O_7$) at chemical building, due to human error by supplier.

11.6.31 The reaction is limited by the available sodium bisulphite from the road tanker. The release rate of sulphur dioxide and the mixing duration are 3.1 kg/s and 400 seconds respectively.

Table 11.12 Mixing Rate and Duration for Scenario 10

Source (*)	Chemical	Qty for Reaction (m^3)	Density (kg/l)	Available Qty for Reaction (mole)	Mixing Rate (mole/s)	Duration (s)
Road Tanker	38% $NaHSO_3$	4 (note 1)	1.33	**19427**	49 ($NaHSO_3$)	400
Storage Tank	50% $C_6H_8O_7$	4	1.24	12919		

Note 1: Road tanker's quantity for reaction is determined by the target storage tank size (50% of the storage tank capacity).
** Road tanker capacity 25 m^3 and storage tank size 8 m^3 are assumed. 1 storage tanks at chemical building.*
 # The molar ratio in the chemical reaction is 3:1 (sodium bisulphite : citric acid).

11.6.32 The hazard is referred to Suphur Dioxide hazard and is further assessed.

Change of Plant Layout

- Unloading of Sodium Hypochlorite

11.6.33 Hazards of sodium hypochlorite solution were assessed in the approved EIA Report. The relevant hazards associated with the proposed OSG system would come from off-site delivery of sodium hypochlorite to the desalination plant under emergencies and on-site use / storage of sodium hypochlorite. According to the approved EIA, it was assumed the hazard was caused by accidental mixing of incompatible chemicals during the transfer process to storage tanks. Since import of sodium hypochlorite from the same chemical supplier for other chemicals is not required for the operation of the proposed OSG system, the risk of accidental mixing during delivery is eliminated. Tank color coding, tank feeding pipe lock out system and use of different coupler / size will prevent feeding wrong chemicals in sodium hypochlorite tanks.

- Location of Sodium Hypochlorite Storage

11.6.34 Sodium hypochlorite solution generated on-site will be stored in OSG buildings. Although incompatible chemical hydrochloric acid will also be placed in the same building, these 2 chemicals will be stored in separate compartments. Moreover, bund with capacity equal to 100% of all tanks in a compartment will be provided to contain any spillages. Moreover, preventive measures as described in **Section 11.6.19** will be implemented. Therefore, there is no risk of mixing of incompatible chemicals for the storage.

- Alignment of Sodium Hypochlorite Pipelines

11.6.35 In the feasibility study stage for the approved EIA, separate pipeline routing was proposed for preventing sodium hypochlorite from accidental mixing with incompatible chemicals due to leaking pipelines. Apart from separate pipeline routing, separate trench containments made of impervious materials for sodium hypochlorite pipeline and other incompatible chemicals pipelines will be used to ensure that leakages could be contained without leading to accidental mixing of incompatible chemicals. The alignment of pipelines and use of separate trenches refer to **Appendix 11C**. Moreover, preventive measures as described in **Section 11.6.19** will be implemented. Therefore, no risk of accidental mixing of sodium hypochlorite with incompatible chemicals along the pipe alignment is anticipated.

- Location of Administration Building

11.6.36 The administration building is moved close to the TKO Area 137 pier with the separation distance of 95 m between the centre of the administration building and the hazardous source at an explosives barge. It is within the hazard zone for explosives unloading operation. Personnel at the building would be impacted by accidents involving detonation of explosives at the pier. It is estimated the number of staff at the administration building is 14 persons during the explosives unloading operation. This is further assessed in Explosives Unloading Pier sections.

- Location of Liquid Carbon Dioxide Storage Area

11.6.37 According to the revised design, there is no change in the storage quantity and operation of liquid carbon dioxide. Referring to descriptions in previous sections and the conceptual plant layout in **Figure 11.1,** the storage location is however different from that assumed in the approved EIA Report. In the latest design, a flexible barrier will be built within the desalination plant along the eastern boundary. The barrier is designed to completely contain debris flow (see **Appendix 11G**). It is proposed in the “Natural Terrain Landslide Hazard Assessment Report (Final), Feb 2017” which has been accepted by GEO. According to historical incidents around the world, the barrier can effectively slow down debris flow in case of barrier failure. The liquid carbon dioxide storage area is at 30m from the toe of slope. Referring to the approved EIA, the soil depth reaching the storage area would be around 1m even without any protective measures. To protect the storage area from soil debris in case of barrier failure, a 1.5m high protective barrier will be constructed at the road side of the internal access road as the second line of defence. Debris flow would only cause leakage of connecting pipelines in the worst case with these preventive measures in place. Therefore, slope failure would not lead to additional hazard or damage, including boiling liquid expanding vapour explosion (BLEVE), to the liquid carbon dioxide storage tanks and surrounding population.

11.6.38 According to the approved EIA, liquid carbon dioxide storage area was not affected by the road transport of explosives. In the current layout, the liquid carbon dioxide storage area is moved away from the western boundary by comparing with the layout as shown in the approved EIA. The 2 psi overpressure zone, which is 125m from the explosion source referring to **Section 11.7.17** in case of explosives truck explosion. Apart from the setback distance of 118m from the western site boundary, the storage facility is completely shielded by other buildings such as Stage 2 RO building, post treatment and chlorine contact basin buildings from the explosion. Shielding effects of buildings in blasts were investigated and evaluated in the study report number *HSL/2001/04 “Explosion Hazard Assessment: A Study of the Feasibility and Benefits of Extending Current HSE Methodology to take Account of Blast Sheltering” of Health & Safety Laboratory UK*. In the desalination plant, CO_2 storage tanks are shielded by 1 and 2 rows of buildings at Stage 1 and Stage 2 respectively. Since the height of CO_2 storage tanks is shorter than, about 50% - 75%, the shielding buildings, findings of the study report are applicable to the desalination plant. Referring to Table 5.2 of the study report, Scenario B with the TNT charge mass 2000 kg, the normalized building height of < 1 m/kg1/3 and 1 to 2 rows of shielding building is more relevant to the setup of the desalination plant. In fact, the desalination plant design provides better shield protection than Scenario B of the study by considering the normalized building height > 1 m/kg1/3 and up to 2.5 m/kg1/3. The zone boundary 140 mbar in Table 5.2 of the study report is corresponding to the 2 psi zone. By looking up Table 5.2, the boundary shift of 23m and 35m for 1 building row and 2 building rows respectively. According to the study finding, minimum 23m reduction in hazard distance (considering only 1 row of shielding building for the conservative case of Stage 1 plant layout) is expected and the corresponding reduced hazard distance for the 2 psi overpressure is estimated as 102m (=125 – 23) i.e. the 118m setback distance is sufficient. Therefore, the storage area would not be impacted by the road transport of explosives.

11.6.39 The hazard is referred to Liquid Carbon Dioxide hazard and is further reviewed and assessed in Liquid Carbon Dioxide sections.

Landfill Gas Utilization for Power Generation

11.6.40 The desalination plant will utilise SNG to generate electricity for part of the electricity consumption. LFG from the adjacent South East New Territories (SENT) Landfill will be collected and processed by an external supplier. SNG will be delivered to the desalination plant by an underground medium pressure pipeline operating at 2.4 barg with maximum flowrate 2,084 m^3/hour. There will not be any storage of SNG in the desalination plant. The SNG processing facility is not part of the Project. QRA is not required for the use and delivery of SNG by referring to correspondences with Electrical and Mechanical Services Department. The generator will be either installed in a generator room or placed at an open space using a modular design.

11.6.41 Composition and properties of the SNG, as advised by Hong Kong and China Gas Company Limited (HKCG), are shown in the following table. In the assessment, the chemical composition is assumed methane (49%), carbon dioxide (25%) and nitrogen (26%). The calculated LFL and UFL are 9E+04 ppm and 3.4E+05 ppm respectively. The gas is flammable. It has fire hazard and asphyxiation effect due to the carbon dioxide content.

Table 11.13 Properties of Synthetic Natural Gas

Chemical Composition	
Methane (CH_4)	> 45%
Carbon dioxide (CO_2)	20 – 30%
Nitrogen (N_2)	20 – 32%
Oxygen (O_2)	< 2%
Hydrogen sulphur (H_2S)	< 1 ppmv
Typical Physical Properties	
Dew point	10^{o}C
Pressure	2.4 barg
Calorific value	17.13 – 17.41 (MJ/Sm^3)
Wobbe Index	17.7 – 18.3 (MJ/Sm^3)

11.6.42 Referring to historical incidents recorded in MHIDAS (Major Hazard Incident Data Service developed by the Safety and Reliability Directorate of the UK Atomic Energy Authority), ARIA and eMARS in relation to failures of power plants involving use of fuel gas, the leakage of fuel gas led to fire and explosion events. Impacts of the SNG failure may lead to potential off-site fatalities and damages to other onsite hazardous sources.

11.6.43 Hazards of SNG for the desalination plant come from (1) gas releases to the surrounding and (2) indoor release due to pipeline / equipment failures. Fire or explosion would be resulted when the gas is ignited.

- Gas Release to the Surrounding

11.6.44 It is likely to occur when the generator is installed outdoor. The release is considered a continuous release with flow rate of 2 kg/s.

- Indoor Release

11.6.45 Because of the high gas flow rate, the generator room would be filled up with flammable gas and the gas concentration would reach the LFL in 60 seconds disregarding the ventilation rate, referring to **Figure 11.5**. Since ignition sources such as hot surface, flame and spark are available in the generator room, flammable gas would be ignited at the early stage of the release. It is assumed that ignition would occur when 50% space of the 1300 m^3 generator room is filled up with flammable gas. The amount of gas accumulated indoor would be approximately 63 kg.

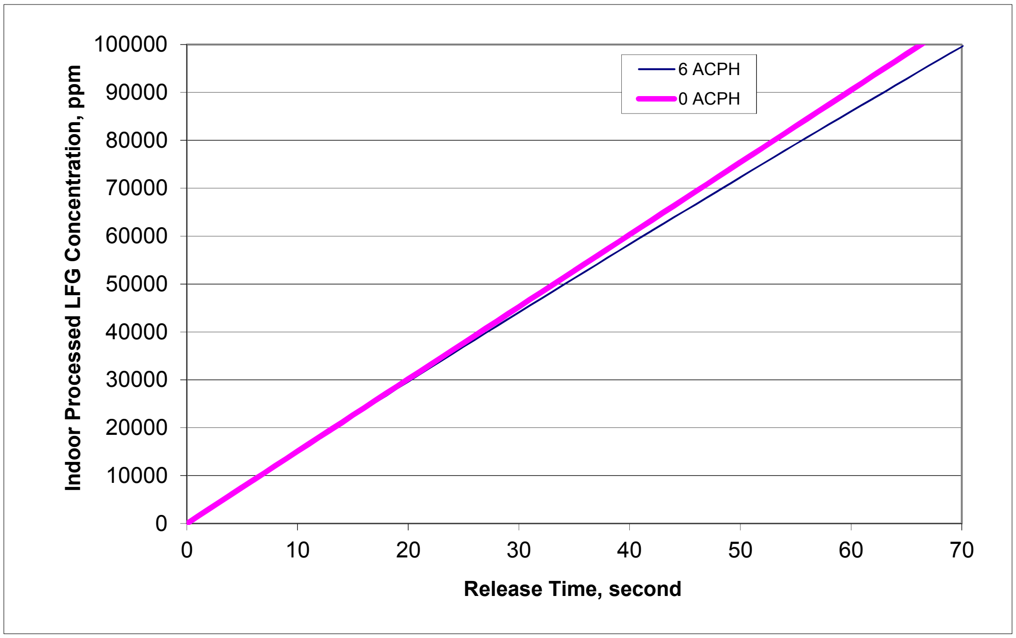


Figure 11.5 Change in Indoor SNG Concentration with Time Assuming Perfect Mixing

11.6.46 These 2 hazardous scenarios are referred to SGN hazards. They are further reviewed and assessed in Synthetic Natural Gas sections.

Use, Storage and Transport of Other Dangerous Goods

11.6.47 Except 38% wt sodium bisulphite solution and 32% wt hydrochloric acid for OSG purpose, there is no additional dangerous goods due to the proposed OSG system operation in comparison with the approved EIA. According to the revised design, there are no changes in the use, types and operation of other dangerous goods in the desalination plant except for some minor changes in the storage quantities. The proposed changes satisfy all the design requirements and measures for other dangerous goods as recommended in the approved EIA Report. The design changes would not cause additional hazard impact in relation to other dangerous goods. Storage quantities of other dangerous goods are updated as follows.

Table 11.14 Storage Quantity of Dangerous Goods at the Chemical Building and OSG Buildings

Chemical	Storage Quantity	Storage Location
Ferric Chloride	2016 m^3	Chemical Building
Sulphuric Acid	1380 m^3	Chemical Building
Citric acid	8 m^3	Chemical Building
Caustic Soda (Sodium Hydroxide)	1944 m^3	Chemical Building, OSG Buildings for Phase 1 & 2
Polyelectrolyte	26 m^3	Chemical Building
Hydrated Lime	1345 tonnes	Chemical Building
Sodium meta-bisulphite	182 m^3	Chemical Building
Anti-scalant	296 m^3	Chemical Building
Sodium Silicofluoride	24 tonnes	Chemical Building
10% wt. Hydrochloric Acid	80 m^3	Chemical Building
32% wt. Hydrochloric Acid	4 m^3	OSG Buildings for Phase 1 & 2
38% wt Sodium Bisulphite	4 m^3	OSG Buildings for Phase 1 & 2

Chemical	Storage Quantity	Storage Location
Sodium Hypochlorite	60 m^3	OSG Buildings for Phase 1 & 2

11.7 Consequence Analysis

11.7.1 Credible hazardous scenarios discussed in the hazard identification section are assessed for the extent of impact in this consequence analysis.

Chlorine Gas from OSG

- Continuous Indoor Chlorine Release

11.7.2 Detailed consequence analysis under the worst wind condition at 1.5 m/s wind speed and F stability class using PHAST 6.7 assuming dispersion over an open space gives 49m downwind distance for LD03 contour in the full bore rupture scenario. For the rest of leak scenarios, the hazard distance is below 30m. A complete set of consequence results refer to **Appendix 11D**. There is no offsite impact for leak size ≤ 25mm comparing with 34m from the centre of OSG building to the nearest site boundary while exhaust points / louvers are located at the southern boundary of OSG buildings with 43m and 51m separation to the western and the northern boundary respectively, referring to **Appendix 11B**. Only chlorine release in full bore rupture events can cause off-site impacts to surrounding population. The chlorine hazard is further assessed in Frequency Analysis section.

Hydrogen Gas from OSG

- Indoor Release

11.7.3 Hydrogen cumulates at congested space of an OSG skid in leakage leading to explosion when dilution is inadequate. Although the hydrogen source presents at the electrolyzer unit only, the congested volume is taken from the whole skid unit as shown in **Appendix 11E** where pipes and containers are located. The congested volume is approximately 57 m^3. The congested volume is conservatively assumed more than 30% occupied by equipment. It is also assumed that hydrogen releases for 10 minutes and is rectified by operating staff such as by turning off the power to the skid. The total amount of hydrogen generated in 10 minutes according to the generator capacity would be 108g and completely discharged to the congested volume. The explosion impact is assessed using the Multi-Energy Explosion model in PHAST 6.7 with confined strength 10 to account for the worst case scenario. It is estimated that the hazard distance is 11m for overpressure of 2 psi as shown in **Figure 11.6**. Based on the estimated hazard distance, it would not cause simultaneous damages to HCl storage compartment and other storage compartments for incompatible chemicals. The generation process would be disrupted immediately following the explosion and would not result in continuous release of chlorine. While the OSG building is constructed from reinforced concrete, the explosion may cause minor damages to the OSG building. Nevertheless, mixing of incompatible chemicals due to direct or secondary impact to storage tanks inside OSG buildings could be avoided with the preventive measures as discussed in **Section 11.6.19**.

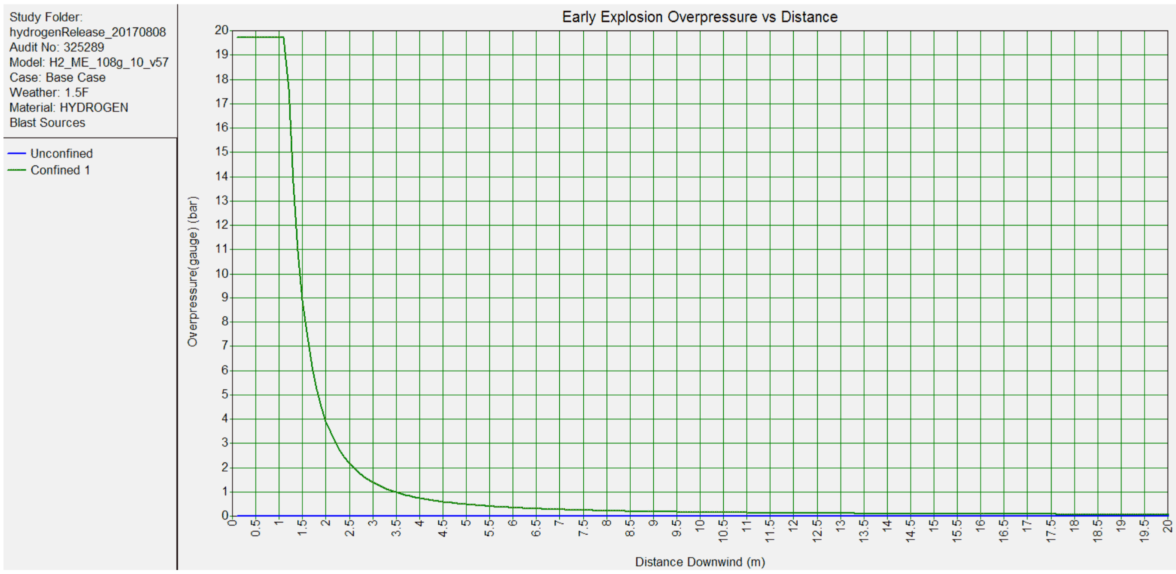


Figure 11.6 Overpressure Level against Distance for Hydrogen Explosion

- External Release Through Vent Pipe

11.7.4 While the vent exit is 3m above the roof floor at the elevation level the same as or higher than surrounding building structures in the desalination plant, there is no risk of trapping hydrogen gas under building canopy. The only hazard comes from ignition of hydrogen gas plume. Results from dispersion model using PHAST 6.7 with horizontal release direction gives the maximum hazard distance for flash fire approximately 3m at wind stability D and speed 4.5 ms^{-1}. Because of the relatively small release rate, release through vent pipe would not lead to jet fire or explosion.

11.7.5 OSG buildings for Phase 1 and Phase 2 are 34 m from the nearest northern site boundary. Release events causing congested volume explosion for hydrogen gas would not cause off-site impact. While OSG buildings for Phase 1 and Phase 2 are 58 m and 90 m from the nearest hazardous source SNG fuelled power generator and liquid carbon dioxide storage area respectively. Hydrogen releases resulting in congested volume explosion would not lead to secondary impact to hazardous sources. Hydrogen hazard is not further assessed in the rest of this report.

Sulphur Dioxide

11.7.6 Dispersion modeling was conducted using PHAST 6.7 assuming open flat terrain and horizontal release direction. The fatality probability is estimated using the Probit equation,

$$\text{Probit} = -19.2 + \ln (C^{2.4} t)$$

where C is concentration in mg/m^3 and t is time of exposure in minutes.

11.7.7 The maximum hazard distance at 1% probability of fatality (LD01) is 291 m under wind stability F and wind speed 1.5 m/s. The complete set of consequence analysis results refers **Appendix 11D**. Maximum hazard distances and the corresponding wind conditions for all scenarios are summarized in **Table 11.15**. Since sulphur dioxide is a dense gas, the plume height is below 4 m according to dispersion modeling results.

Table 11.15 Summary of Maximum Hazard Distances for Accidental Mixing Scenarios

Scenario	Description	Maximum Hazard Distance (Note 1) (m)	Wind Condition	
			Stability	Speed (m/s)
1A / 1B	32% wt HCl to $NaHSO_3$ tank	145	D	2
2A / 2B	$NaHSO_3$ to 32% wt HCl tank	142 (Note 1)	D	2

Scenario	Description	Maximum Hazard Distance (Note 1) (m)	Wind Condition	
			Stability	Speed (m/s)
3A / 3B	$FeCl_3$ to $NaHSO_3$ tank	90	D	2
4	$NaHSO_3$ to $FeCl_3$ tank	291 (Note 1)	F	1.5
5A / 5B	10% wt HCl to $NaHSO_3$ tank	101	D	2
6	$NaHSO_3$ to 10% wt HCl tank	260 (Note 1)	F	1.5
7A /7B	H_2SO_4 to $NaHSO_3$ tank	150 (Note 1)	D	2
8	$NaHSO_3$ to H_2SO_4 tank	291 (Note 1)	F	1.5
9A / 9B	C6H8O7 to $NaHSO_3$ tank	145	D	2
10	$NaHSO_3$ to $C_6H_8O_7$ tank	263	F	1.5

Note1: The hazard distance refers to the LD01 contour. In general, LD is generated by taking into account the dispersion result and exposure time at a point. Although the dispersion reaches steady state at certain release time say 20s, the toxic dose increases with the exposure time. In PHAST / SAFETI, the exposure time depends on the release duration to represent the worst case exposure scenario.

11.7.8 Sulphur dioxide generated in accidental mixing events causes impacts to off-site population. Frequencies of occurrence for those accidental mixing events are further discussed in the Frequency Analysis section.

Synthetic Natural Gas

- Gas Release to the Surrounding

11.7.9 Dispersion modeling was conducted using PHAST 6.7 assuming open flat terrain and horizontal release direction. Assessment criterion for jet fire is 4 kW/m^2. The maximum hazard distance for jet fire is 24 m under wind stability D and speed 4.5 m/s.

11.7.10 The flame length of the jet fire is 18m. The jet fire would not cause any secondary impacts to other hazardous sources within the desalination plant .

- Indoor Release

11.7.11 Multi-Energy Explosion model in PHAST 6.7 was applied to estimate the overpressure impact by assuming confined strength 10 and the congested volume equivalent to the building volume 1300 m^3. The confined strength is obtained according to criteria listed in TNO Yellow Book where obstruction is conservatively assumed high with parallel plane confinement and high in ignition source. The assessment criterion for the explosion impact is overpressure of 2 psi. The maximum hazard distance for an explosion is 47 m.

11.7.12 The SNG power generator is 56 m from the nearest site boundary, 58 m from OSG building for Phase 1 and 70 m from the liquid carbon dioxide storage area. Failure of SNG power generator and associated facilities resulting in explosion and fire impingement would lead to neither off-site impact nor secondary impact to on-site hazardous sources. Therefore, SNG hazard is not further assessed.

Liquid Carbon Dioxide

11.7.13 Since there is no change in transport and onsite storage method as well as operation requirements, modeling results from the approved EIA remain valid.

11.7.14 Referring to the approved EIA, the hazard distance for toxic impact of liquid carbon dioxide is 39m. The nearest distance from the centre of the liquid carbon dioxide storage area to the western site boundary, which is close to surrounding population, is 118m. Therefore, there is no toxic impact of on-site liquid carbon dioxide to off-site population.

11.7.15 Off-site transport of liquid carbon dioxide has off-site impact. However, findings of the consequence analysis in the approved EIA are valid. The liquid carbon dioxide hazard is further discussed in the frequency analysis and the cumulative risk sections in this report.

Explosives Unloading Pier

11.7.16 There is no change in explosives unloading operation or the quantity of explosives involved. According to the consequence modeling results in the approved EIA and the Working Paper No. 5, the southern portion of the Project Site and the administration building in the current layout falls within the 161m hazard distance for 1% fatality probability, which is set as the threshold limit in the estimation of fatalities, of the explosives unloading pier. Accidental detonation of explosives would lead to structural damages to buildings, as well as the administration building, and falling of objects during both the construction and the operation stages. Construction workers during the construction stage and personnel of the desalination plant during the operation stage would be impacted in associated explosion events. During construction stage, construction workers will be restricted from entering the 161m range centered at the explosives barge during explosives unloading operation. This restriction will be imposed on the Contract Requirements. Since there will not be any fatalities in explosion events, the risk to construction workers is eliminated. Therefore, the hazard for the construction stage is not further assessed. However, the hazard to personnel in the administration building during the operation stage is further discussed in the rest of this report.

11.7.17 According to the formula given in the Queensland Explosives Information Bulletin 50 Version 4 (current) Section 12 (the Bulletin 50) and also making reference to Kingery-Bulmash Blast Parameter Calculator on the website of International Ammunition Technical Guidelines, United Nation, the required separation distance for 5000 kg and 1750 kg TNT equivalent explosives is 178 m and 125 m respectively.

11.7.18 The Bulletin 50 also states that quantitative risk assessment (QRA) may be applied to justify the risk as low as reasonably practicable (ALARP) when the separation distances for Class 1 explosives cannot be met. QRA is adopted in the approved EIA, Working Paper No. 5 and this Environmental Review Report (ERR) to give the justification.

11.7.19 Referring to the approved EIA, dangerous goods in chemical building would not lead to hazard to life issue by considering their concentrations in the atmosphere due to accidental spillage and the escape factor of the surrounding population. The finding is valid even if the chemical building is damaged in an explosion. Moreover, the chemical building is shielded by the solid handling building and other buildings which would absorb most of blast impacts in an explosion. Although the chemical building is moved closer to the explosives unloading pier, damages to the chemical building and chemicals inside the building would neither cause secondary impact to surrounding population nor contribute to the outcome of the QRA. Other on-site hazardous sources would not lead to secondary impact in explosion events while the liquid carbon dioxide storage area is 400 m away. Therefore, consequence modeling results from the approved EIA and the Working Paper No. 5 remain valid and are adopted for the QRA in this ERR.

11.8 Frequency Analysis

11.8.1 Referring to findings from consequence analyses in the previous section, chlorine, hydrogen, sulphur dioxide, off-site transport of liquid carbon dioxide and explosives unloading pier hazards are further assessed using frequency analysis. Failure data and their reference sources are listed in **Table 11.16**.

Table 11.16 Basic Failure Data

Item	Failure Rate	Reference Source / Remarks
Pipework failure (full bore rupture) for chlorine gas	1E-06 /m/yr	Ref.1; HSE; pipe diameter 0-49mm

Item	Failure Rate	Reference Source / Remarks
Failure of 2 or more chlorine detectors	2.1E-05	Ref.2; based on fail-dangerous failure frequency for chlorine leak detector 2.5E-3 per year. Assuming monthly proof test and a common mode failure beta factor of 0.2, probability of failure on demand of 2 or more detectors = 0.2*2.5E-3*(1/12)/2=2.1E-5
No trip signal to ventilation fan(s)	1E-4	Ref.2
Failure to close air damper on demand	2.6E-3	Ref.2; damper failure frequency 6.2E-2 per year. Assuming monthly proof test, probability of failure on demand=6.2E-2*(1/12)/2=2.6E-3
Operating staff fail to shutdown ventilation system immediately by manual means	0.1	Ref.3; assuming highly complex task, considerable stress, little time to perform it.
Human error	0.01	The approved EIA, Ref.4
Ref.1: Health and Safety Executive (HSE), Failure Rate and Event Data for Use within Risk Assessments, 2012. Ref.2: ERM, Reassessment of Chlorine Hazard for Eight Existing Water Treatment Works: Methodology Report, 1997. Ref 3 International Association of Oil & Gas Producers (OGP), Risk Assessment Data Directory, Human Factors in QRA, Report No. 434-5, 2010. Ref.4: WSD, EIA for Desalination Plant at Tseung Kwan O, 2015.		

Chlorine Gas from OSG

11.8.2 Under normal operation, streams 31, 32 and 33 as shown in the process flow diagram in **Appendix 11A** for gaseous chlorine are under negative pressure. Streams 19, 21, 22, 23 and 37 contain mixture of gaseous chlorine and brine solution. Streams 21 and 37, in which the chlorine content is much lower than at stream 19, 22 or 23, do not have continuous liquid flow and is not further considered. There are 33 flanges, 20 valves, 6 instruments and 2 other fittings along streams 19, 22, 23, 31, 32 and 33. Length of pipeline for streams 22 & 23 are 10m. Length of pipeline for streams 31, 32 & 33 are 50m. Referring to findings from consequence analysis in **Section 11.7.2** for various leak sizes, chlorine releases for leakage sizes with equivalent hole size less than or equal to 25mm would not lead to offsite impact. The hole size of 25mm represents the large leak scenario for pipeline and failure of spiral wound gasket. Spray releases from flanges, valves or other fittings would have even smaller leak size and would lead to smaller outflow than in 25mm leak. Full bore rupture is the only scenario leading to offsite impact and is considered in the frequency analysis.

11.8.3 The frequency of occurrence for chlorine discharging to the atmosphere is derived from the event tree as shown in **Appendix 11F**. The failure frequency of chlorine pipelines is estimated from the failure rates for full-bore rupture of 0-49 mm diameter pipe and is equal to 1E-06 per m per year which is based on failure data as published by Health and Safety Executive, UK (HSE). The length of chlorine pipeline inside each OSG building is approximately 60 m covering gaseous chlorine and chlorine-brine mixture pipelines. Only pipeline is counted by considering that flange failure and pipe leak would not lead to offsite impact. The event tree takes into account failures of various safeguard measures including chlorine detector, chlorine scrubber and ventilation system. The frequency of occurrence for chlorine discharging to the atmosphere is estimated 1.38E-06 per year for each OSG building.

Sulphur Dioxide

11.8.4 The frequency analysis method and failure probabilities involving human error are adopted from the approved EIA. Assumptions on delivery frequencies for chemicals are summarized in the following table.

Table 11.17 Delivery Frequencies for Chemicals

Chemical	Road Tanker Deliveries Per Year	Remarks
32% wt HCl	9	The same number of deliveries for each phase

Chemical	Road Tanker Deliveries Per Year	Remarks
38% wt $NaHSO_3$	9	The same number of deliveries for each phase
10% wt HCl	13	Updated according to the storage quantity
$FeCl_3$	327	Updated according to the storage quantity
H_2SO_4	224	Updated according to the storage quantity
$C_6H_8O_7$	4	The same as the approved EIA

11.8.5 Frequencies of occurrence for accidental mixing scenarios are derived from fault trees as shown in **Figure 11.7** to **Figure 11.11**. Since the total frequency of occurrence for sodium bisulphite is 6.76E-08 per year, the risk impact is further assessed in the rest of the report.

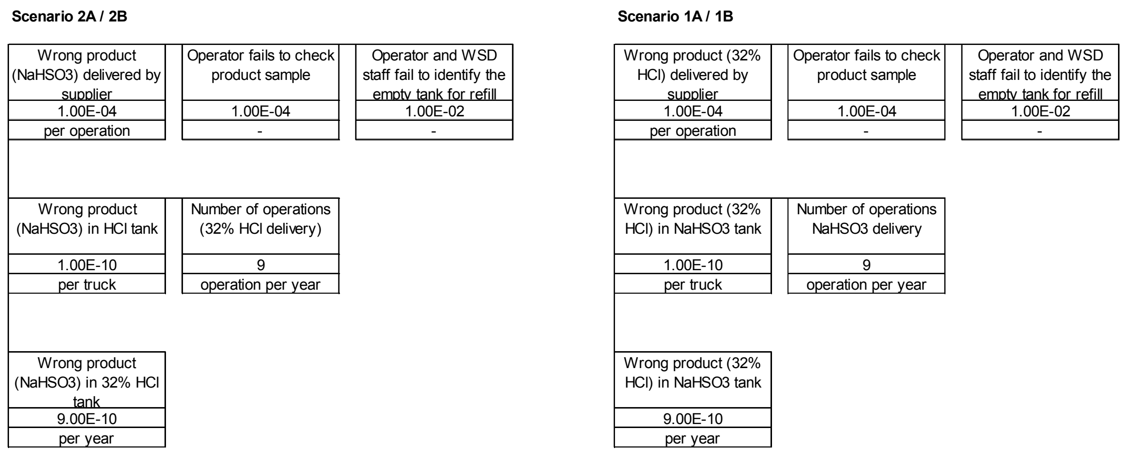


Figure 11.7 Frequencies of Occurrence for Scenario 1A / 1B and Scenario 2A / 2B

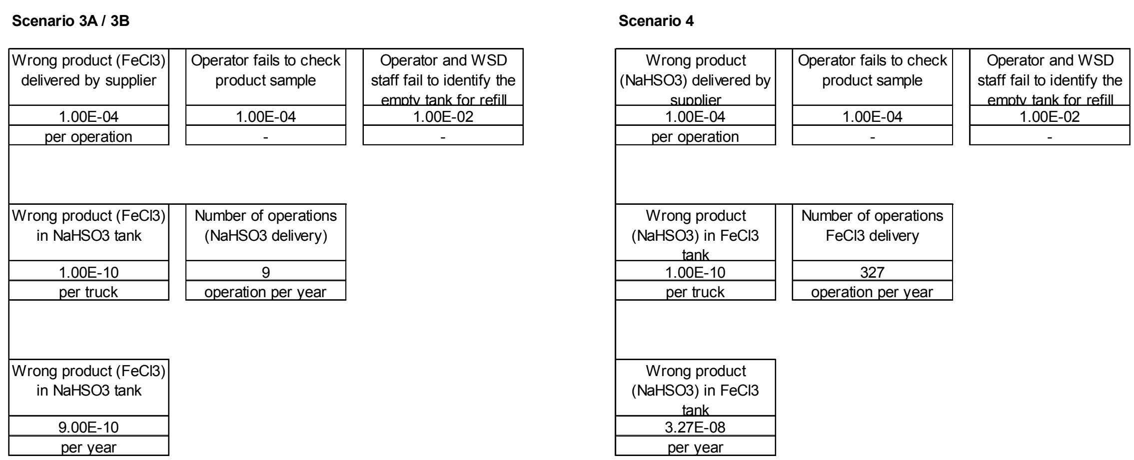


Figure 11.8 Frequencies of Occurrence for Scenario 3A / 3B and Scenario 4

Scenario 5A / 5B

Wrong product (HCl 10%) delivered by supplier	Operator fails to check product sample	Operator and WSD staff fail to identify the empty tank for refill
1.00E-04	1.00E-04	1.00E-02
per operation	-	-

Wrong product (HCl 10%) in NaHSO3 tank	Number of operations (NaHSO3 delivery)
1.00E-10	9
per truck	operation per year

Wrong product (HCl 10%) in NaHSO3 tank
9.00E-10
per year

Scenario 6

Wrong product (NaHSO3) delivered by supplier	Operator fails to check product sample	Operator and WSD staff fail to identify the empty tank for refill
1.00E-04	1.00E-04	1.00E-02
per operation	-	-

Wrong product (NaHSO3) in HCl 10% tank	Number of operations HCl 10% delivery
1.00E-10	13
per truck	operation per year

Wrong product (NaHSO3) in HCl 10% tank
1.30E-09
per year

Figure 11.9 Frequencies of Occurrence for Scenario 5A / 5B and Scenario 6

Scenario 7A / 7B

Wrong product (H2SO4) delivered by supplier	Operator fails to check product sample	Operator and WSD staff fail to identify the empty tank for refill
1.00E-04	1.00E-04	1.00E-02
per operation	-	-

Wrong product (H2SO4) in NaHSO3 tank	Number of operations (NaHSO3 delivery)
1.00E-10	9
per truck	operation per year

Wrong product (H2SO4) in NaHSO3 tank
9.00E-10
per year

Scenario 8

Wrong product (NaHSO3) delivered by supplier	Operator fails to check product sample	Operator and WSD staff fail to identify the empty tank for refill
1.00E-04	1.00E-04	1.00E-02
per operation	-	-

Wrong product (NaHSO3) in H2SO4 tank	Number of operations H2SO4 delivery
1.00E-10	224
per truck	operation per year

Wrong product (NaHSO3) in H2SO4 tank
2.24E-08
per year

Figure 11.10 Frequencies of Occurrence for Scenario 7A / 7B and Scenario 8

Scenario 9A / 9B

Wrong product (C6H8O7) delivered by supplier	Operator fails to check product sample	Operator and WSD staff fail to identify the empty tank for refill
1.00E-04	1.00E-04	1.00E-02
per operation	-	-

Wrong product (C6H8O7) in NaHSO3 tank	Number of operations (NaHSO3 delivery)
1.00E-10	9
per truck	operation per year

Wrong product (C6H8O7) in NaHSO3 tank
9.00E-10
per year

Scenario 10

Wrong product (NaHSO3) delivered by supplier	Operator fails to check product sample	Operator and WSD staff fail to identify the empty tank for refill
1.00E-04	1.00E-04	1.00E-02
per operation	-	-

Wrong product (NaHSO3) in C6H8O7 tank	Number of operations C6H8O7 delivery
1.00E-10	4
per truck	operation per year

Wrong product (NaHSO3) in C6H8O7 tank
4.00E-10
per year

Figure 11.11 Frequencies of Occurrence for Scenario 9A / 9B and Scenario 10

Liquid Carbon Dioxide

11.8.6 There is no change in the delivery frequency of liquid carbon dioxide to the desalination plant. Failure frequencies for off-site transport of liquid carbon dioxide in the approved EIA remain valid.

Explosives Unloading Pier

11.8.7 There is no change in the assumption for explosives unloading operation and delivery frequency at the pier. Failure frequencies for explosives unloading at TKO Area 137 pier in the approved EIA remain valid.

11.9 Secondary Impact

11.9.1 Secondary impact refers to indirect or induced hazardous event in which another hazardous source is initialized by a hazardous event of an initiating hazardous source. In general, toxic effect does not cause knock-on impact to other hazardous sources. Simultaneous failure of two hazardous sources, which has already been discussed in the hazard identification, is not covered by this section. A matrix table is presented in **Table 11.18** to cover the following hazardous sources,

- Chlorine (OSG)
- Hydrogen (OSG)
- Sodium hypochlorite
- 38% wt sodium bisulphite
- 32% wt hydrochloric acid
- Liquid carbon dioxide
- Explosive unloading pier
- Other dangerous goods
- SNG power generation.

Table 11.18 Evaluation of Secondary Impacts

Source \ Target	Chlorine (OSG)	Hydrogen (OSG)	Sodium Hypochlorite	Sodium Bisulphite	32% wt HCl	Liquid Carbon Dioxide	Explosives Unloading Pier	Other DGs	SNG Power Generation
Chlorine (OSG)		No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Hydrogen (OSG)	May result in indoor chlorine release but no offsite impact (Note 4)		Separate compartment and provided bund containment in case of spillage	Separate compartment and provided bund containment in case of spillage	Separate compartment and provided bund containment in case of spillage	93 m separation; no impact (Note 3)	494 m separation; no impact (Note 3)	388 m separation; no impact (Note 3)	58 m separation; no impact (Note 3)
Sodium Hypochlorite	No impact	No impact		No impact	No impact	No impact	No impact	No impact	No impact
Sodium Bisulphite	No impact	No impact	No impact		No impact	No impact	No impact	No impact	No impact
32% wt HCl	No impact	No impact	No impact	No impact		No impact	No impact	No impact	No impact
Liquid Carbon Dioxide	Risk <1E-9/yr; no impact	Risk <1E-9/yr; no impact	Risk <1E-9/yr; no impact	Risk <1E-9/yr; no impact	Risk <1E-9/yr; no impact		Risk <1E-9/yr; no impact	Risk <1E-9/yr; no impact	Risk <1E-9/yr; no impact
Explosives Unloading Pier	494 m separation; no impact (Note 1)	494 m separation; no impact (Note 1)	494 m separation; no impact (Note 1)	494 m separation; no impact (Note 1)	494 m separation; no impact (Note 1)	410 m separation; no impact (Note 1)		Would not cause hazardous scenario even damaged in explosions (Note 2)	475 m separation; no impact (Note 1)
Other DGs	No impact	No impact	No impact	No impact	No impact	No impact	No impact		No impact
SNG Power Generation	58 m separation; no impact (Note 3)	58 m separation; no impact (Note 3)	58 m separation; no impact (Note 3)	58 m separation; no impact (Note 3)	58 m separation; no impact (Note 3)	70 m separation; no impact (Note 3)	475 m separation; no impact (Note 3)	378 m separation; no impact (Note 3)	

Note 1: The separation distance is greater than the required separation distance 178m for the explosives unloading pier.
Note 2: No hazard to life issue by considering chemicals' concentrations in the atmosphere due to accidental spillage and the escape factor of the surrounding population
Note 3: The separation distance is greater than the maximum hazard distance 47 m (thermal radiation of 4kW/m^2) for SNG Power Generation and 11m for Hydrogen (OSG).
Note 4: Chlorine gas pipeline close to the explosion source may be damaged. Chlorine generation will be disrupted in the explosion.

11.10 Risk Analysis

11.10.1 The risk summation is undertaken using SAFETI, except for the explosives unloading pier which is manually calculated using a spreadsheet. The individual risk and societal risk in terms of FN curve and Potential Loss of Life (PLL) are evaluated in the risk summation process for all hazardous events to determine the total risk. Results are compared with the criteria in Annex 4 of the EIAO TM.

Chlorine

11.10.2 The individual risk contours for the chlorine hazard are shown in **Figure 11.12**. The maximum individual risk is at magnitude of 1E-07/yr and the off-site individual risk does not exceed 1E-05/yr. The individual risk for the chlorine hazard is compliant with Annex 4 of the EIAO TM.

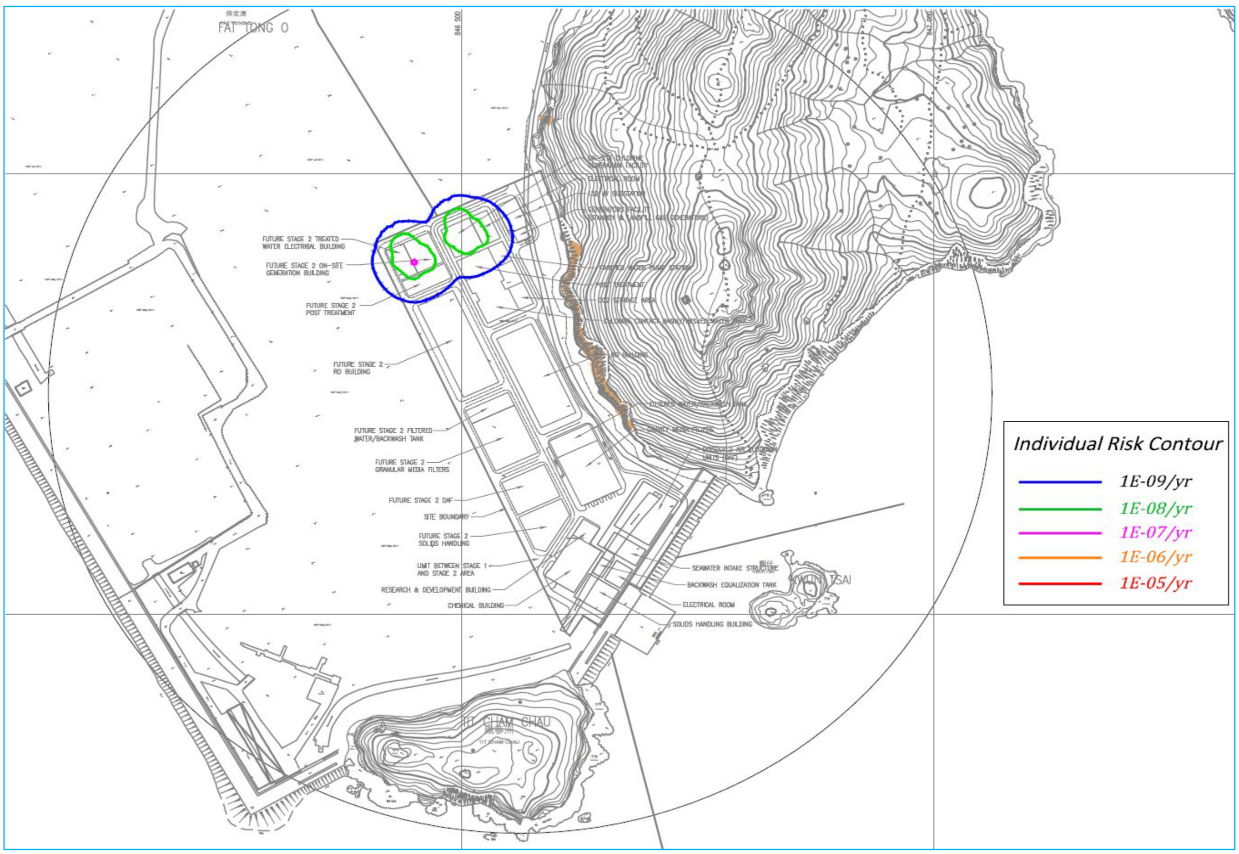


Figure 11.12 Individual Risk Contours for Chlorine Assessment

11.10.3 The FN curve for the chlorine hazard is shown in **Figure 11.13**. It is within the ACCEPTALBE region and well below 1E-09 per year, out of the societal risk criteria range. The PLL is 1.3E-10 per year. The societal risk for the chlorine hazard is compliant with Annex 4 of the EIAO TM.

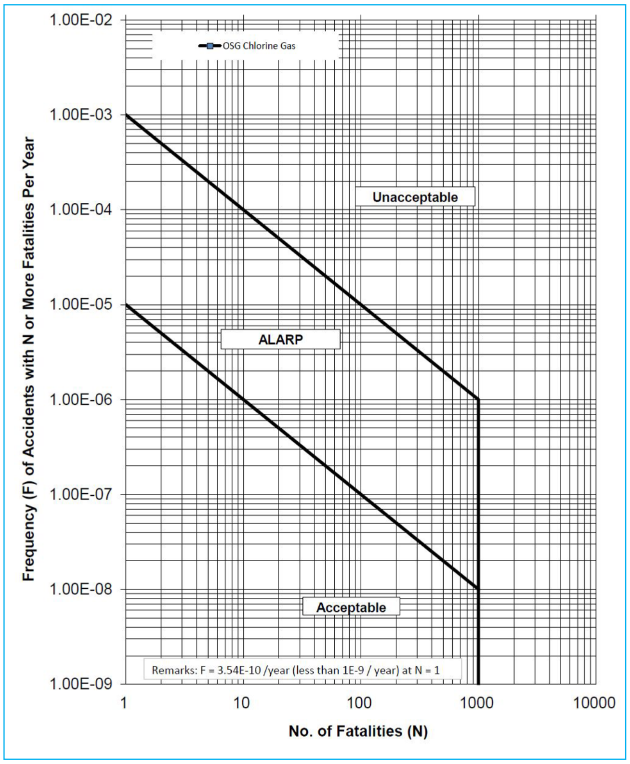


Figure 11.13 FN Curve for Chlorine Assessment

Sulphur Dioxide

11.10.4 The individual risk contours for the sulphur dioxide hazard are shown in **Figure 11.14**. The maximum individual risk is at magnitude of 1E-08/yr and the off-site individual risk does not exceed 1E-05/yr. The individual risk for the sulphur dioxide hazard is compliant with Annex 4 of the EIAO TM.

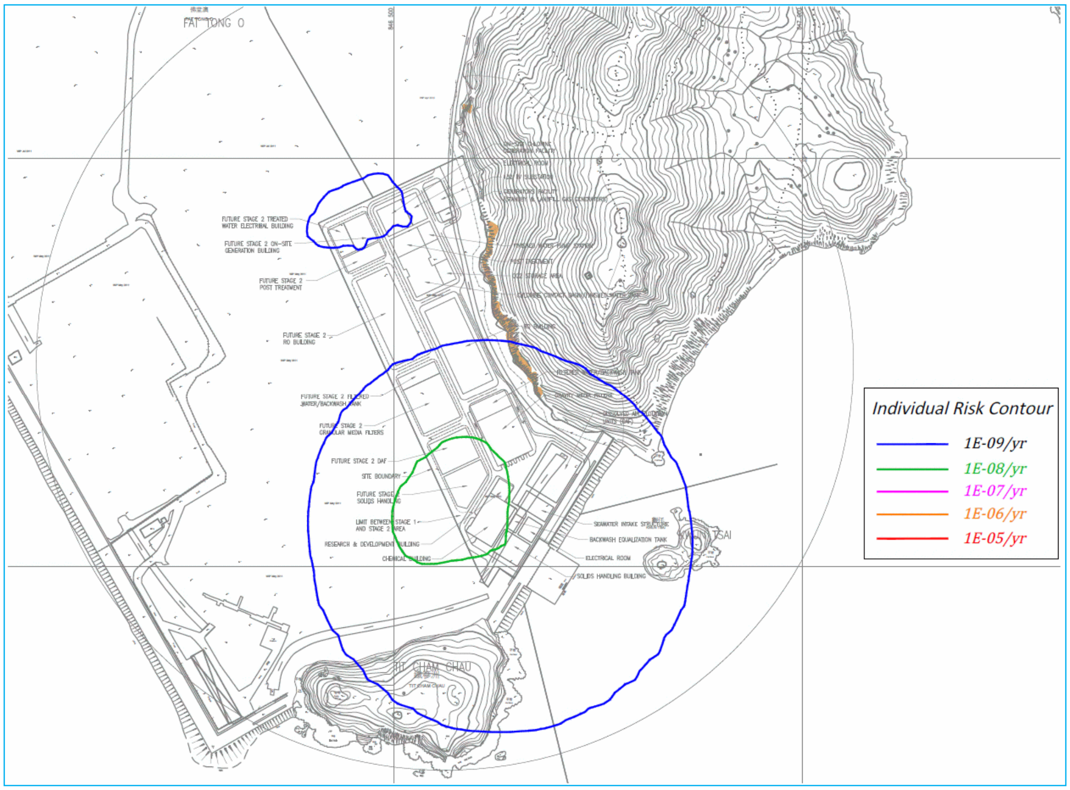


Figure 11.14 Individual Risk Contours for Sodium Bisulphite Assessment

11.10.5 The FN curve for the sulphur dioxide hazard is shown in **Figure 11.15**. It is within the ACCEPTALBE region and below the lower bound of ALARP region. The PLL is 4.61E-08 per year. The societal risk for the sulphur dioxide hazard is compliant with Annex 4 of the EIAO TM.

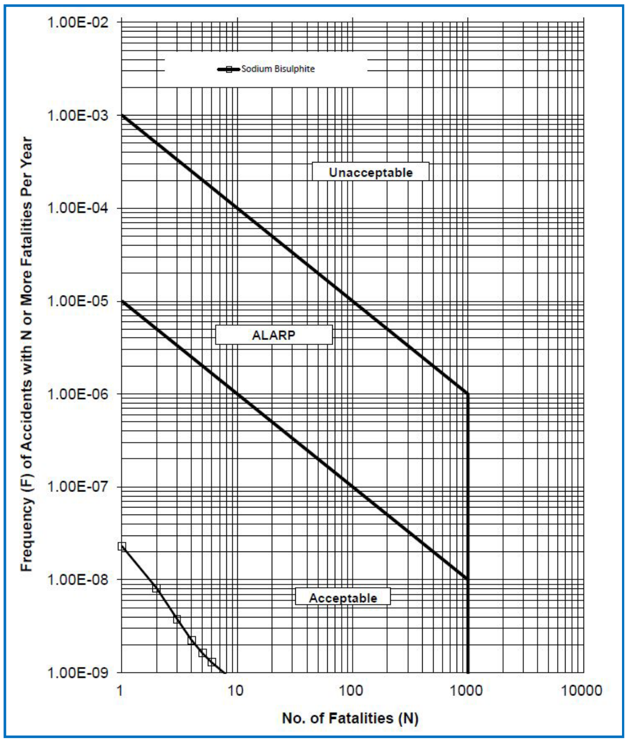


Figure 11.15 FN Curve for Sodium Bisulphite Assessment

Liquid Carbon Dioxide

11.10.6 The individual risk contours for the liquid carbon dioxide hazard are shown in **Figure 11.16**. The maximum individual risk is at magnitude of 1E-08/yr and the off-site individual risk does not exceed 1E-05/yr. The FN curve for the liquid carbon dioxide hazard is shown in **Figure 11.17**. It is within the ACCEPTALBE region. The PLL is 1.46E-08 per year. Both individual risk and societal risk for the liquid carbon dioxide hazard are compliant with Annex 4 of the EIAO TM and at an acceptable level.

Figure 11.16 Individual Risk Contours for Liquid Carbon Dioxide Assessment

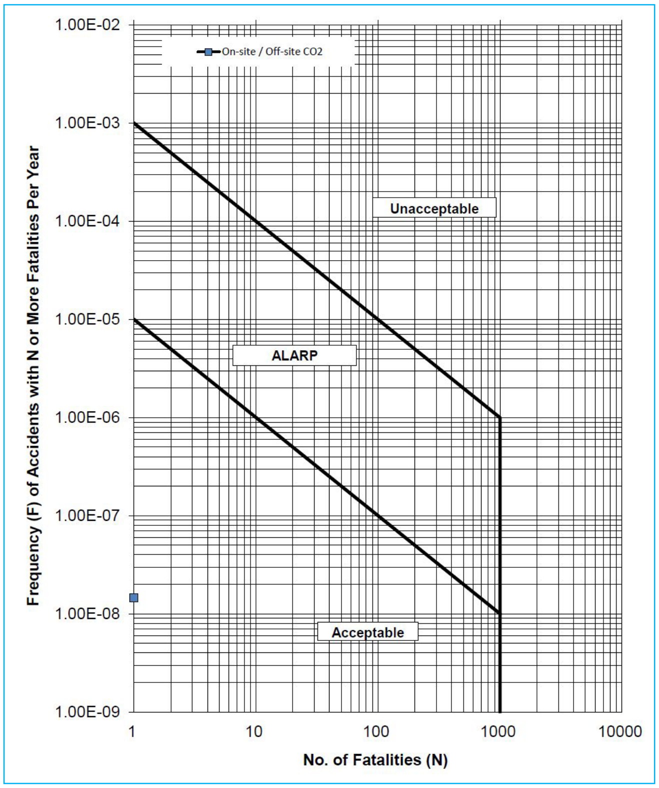


Figure 11.17 FN Curve for Liquid Carbon Dioxide Assessment

Explosives Unloading Pier

11.10.7 There is no change in the individual risk contours for the explosives unloading pier hazard. The individual risk contours are shown in **Figure 11.18**. The indoor risk is presented and is considered the worst scenario by covering larger area than the outdoor risk. However, the addition of 14 staff inside the administration building to the original population assumption of 1 pedestrian and 4 passengers in a car near the explosives unloading pier changes the societal risk outcome. The FN curve for the explosives unloading pier hazard is shown in **Figure 11.19**. It is within the ACCEPTALBE region. The PLL is 8.64E-06 per year. Both individual risk and societal risk for the explosives unloading pier hazard are compliant with Annex 4 of the EIAO TM and at an acceptable level.

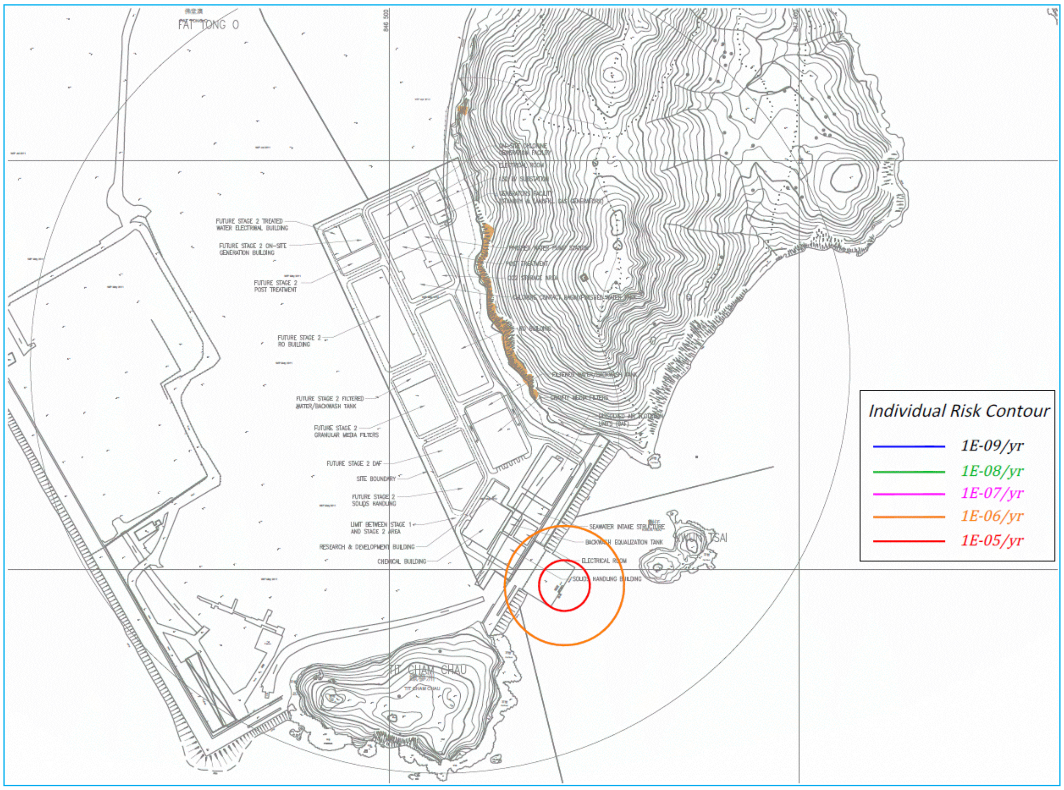


Figure 11.18 Individual Risk Contours (Indoor Risk) for Explosives Unloading Pier Assessment

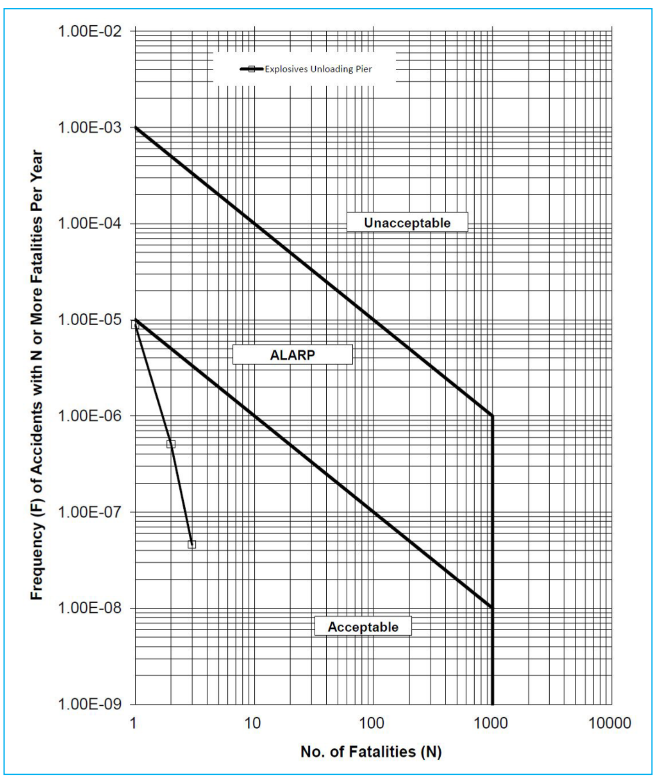


Figure 11.19 FN Curve for Explosives Unloading Pier Assessment

11.11 Cumulative Impacts

11.11.1 Since the impact zone for the current design of the proposed desalination plant is reduced in comparison with the one assessed in the approved EIA, the cumulative impact zone is revised accordingly. Cumulative risks in terms of individual risk contours and FN curves are shown in **Figure 11.20** and **Figure 11.21**. Individual risk contours show that there is no off-site risk larger than 1E-05/year. Also, the FN curve for cumulative risk is within the "Acceptable" region. Therefore, the cumulative risk level is acceptable.

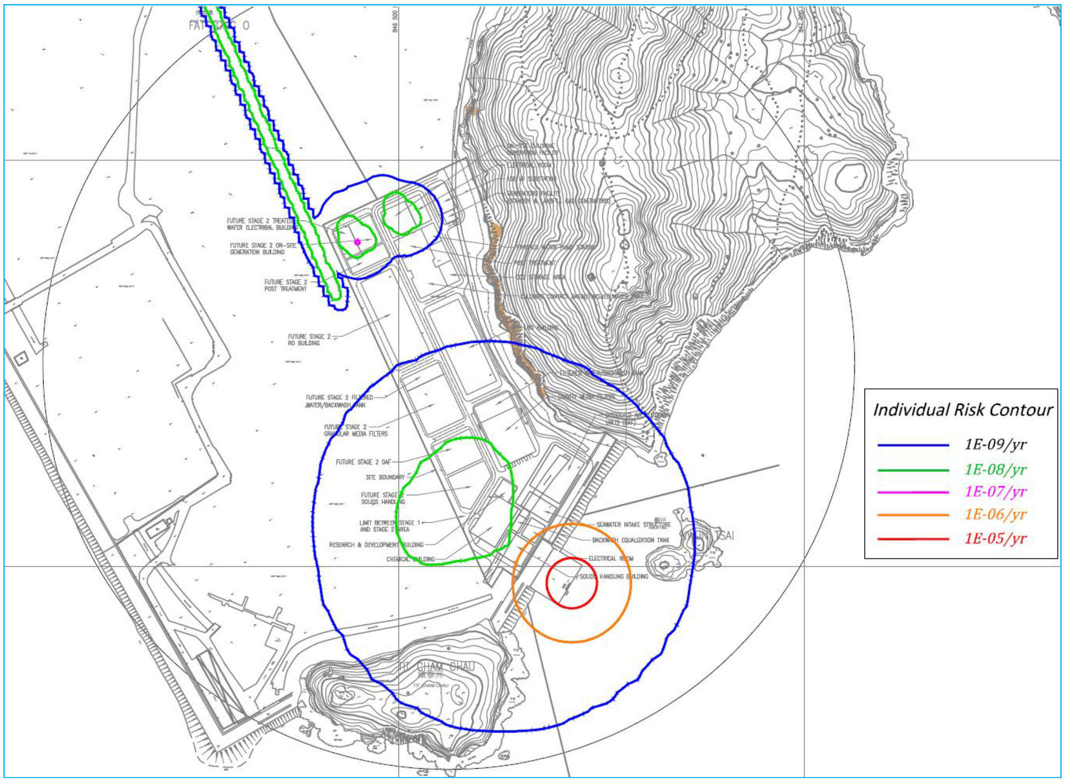


Figure 11.20 Cumulative Risk - Individual Risk Contours

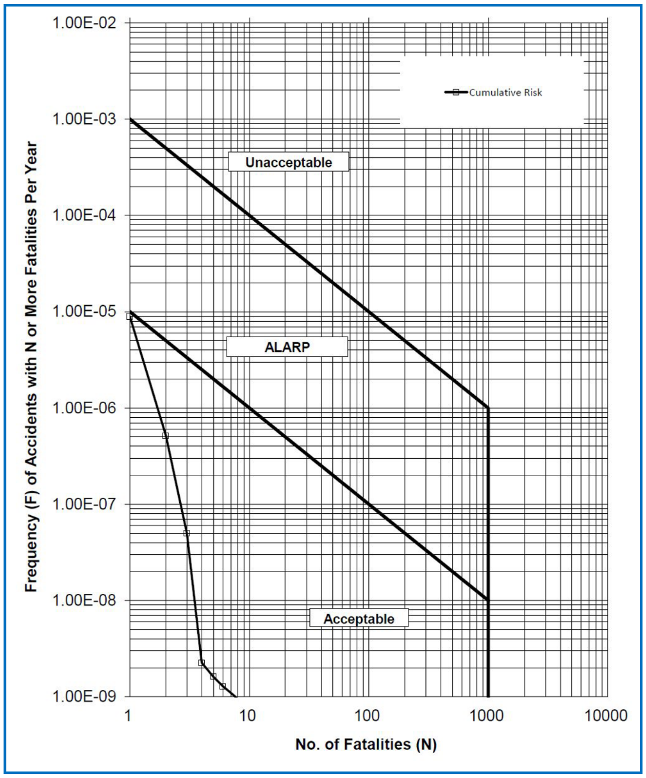


Figure 11.21 Cumulative Risk – FN Curve

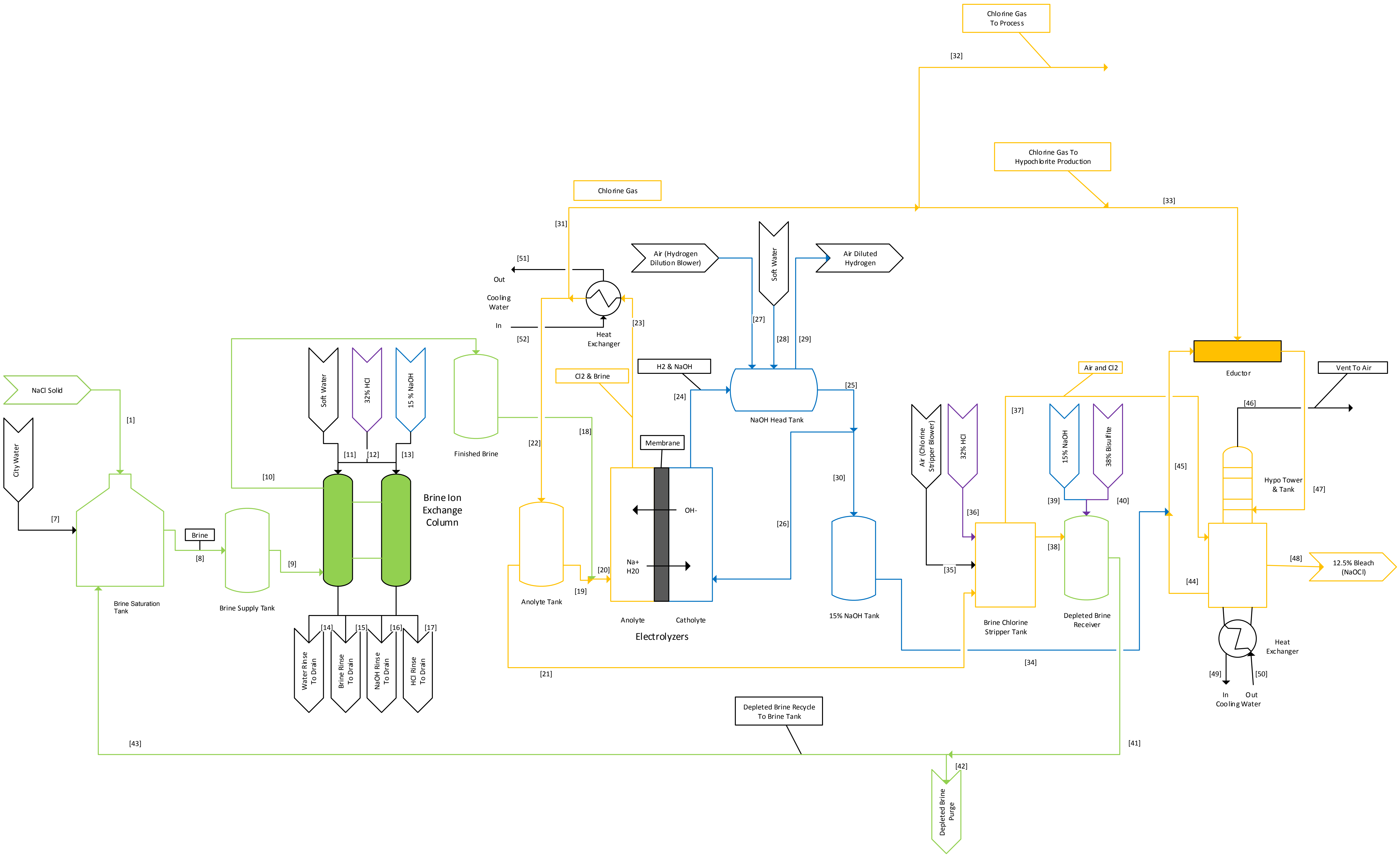
11.12 Conclusions and Recommendations

11.12.1 Changes in the design of the proposed desalination plant have been reviewed and assessed for potential hazard to life impacts. The assessment methodology and assumptions are based on the approved EIA. The cumulative risk of the proposed desalination plant, through interaction or in combination with other existing, committed and planned developments involving DGs in the vicinity of the proposed desalination plant has also been assessed.

11.12.2 In all cases, the individual risk complies with the Hong Kong Risk Guidelines and the societal risk lies in the acceptable region. Therefore, the operation of the desalination plant for the current design is acceptable in terms of both individual risk and societal risk as stipulated in Annex 4 of the TM. Safeguard measures are recommended to ensure the risk associated with the on-site chlorine generation and DGs at the proposed desalination plant complies with the Hong Kong Risk Guidelines and stays in “Acceptable” region.

APPENDIX 11A

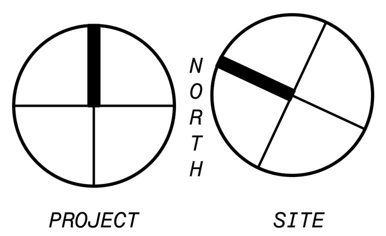
PROCESS FLOW DIAGRAM FOR OSG

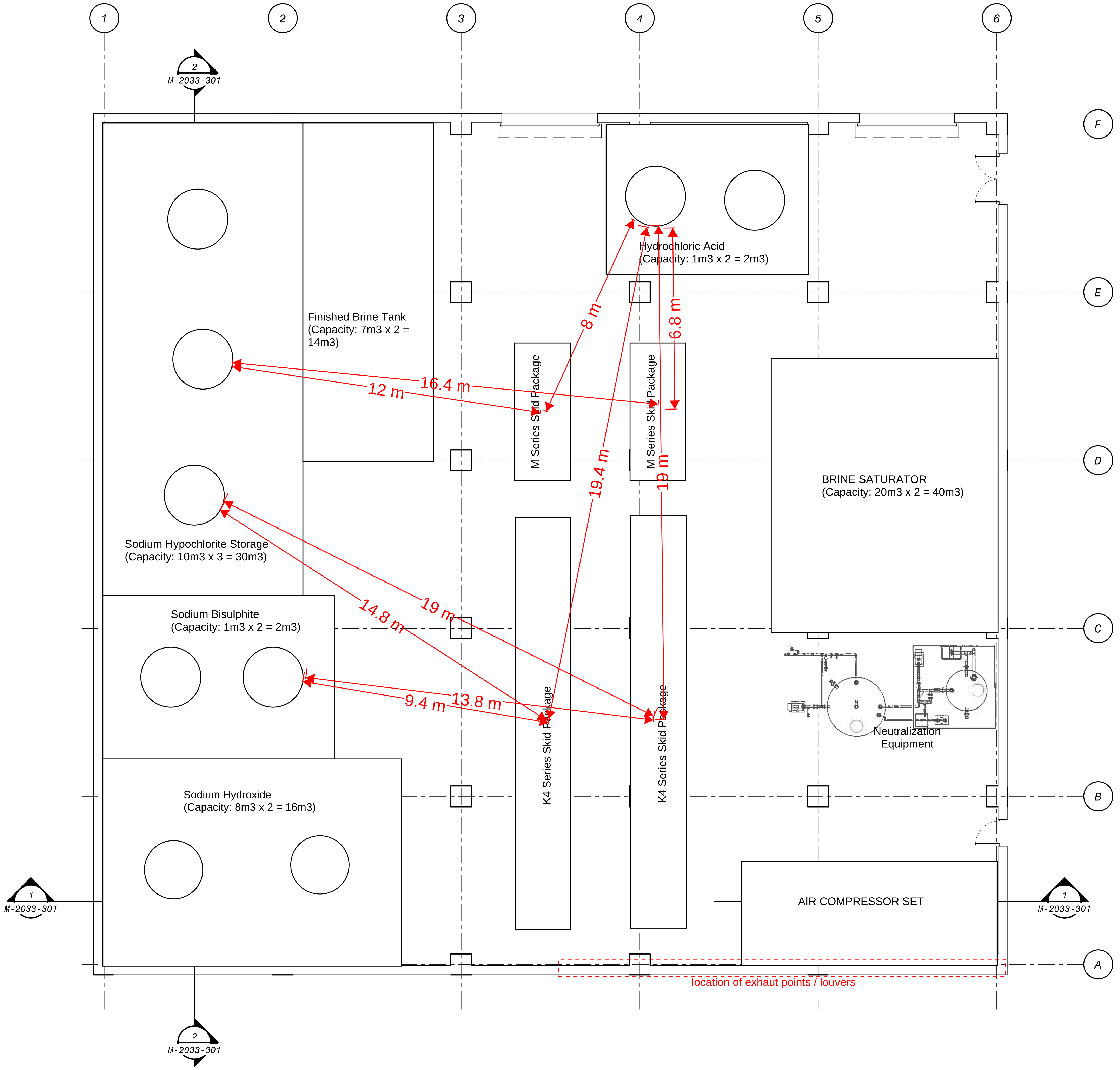


Chlorine Gas
To Process
[32]
Chlorine Gas To
Hypochlorite Production
[33]
Chlorine Gas
[31]
[51]
Out
Cooling
Water
In
[52]
Heat
Exchanger
[23]
Air (Hydrogen
Dilution Blower)
Soft Water
Air Diluted
Hydrogen
[27]
[28]
[29]
NaCl Solid
[1]
City Water
[7]
Brine Saturation
Tank
Brine
[8]
Brine Supply Tank
[9]
[10]
Soft Water
32% HCl
15 % NaOH
[11]
[12]
[13]
Brine Ion
Exchange
Column
Finished Brine
[14]
[15]
[16]
[17]
Water Rinse
To Drain
Brine Rinse
To Drain
NaOH Rinse
To Drain
HCl Rinse
To Drain
Cl2 & Brine
H2 & NaOH
[22]
[18]
[24]
Membrane
OH-
Na+
H20
[20]
[19]
Anolyte Tank
Anolyte
Catholyte
Electrolyzers
NaOH Head Tank
[25]
[30]
[26]
15% NaOH Tank
[21]
[34]
Air (Chlorine
Stripper Blower)
32% HCl
[36]
[35]
Air and Cl2
[37]
15% NaOH
38% Bisulfite
[39]
[40]
[38]
Brine Chlorine
Stripper Tank
Depleted Brine
Receiver
Eductor
Vent To Air
[46]
[45]
Hypo Tower
& Tank
[47]
[44]
[48]
12.5% Bleach
(NaOCl)
Heat
Exchanger
[49]
[50]
In
Out
Cooling Water
Depleted Brine Recycle
To Brine Tank
[43]
[41]
[42]
Depleted Brine
Purge

APPENDIX 11B

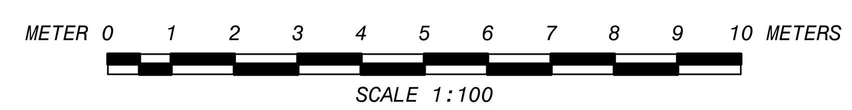
INDICATIVE DIAGRAM FOR THE LAYOUT INSIDE OF THE OSG BUILDING





OPERATING LEVEL GA

1 : 100



PRELIMINARY - NOT FOR CONSTRUCTION

NOTES:
1. Cooling Water and Chiller Plant Unit assumed to be on the roof

Revision	Date	Description	Initial
B	10/12/16	ISSUED FOR PRICING	AV
A	10/5/16	ISSUED FOR INTERNAL REVIEW	AV

	Designed	Checked	Drawn	Checked
Initial	Designer	Checker	Author	Author
Date	XX/XX/XXXX	XX/XX/XXXX	XX/XX/XXXX	XX/XX/XXXX

Approved

Agreement No.
CE 8/2015 (WS)

Contract Title
DESALINATION PLANT AT TSEUNG KWAN O – INVESTIGATION, DESIGN AND CONSTRUCTION

Drawing Title
ON–SITE CHLORINE GENERATION BUILDING MULTI–DISCIPLINE OPERATING LEVEL GA

Drawing No. M–2033–102
Revision B

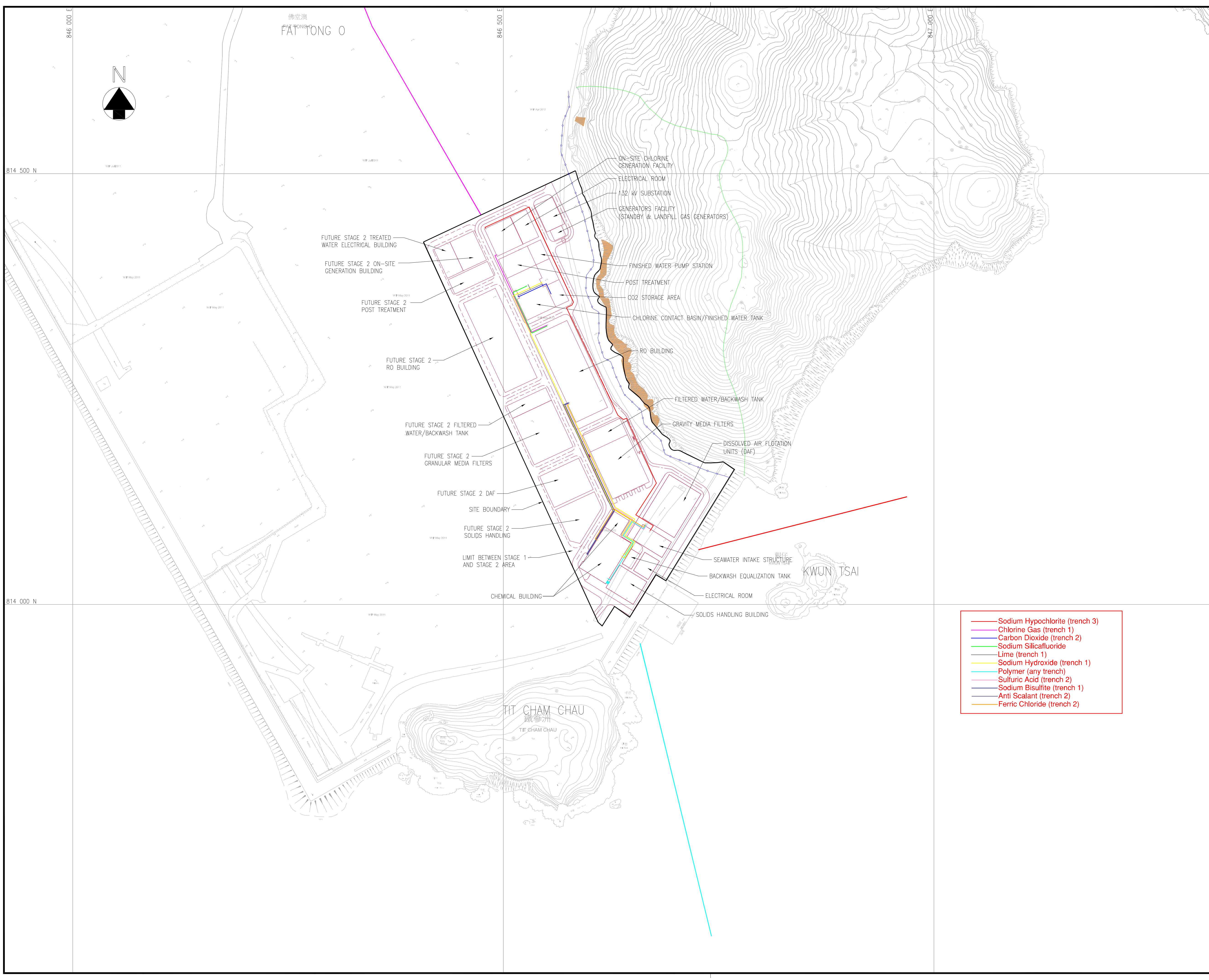
Scale 1 : 100

水務署
Water Supplies Department

BLACK & VEATCH HONG KONG LIMITED
博威工程顧問有限公司

APPENDIX 11C

INDICATIVE DIAGRAMS FOR THE ALIGNMENT OF PIPELINES



MAP NOS. 12SW11D, 12SW12C
12SW16B & 12SW17A

LEGEND:

- INDICATIVE FLEXIBLE BARRIER ALIGNMENT
- LAYOUT PLAN
- INDICATIVE LOCATION OF SEAWATER INTAKE PIPELINE
- INDICATIVE LOCATION OF SUBMARINE OUTFALL PIPELINE
- PROPOSED FRESH WATER MAIN
- SITE FOR DESALINATION PLANT
- STUDY AREA FOR SLOPE MITIGATION WORKS
- ROCK SLOPE IMPROVEMENT/STABILIZATION WORKS

Revision	Date	Description		Initial
	Designed	Checked	Drawn	Checked
Initial				
Date				

Approved

Agreement No.
CE 8/2015 (WS)

Contract Title
FIRST STAGE OF DESALINATION PLANT AT TSEUNG KWAN O – INVESTIGATION, DESIGN AND CONSTRUCTION

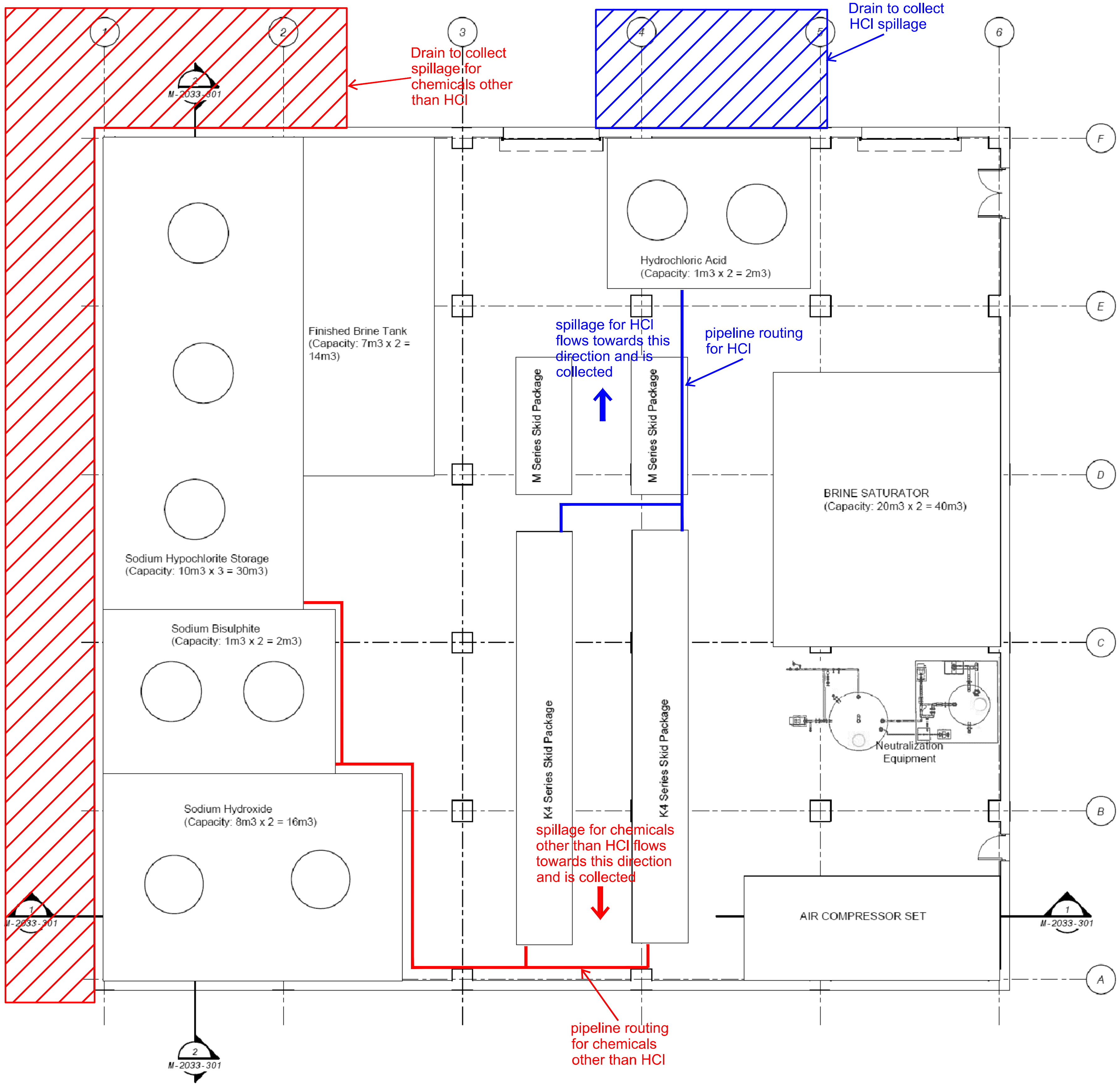
Drawing Title
PLANT LAYOUT

Drawing No. FIGURE 2.1
Revision –

Scale A1 1 : 2000
A3 1 : 4000

水務署
Water Supplies Department

BLACK & VEATCH HONG KONG LIMITED
博威工程顧問有限公司



OPERATING LEVEL GA

1 : 100

APPENDIX 11D

RESULTS OF CONSEQUENCE ANALYSIS

Results of Consequence Analysis

Chlorine Dispersion

Wind Condition (stability – speed)	Hazard Distance based on LD03 from PHAST model (m)
Continuous release at 5 g/s to atmosphere (full bore rupture)	
B 3	13
D 2	21
D 4.5	17
F 1.5	49
Continuous release at 1.7 g/s to atmosphere (25mm leak)	
B 3	8
D 2	13
D 4.5	10
F 1.5	30
Continuous release at 0.46 g/s to atmosphere (13mm leak)	
B 3	4
D 2	7
D 4.5	6
F 1.5	17
Continuous release at 0.02 g/s to atmosphere (3mm leak)	
B 3	1.1
D 2	1.7
D 4.5	1.4
F 1.5	3.8

Sulphur Dioxide Dispersion

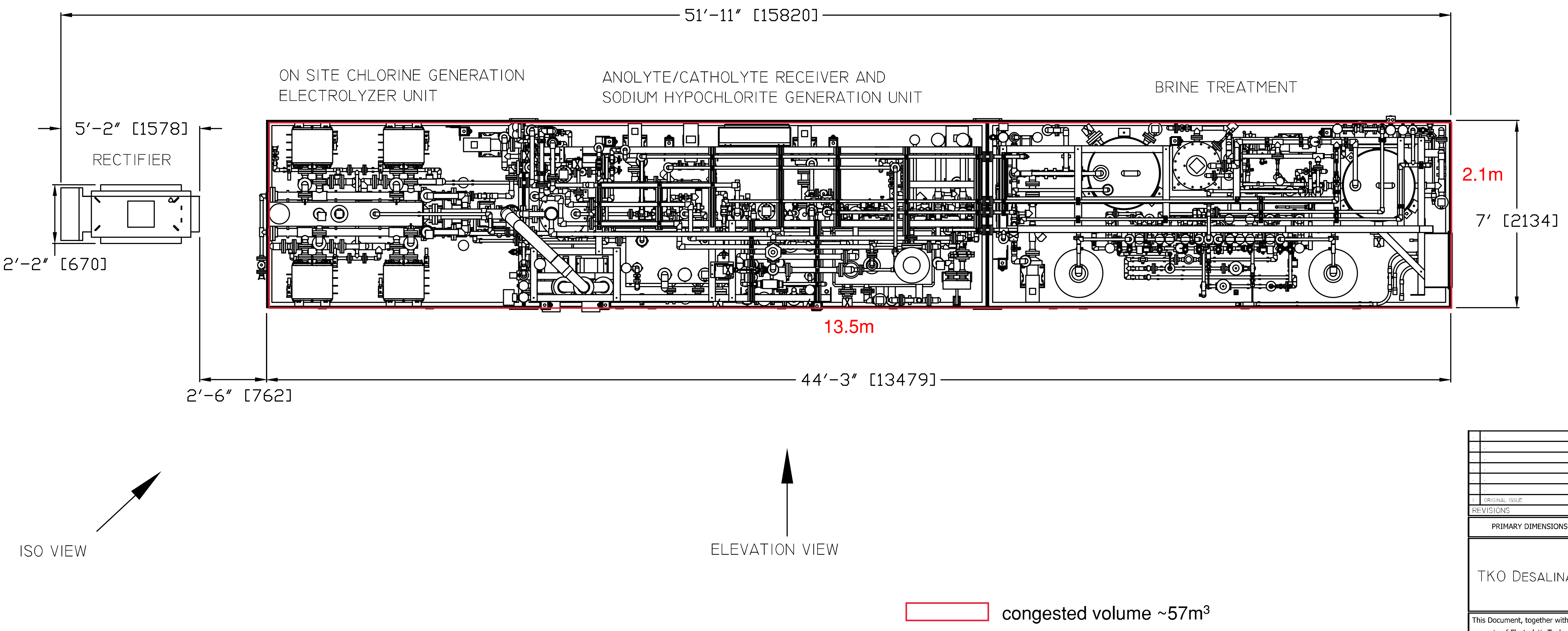
Wind Condition (stability – speed)	Hazard Distance based on LD01 from PHAST model (m)
Scenario 1A/1B	
B 3	134
D 2	145
D 4.5	131
F 1.5	126
Scenario 2A/2B	
B 3	106
D 2	142
D 4.5	103
F 1.5	124
Scenario 3A/3B	
B 3	69
D 2	90
D 4.5	69
F 1.5	86
Scenario 4	

Wind Condition (stability – speed)	Hazard Distance based on LD01 from PHAST model (m)
B 3	155
D 2	228
D 4.5	184
F 1.5	291
Scenario 5A/5B	
B 3	81
D 2	101
D 4.5	80
F 1.5	99
Scenario 6	
B 3	141
D 2	201
D 4.5	155
F 1.5	260
Scenario 7A/7B	
B 3	138
D 2	150
D 4.5	138
F 1.5	128
Scenario 8	
B 3	155
D 2	228
D 4.5	184
F 1.5	291
Scenario 9A/9B	
B 3	133
D 2	145
D 4.5	134
F 1.5	126
Scenario 10	
B 3	131
D 2	177
D 4.5	134
F 1.5	263

APPENDIX 11E

ESTIMATION OF CONGESTED VOLUME FOR HYDROGEN EXPLOSION

THE FLOOR AREA OR CONCRETE PAD THAT THIS EQUIPMENT IS PLACED ON MUST BE LEVEL AND SMOOTH WITHIN 1/8"[3.2].
NO PROJECTIONS ARE ALLOWED. PAD SHOULD BE AT LEAST 4"[102] BEYOND EDGE OF SKID.



1	ORIGINAL ISSUE	4/26/2016
REVISIONS		DATE

PRIMARY DIMENSIONS IN INCHES, SECONDARY DIMENSIONS IN MILLIMETERS

TKO DESALINATION PLANT PROJECT-OSG

DRAWN .	TITLE PLAN 454 KG CHLORINE GAS GENERATOR		
CHECKED .			
APPROVED .	DRAWING NO. 8-100-XXX-001		Electrolytic Technologies LLC
DATE 4.1.16			
SHEET 1 OF 3	SCALE 1:50	REV 1	

11 x 17

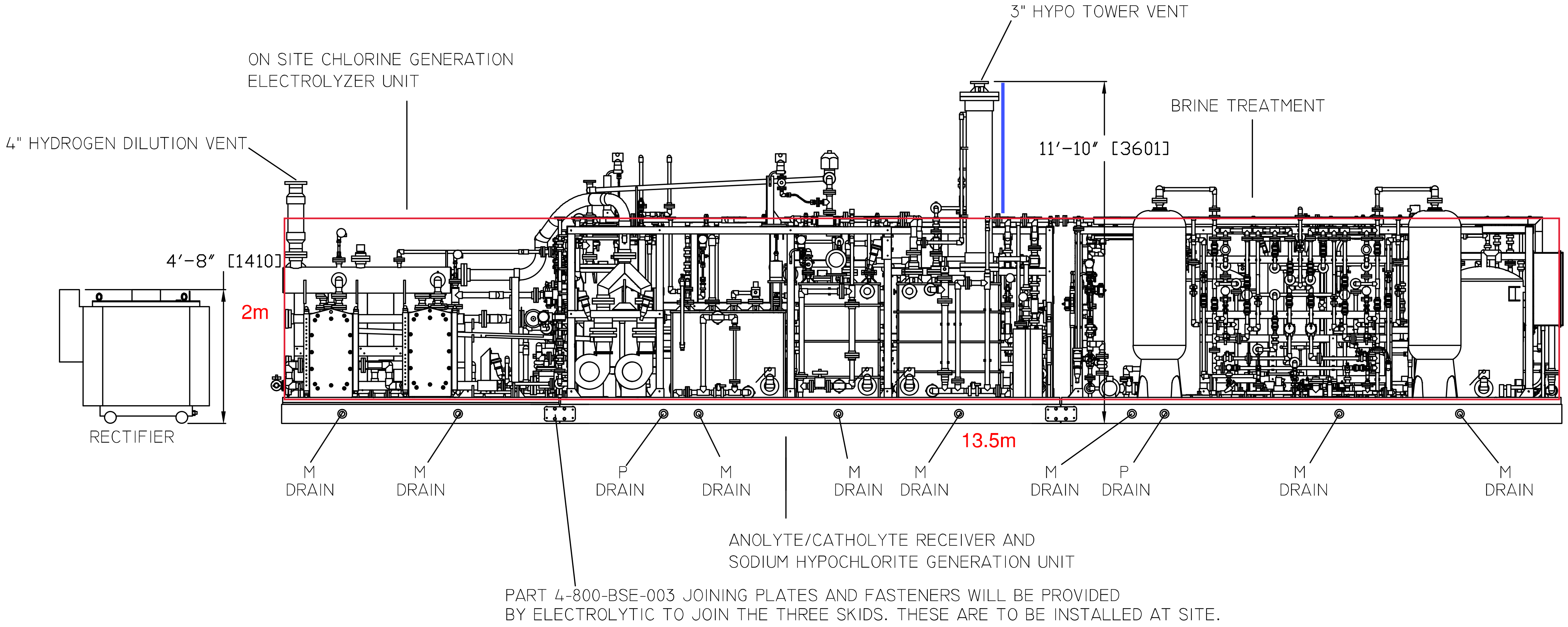
DRAINS:

ALL DRAIN CONNECTIONS ON THE EQUIPMENT ARE 1-1/2" PVC SOCKET.

P = PROCESS DRAIN - PROCESS DRAINS MAY CONTAIN CHLORINATED BRINE, HCL, SODIUM HYPOCHLORITE AND CAUSTIC SODA. THESE DRAINS ARE KEPT SEPARATE FROM THE MAINTENANCE DRAINS.

M = MAINTENANCE DRAIN - MAINTENANCE DRAINS ARE CONNECTED TO DECK DRAINS ON THE THREE SKIDS EACH SKID HAS A PVC DECK ENCLOSED WITH A 2" HIGH BARRIER TO CONTAIN WASH DOWN WATER AND SPILLS DURING MAINTENANCE OF EQUIPMENT.

ADAPTER FLANGES 1-1/2"/METRIC AND 1-1/2" PIPE WILL BE PROVIDED BY ELECTROLYTIC FOR INSTALLATION AT SITE.



PRIMARY DIMENSIONS IN INCHES, SECONDARY DIMENSIONS IN MILLIMETERS

TKO DESALINATION PLANT PROJECT-OSG

DRAWN .	TITLE ELEV 454 KG CHLORINE GAS GENERATOR
CHECKED .	
APPROVED .	DRAWING NO. 8-100-XXX-001
DATE 4.1.16	
SHEET 2 OF 3	SCALE 1:50 REV 1

Electrolytic Technologies LLC

11 x 17

APPENDIX 11F

EVENT TREE FOR INDOOR RELEASE OF CHLORINE

Event Tree for Indoor Chlorine Release

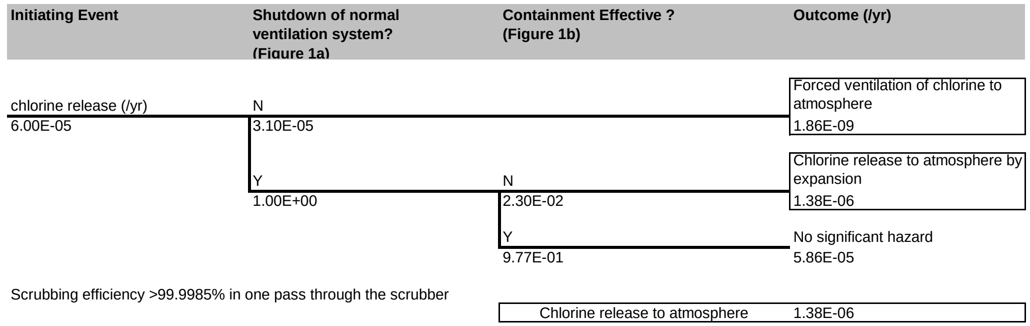
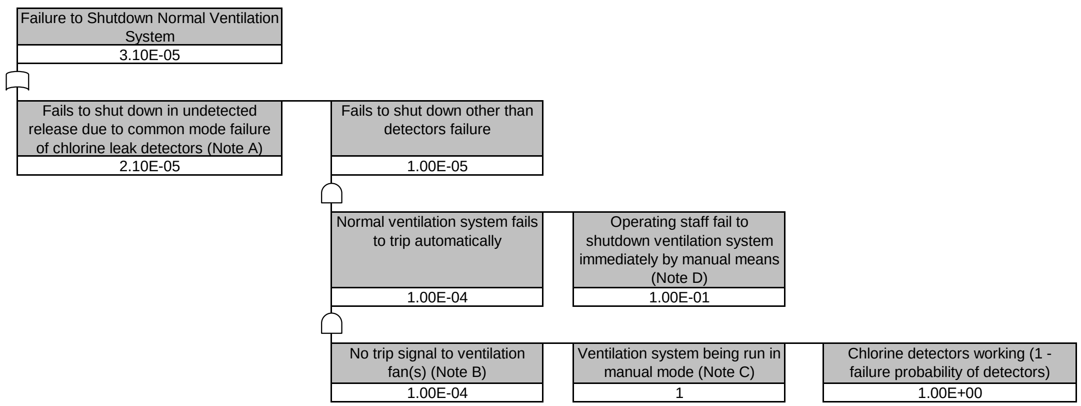


Figure 1a - Failure to Shutdown Normal Ventilation System



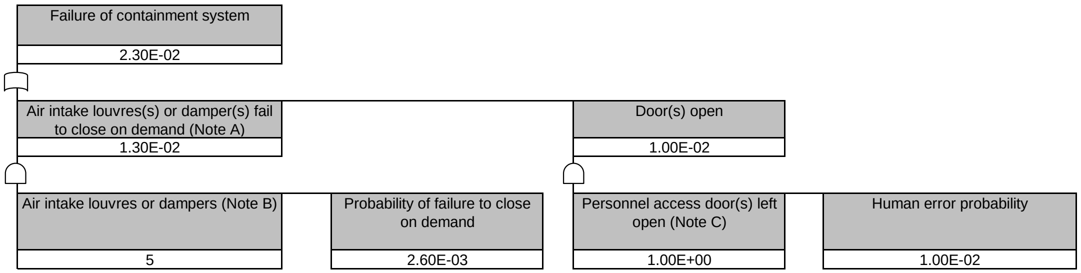
Note A: The primary concern is chlorine releases from pipework in OSG building. At least 2 chlorine detectors in OSG building are assumed. Common mode failure of these detectors will dominate the overall failure frequency

Note B: The primary concern is failure of the normal ventilation fans to trip. It is considered the ventilation fans have self-closing dampers on the fan outlet. Even if one of these dampers were remain open (unlikely given the fail-safe design), then with the chlorine absorption system running the chlorine bearing air will preferentially pass to the scrubber. Taken as typical probability of failure of relay (fail-safe design)

Note C: A manual mode is provided for the normal ventilation system.

Note D: It is conservatively asumed probability of human error for manual shutdown failure in emergency situation as 0.1.

Figure 1b - Failure of Containment System



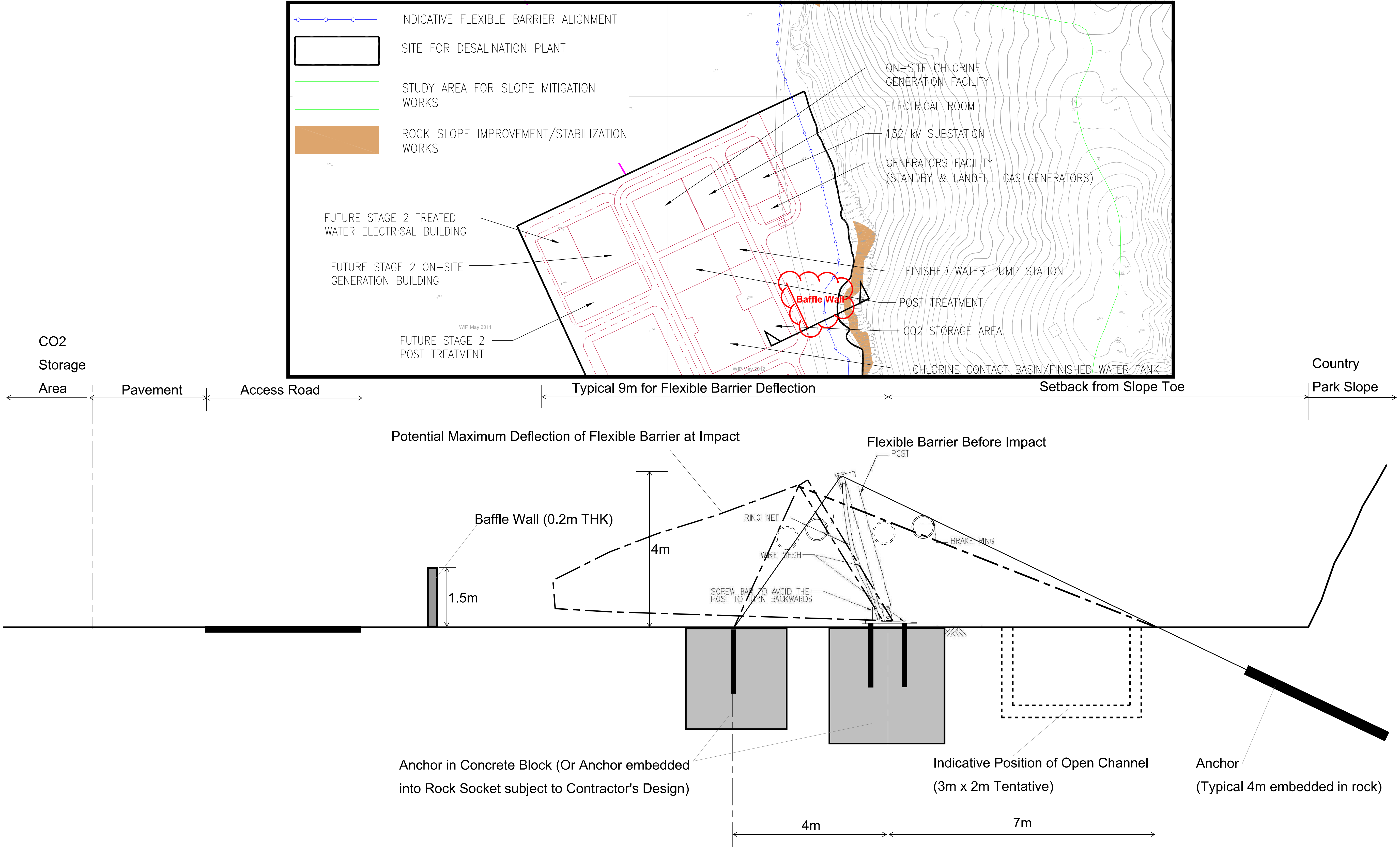
Note A: Mechanical failure of the air intake louvres (including the air intake dampers with a forced air supply)

Note B: An electrically-operated isolating damper is provided in the scrubber intake for recycling which opens automatically when the scrubber fan starts up. An additional isolating damper is provided to isolate the normal ventilation system when the scrubber system is operating. The scrubber system is normally set to recycle air back to the OSG building. This is affected by means of a pair of electrically operated change-over dampers controlled manually from the local control panel. The number of dampers is conservatively estimated 5.

Note C: Assuming all personnel going in and coming out from the OSG building would probably make human error of not closing the door.

APPENDIX 11G

PLAN AND SECTION OF BAFFLE WALL



Section of CO2 Storage Area and Flexible Barrier (5,000kJ)

Scale 1:100

APPENDIX 11H

REVIEW OF HISTORIC INCIDENTS (SODIUM BISULPHITE)

Review on Historical Incidents (Sodium Bisulphite)

Data Source	Date	Location	Description
ARIA, No.5666	1994.07.27	La Chapelle Saint Luc, France	Following a handling error when delivered to a surface treatment plant, 200L of sulfuric acid were discharged into a tank containing a residue of sodium bisulfite. An exothermic reaction occurs, the bisulfite decomposes and a toxic cloud (aerosol of sulfuric acid and sulfur dioxide) intoxication slightly 16 people including 2 firefighters.
ARIA, No.6886	1995.04.24	Berre-L'etang, France	In the unit processing effluent from a petrochemical complex, red vapors are emitted through the vent of a tank after delivery of phosphoric acid. The exothermic chemical reaction is due to pollution of the road tank by sodium bisulphite which has acted as a reaction catalyst on phosphoric acid supplemented with 1% nitric acid and containing traces of organic matter.
ARIA, No.10851	1997.02.26	Les Mureaux, France	A driver connected one of the three transported containers to a tank containing 400 litres of 35% sodium bisulphite solution. A technician observed bubbling of the liquid in the tank and informed the driver who promptly stopped the transfer. A 98% sulphuric acid container that was properly labelled but covered by a plastic cover was accidentally connected instead of the bisulphite tank. The 5 to 10 litres of transferred acid reacted with the bisulphite. An SO_2/SO_3 cloud entered a neighbouring building effecting eight people located between 15 and 30 m from the unit.
ARIA, No.13717	1998.08.08	San Severino Marche, Italy	In a chemical company, a 15,000L tank containing sodium bisulphite was loaded into another tank containing phosphoric acid. Nine coastal residents slightly intoxicated by sulphurous anhydrite emissions go to the hospital and two women (one of whom is pregnant) are kept in preventive observation. Firefighters are clearing the scene.
ARIA, No.17224	2000.02.09	Scionzier, France	In a metal works, five slightly intoxicated persons were hospitalized following an error in handling when 1000 liters of chlorinated liquid (HCl?) was discharged into a 5 m^3 tank of sodium bisulfite.
ARIA, No.27511	2004.07.05	Muizon, France	During the unloading of a tanker lorry at an industrial laundry, 50L of sulphuric acid were mistakenly poured into a tank containing 200L of sodium bisulphite. Sulphur dioxide (SO_2) immediately spread throughout the delivery area. The driver closed the valves, but the toxic cloud driven by the wind engulfed the rest of the plant. The establishment was evacuated and the gendarmes (French military police) set up a 200 m safety perimeter. The production section and the unloading area were ventilated. The vapours incapacitated around twenty employees.

Data Source	Date	Location	Description
ARIA, No.29036	2005.01.26	Thyez, France	In an effluent detoxication station of a surface treatment plant, chlorine was released when 800L of sodium hypochlorite was accidentally transferred into a tank containing 600L of sodium bisulphite. The accident occurred when 1000L of soda lye, 1000L of liquid bleach and a container transporting 24 carboys of hydrochloric acid were being delivered by a company trading in chemicals. The truck driver accidentally connected the sodium hypochlorite tank of the vehicle to the filling inlet of sodium bisulphite despite the clear labelling. This occurred during the temporary absence of a factory employee who was away to get a power lift truck to unload the HCl. The chlorine spread to the effluent treatment workshop, outside the premises and also to the production building connected to the wastewater treatment plant by leaking pipe ducts.
ARIA, No.35204	2008.09.19	Brive La Gaillarde, France	An operator of a surface treatment plant cut the bottom bung of a bath of fluoro-nitric acid by moving one of the plates of a neighboring grating; 15L of bath was poured into the retention. To limit the loss of products, the employee pumped the acid solution into an unwashed container still containing sodium bisulfite without first reading the label affixed to the container stipulating not to mix the two chemicals. Toxic nitrous vapors escaped from the moving tank and the pumping was suspended.
ARIA, No.41129	2011.10.18	Valence, France	Sulfur fumes overcame 6 employees at a metal surface treatment shop, following the overdose of a sodium bisulfite bath. The 6 employees were taken to the hospital for examinations. The activity of the establishment was interrupted during the rest of the night. A failure of a solenoid valve was the cause of the accident.
ARIA, No.44609	2013.11.15	Bernaville, France	In an electroplating plant manufacturing perfume plugs, 150L of sulfuric acid and 150L of sodium bisulphite are accidentally mixed causing the release of toxic vapors.

APPENDIX 12A

LIST OF MAJOR ASSUMPTIONS FOR HAZARD ASSESSMENT

List of Major Assumptions for Hazard Assessment

Parameter	Value	Remarks
On-site Chlorine Generation		
Chlorine generation rate	2250 kg per day	To be implemented in 2 stages at 2 OSG buildings; Section 11.3.4 and 11.6.7 of this ERR.
Number of generators	4 units	Section 11.3.4 and 11.6.6 of this ERR
Ventilation rate	6 ACPH	Section 11.6.7 of this ERR
Volume of OSG building	4000 m^3	Section 11.6.7 of this ERR
Chlorine Gas		
Discharge of chlorine gas to the atmosphere	No vent pipe will be provided for direct discharge to the atmosphere	Section 11.6.5 of this ERR.
Safety measures	- Chlorine detectors - Chlorine scrubber system - Activation of recycle damper when chlorine scrubber is in operation - Separation distance between the centre of OSG building and the nearest site boundary greater than 30m - Separation distance between the exhaust points / louvers of OSG buildings and the nearest site boundary greater than 30m	Appendix 11B, Appendix 11F, Section 11.3.6-11.3.12, Section 11.7.2 and Section 11.8.2 of this ERR.
Hydrogen Gas		
Discharge of hydrogen gas to the atmosphere	Individual vent pipe will be provided for each generator	Section 11.6.11 of this ERR.
Concentration of hydrogen gas for discharge to the atmosphere	1% of LFL for hydrogen.	Section 11.6.11 of this ERR.
Hydrogen explosion due to failure of OSG units	Sufficient separation will be provided between the chemical tanks and OSG units so as to avoid simultaneous failure of tanks containing incompatible chemicals	Section 11.7.3 of this ERR.
Sodium Bisulphite Assessment		
Unloading rate from road tanker	10 l/s	Section 11.6.20

Parameter	Value	Remarks
Road tanker capacity	25 m^3	Table 11.3 – 11.12 of this ERR
Concentration of NaHSO3 solution	38% wt	Stored in 1 m^3 tanks; Table 11.3 of this ERR
Number of NaHSO3 storage tanks	4 separate tanks, not connected.	Table 11.3 of this ERR
Number of NaHSO3 deliveries	9 tankers per year	Table 11.17 of this ERR
Concentration of 32% HCl	32% wt	Stored in 1 m^3 tanks; Table 11.4 of this ERR
Number of 32% HCl storage tanks	4 separate tanks, not connected.	Table 11.4 of this ERR
Number of 32% HCl deliveries	9 tankers per year	Table 11.17 of this ERR
Concentration of HCl in FeCl3 solution	5% wt	Stored in 252 m^3 tanks; Table 11.6 of this ERR
Number of FeCl3 storage tanks	8 separate tanks, not connected.	Table 11.6 of this ERR
Number of FeCl3 deliveries	327 tankers per year	Table 11.17 of this ERR
Concentration of 10% HCl solution	10% wt	Stored in 40 m^3 tanks; Table 11.8 of this ERR
Number of 10% HCl storage tanks	2 separate tanks, not connected.	Table 11.8 of this ERR
Number of 10% HCl deliveries	13 tankers per year	Table 11.17 of this ERR
Concentration of H2SO4 solution	98% wt	Stored in 138 m^3 tanks; Table 11.10 of this ERR
Number of H2SO4 storage tanks	10 separate tanks, not connected.	Table 11.10 of this ERR
Number of H2SO4 deliveries	224 tankers per year	Table 11.17 of this ERR
Concentration of C6H8O7	32% wt	Stored in 8 m^3 tanks; Table 11.12 of this ERR
Number of C6H8O7 storage tanks	1 tank	Table 11.12 of this ERR
Number of C6H8O7 deliveries	4 tankers per year	Table 11.17 of this ERR
The case of right product delivered into the wrong tank is eliminated.	- There are safety measures in placed to avoid right product delivered into the wrong tank, e.g. - hoses and couplers for transferring of NaHSO3, HCl, FeCl3, H2SO4 and C6H8O7 are different in size to avoid connecting road tankers of incompatible chemicals to corresponding storage tanks - Warning signs will be displayed at the inlet of each storage tank to show chemical name and to warn the potential hazards of mixing incompatible chemicals. - NaHSO3, NaOCl (emergency operation), HCl, FeCl3, H2SO4 and C6H8O7 will be delivered by road	Refer to safety measures in Table 13.39 of the approved EIA and Section 11.6.17 of this ERR.

Parameter	Value	Remarks
	tankers. - 10% HCl, FeCl3, H2SO4 and C6H8O7 at chemical building will be stored in double containment tanks. - 10% HCl, FeCl3, H2SO4 and C6H8O7 flowing outside of the chemical building will be collected by road side drains. - Perimeter drain will be installed surrounding HCl, NaHSO3 and NaOCl storage compartments at OSG buildings. - bunds will be provided for all storage compartments. - OSG buildings are located 380 m away from the chemical building. - Double containment will be provided for HCl pipelines in OSG buildings - Alignment of HCl pipeline is away from pipelines for other incompatible chemicals in OSG building - Floor surface gradient will be used for directing spillage of incompatible chemicals to different locations such that HCl will be collected to a separate drain system. - Only one storage tank will be connected to delivery pipeline at any one time to minimize the amount of spillage. - Pipe pressure will be continuously monitored. Pumps will be immediately shut down if irregular pressure drops occur. - Vibration sensing system will be installed along pipelines. Pumps will be immediately shut down if excessive vibration is detected to minimize the amount of leakage through damaged pipelines.	
SNG Assessment		

Parameter	Value	Remarks
Operating Pressure	2.4 barg	Section 11.6.39 of this ERR.
Maximum Flowrate	2,084 m^3/hour.	Section 11.6.39 of this ERR.
Volume of the generator room for explosion assessment	1300 m^3	Section 11.6.44 of this ERR.
Liquid Carbon Dioxide		
Number of CO2 storage tank	16 units	Section 13.5.3 of the approved EIA.
Type of storage tank	Vacuum insulated	Section 13.5.3 of the approved EIA.
Storage tank capacity	100 tonnes per tank	Section 13.5.3 of the approved EIA
Type of vaporizer	Ambient	Section 13.5.3 of the approved EIA
Transport mode	By road tanker	Section 13.5.3 of the approved EIA
Safety measures considered in the frequency analysis	- Vacuum insulated, double containment - 2 sets of pressure relief valves (PRVs) on inner containment. The 2 sets of PRVs are connected by a switchover valve. Each set consists of 2 PRVs. - Plate pressure relief device on outer containment (considered on storage tanks only) - Trycock for overfilling alarm and warning - High level alarm to operating staff at control room for liquid level monitoring and warning.	Annex J1 Fault tree analysis and Annex J2 HAZID worksheet
Separation distance between CO2 storage area and the explosive truck during offsite transport	Set back the CO2 storage with sufficient clearance so that the overpressure resulting from explosion of explosive vehicle during offsite transport that reaches the storage is less than 2 psi.	Ref. 3.6 in the HAZID worksheet of Annex J2
Separation distance between CO2 storage area and the explosive offloading pier	Set back the CO2 storage with sufficient clearance so that the overpressure resulting from explosion of explosives at the offloading pier that reaches the storage is less than 2 psi.	Ref. 3.6 in the HAZID worksheet of Annex J2
Separation distance between CO2 storage area and the site boundary	Approximately 100m	Section 13.5.6 of the approved EIA; for avoiding offsite toxic impact; Section 11.7.14 of this ERR.

Parameter	Value	Remarks
Preventive measures for landslide hazard	- a flexible barrier will be built within the desalination plant along the eastern boundary. - a 1.5m high protective barrier will be constructed at the road side of the internal access road.	Section 11.6.36 of this ERR.
Explosives Unloading Pier		
Hazard zone during explosives unloading operation in the construction phase of the desalination plant	construction workers will be restricted from entering the 161m range centered at the explosives barge during explosives unloading operation. This restriction will be imposed on the Contract Requirements.	Section 11.7.16 of this ERR.
Separation distance between administration building and explosives unloading pier	95 m between the centre of the administration building and the hazardous source at an explosives barge.	Section 11.6.35 of this ERR.
Population at administration building during explosives unloading operation	14 persons	Section 11.10.7 of this ERR.
Other DGs		
Not applicable	--	--

Appendix E:

Proposed Rectification Measures

No.	Problems Observed in Existing OSCG Plant	Proposed Corrective Measures for TKO Desalination Plant's OSCG Plant	Contractor Design for TKO Desalination Plant's OSCG Plant
1	Improper functioning of the pumps at waste sump	a. Pump functioning will be checked and corrected. b. Waste sump will be provided with a localized low point to minimize the volume of liquid retained at the pump cut-out level.	The functioning of sump evacuation pump will be regularly checked, and fault alarm signal will be initiated to warn the operator in the event of no flow. Besides, the system design provides two separate waste sump pits for EACH OSCG Skid to segregate the waste collected from skid by compatibility. In the OSCG process, the two incompatible chemicals are Sodium Hypochlorite (NaOCl) and Hydrochloric Acid (HCl). This design segregates NaOCl in a separate sump pit to avoid it reacting with HCl. The detail will be provided in an Operational Manual as well as a Standard Operation Procedure (SOP) on how to handle process fluids during normal operation and maintenance activities. Bisulfite is only dosed within the skid for the dechlorination of brine at specific intervals based on oxidation-reduction potential (ORP) set points. It is not a continuous operation. There is no routine discharge of bisulfite. The potential release of bisulfite will only occur by the action of the operators. NO chemical storage tanks will be drained to the waste sump. For maintenance purposes, chemicals need to be discharged to intermediate bulk container (IBC) totes. Any resulting wastewater from the maintenance activities can be sent to the waste disposal facilities. A localized local point will be provided at the waste sump, and the self-priming waste pumps will be connected to the lowest point to minimize the residual chemical within the sump. In addition, the maximum flow from the system to the sump will be 60 Litre Per Minute (LPM) from the brine dechlorination, and the pumps at the waste sumps provide for 165 LPM, which will avoid any overflowing between compartments.
2	Oversight and insufficient on-spot site supervision	a. Waste sump level to be monitored by additional level electrodes or level transmitters b. Standard Operations Procedures for process draining will be provided to AJCJV (Acciona-Jardine-China state Joint Venture) operators and RSS (Resident Site Staff). c. Refreshing training will be provided to AJCJV operators and RSS. d. 7 /24 manned operation with well-qualified and experienced operators will be implemented. e. 7 /24 improved on-spot supervision by RSS Assistant Inspectors of Works (AIOW) and above (AIOW, Inspectors of Works, Senior Inspectors of Works, Resident Engineers, Senior Resident Engineers) in a systematic manner during T&C will be implemented.	The pump control will be interlock to the level electrode to prevent any abnormal operation. There is 2 shift per day (24 hours), and each shift will involve 2 experienced operators per shift for the OSCG. While the plant can be operated by one person, for safety reasons, a duty-standby operator is recommended to maintain the continuous monitor of the system. In addition, we will also arrange a quarterly refresh training to those operators. Under regular operation, no NaOCl should be drained to the waste equalization. This should only happen during maintenance activities. A SOP will describe all necessary steps to avoid sending any concentrated hypo to the hypo waste pit and, therefore to the waste equalization. For example, the hypo in the conversion tank needs to be transferred to the storage tanks. The remaining hypo needs to be diluted with softened water prior to discharge to the sump pit. Then, it can be sent to the equalization tank. During maintenance activities, there should be no waste from regeneration, therefore, no HCl will be drained to the equalization tank. During maintenance activities, the waste treatment does not operate in auto-mode. It is manually managed by operator. Also, the SOP will establish the correct procedures to handle the waste system to avoid mixing of incompatible wastes. For example, before sending hypo from the sump pit to the equalization, the operator needs to transfer any low pH solution inside the equalization tank, to the neutralization tank where it will be neutralized. Then, the hypo can be sent to the equalization.

No.	Problems Observed in Existing OSCG Plant	Proposed Corrective Measures for TKO Desalination Plant's OSCG Plant	Contractor Design for TKO Desalination Plant's OSCG Plant
3	Use of concentrated HCl	a. Alarms will be added to the program, which shows each operation step of the regeneration process (including acid addition or caustic addition), under these two conditions: 1) If conductivity (Acid and Caustic) is out of range when softened water flow is detected, alarm will warn the operator but will not stop the regeneration process. 2) Alarm will be triggered if no softened water flow is detected. This alarm will stop the regeneration process and stay in the current stage until the alarm is cleared and reset. System will resume from that stage. b. A warning alarm will be added to notify the operators that brine softener columns are about to start regeneration when it is approaching the set point value for regeneration/column.	Confirmed. The program includes several alarms to inform the operator that the regeneration of a column is about to start. Also, several alarms will interrupt the regeneration process if any of them is activated. 1) No softened water flow as measured by flowmeter of soft water to ion exchange filters 2) High HCL concentration alarm as measured by conductivity meter of acid. 3) High NaOH concentration as measured by conductivity meter of alkaline. 4) High High level alarm in sump pits as measured by level transmitters on waste pits for both process and hypo drainages
4	Allowing HCl to react with incompatible chemicals such as hvoo	a. A separate compartment for collecting the HCl process drain and maintenance drain will be adopted.	Our waste treatment process consists of two stages; 1) Equalization and 2) Neutralization. The main function of the equalization tank is to act as a buffer: to collect the raw incoming solution that comes at widely fluctuating rates, concentrations, and other characteristics. The purpose of this is to have a "homogeneous" solution prior to the neutralization process. When this is achieved, then this "homogeneous" solution is transferred to the neutralization tank. The purpose of the neutralization tank is to have a neutralization chemical reaction. A neutralization is the chemical reaction between an acid (HCl) and a base (NaOH) to form salt (NaCl) and water and has a neutral pH (7) so the treated solution can be safely discharged into sanitary sewer systems in compliance with local regulations. This waste treatment process system will have control and interlock design to only allow transfer of chemical waste from each waste sump pit to the equalization tank when the waste stored inside the equalization tank is compatible, or otherwise after the incompatible waste inside the equalization tank is completely transferred to the neutralization tank for neutralization (i.e. evacuated). The tank will have an operational range between low and high level setpoint. During maintenance activities, which are the ones with higher risk of incompatible chemicals to be mixed (i.e. hypo and HCl), the operator needs to strictly follow the SOP to minimize the probability of mixing incompatible chemicals.

No.	Problems Observed in Existing OSCG Plant	Proposed Corrective Measures for TKO Desalination Plant's OSCG Plant	Contractor Design for TKO Desalination Plant's OSCG Plant
5	Ineffective extraction of Chlorine by dry scrubber	a. An individual duct for extraction of chlorine to the dry scrubber direct from waste sump will be provided if necessary. b. Locations of extraction ducts will be critically reviewed and revamped if required to ensure effective and efficient abstraction of any chlorine gas throughout the OSCG plant room.	Based on the design previously described the possibility of generating fumes in the waste sump area is minimized, our design does not have any extraction system for this area. As explained above, the design considers splitting the drain pits and installing a switch which is the interlock signal to start the pump. This switch will be placed at the lowest possible position form the bottom of the sump. This will prevent for any excessive amount of waste to remain in the sump pit. The design contemplates the maximum flow from the system to the sump will be 60 LPM from the brine dichlorination purge. The pumps at the waste sumps provide for 165 LPM this will avoid any overflowing between compartments. Design contemplates the installation of several chlorine detectors strategically located at different points around the OSCG to detect and display any high concentration of chlorine. In addition, the detectors will send a signal to the Programmable Logic Controller (PLC) that will shutdown the OSCG production if a high concentration alarm is activated. The scrubber has a removal capacity of 99.5%. It has a fixed removal capacity based on the volume of resin and the total chlorine mass that pass through it. This scrubbing system is only connected to the hypo tower vent and in no way serves for other purpose. Besides, the scrubber is provided with sampling ports to take samples and periodic testing to the media will be arranged. Sufficient absorbent media for resin will be kept on site for replacement purpose with due consideration taken into the time lapse for testing and delivery of absorbent media. About the room extraction, AJCJV will arrange the extraction pipe along the skid room and chlorinators room, particular at points that is apt to trap chlorine gas. It is designed to provide enough capacity for both rooms.
6	The Direct Fire Link (DFL) suspended and Emergency Shutdown System (ESD) bypassed	a. The DFL and ESD shall remain in service continuously at all times. b. Both RSS and AJCJV operators will carry out checking to ensure that the ESD is in service. AFA panel and alarms will be tested regularly to ensure the system is functional.	Confirmed. The AJCJV will conduct a regular checking as per the SOP to monitor the health function of the DFL and ESD system with verification by the RSS.