ADNOC Classification: Internal

Conceptual Selection Report

Project Name	Project Number
Project Wave	P30280

Current VAP stage:	Select – Concept Selection

Project type and class				
Project type	Exploration and production (E&P)		Major Maintenance and infrastructure	
	Production expansion	✓	Maintenance	
	Production sustainability		Infrastructure	
Project class	Major project			
	Significant project	✓		
	Minor project			

Signatories				
Role	**Name**	**Job title**	**Signature**	**(MM/YYYY)**
TC - Engineering	Abdulla Luqman	Project Engineering Manager		09/2019
	Hesham Mohamed Al Johi	Manager Engineering (BAB/NEB)		09/2019
	Sami Al Ankar	Manager In-House Engineering		09/2019
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1. PROJECT DESCRIPTION

1.1 Project Overview

The main objective is to assess and evaluate a techno-economical alternative to aquifer water for feeding BAB, NEB, Bu Hasa and South East injection demands. Latest 2019-2023 business plan profiles were utilized for BAB, NEB and Bu Hasa conceptual development. South East requirements were included at a later stage of the project and were incorporated in the Concept Selection study utilizing P5 Profiles.

The alternate sources considered for injection water include Produced Water re-injection and Seawater.

This project is envisaged to reduce the operating expenditure required for each barrel of injection water and to minimize the drawdown and the pressure depletion of Dammam, Umm Er Radhuma and Simsima aquifers.



Figure 1-1: ADNOC Onshore Fields locations

1.2 Project Description

Project Wave represent ADNOC ++ initiatives for ensuring an additional source of water for injection in ADNOC Onshore fields. The scope of the project looks to utilize treated seawater as an alternative for all ADNOC Onshore fields (BAB, Bu Hasa, NEB and South East).

Potential benefits of utilizing sea water as a complimentary source of water for injection demand includes:

- Sustainable source for water injection
- Contain aquifer depletion and adverse impacts of pressure decline

- Improve Injectivity in marginal, low permeability reservoirs
- Conceptually reduce simulation cost of injectors due to lower TSS
- Reduce future CAPEX & OPEX by reducing the number of Water injection clusters, ESPs, pulling hoist, manpower, power consumption, etc.
- Improve operational efficiency, reduce injection downtime and improve system efficiency through centralization of treatment facility
- Potentially provide incremental oil recovery by utilizing Low-Sal treated seawater. Studies conducted by ADNOC-Upstream EOR.

1.3 Proposed / New Facilities

The project's proposed facilities involve the following:

- Building a Seawater Filtration and Sulphate Reduction Plant (SRP) with a network of pipelines to transport treated, filtered, low-sulphate sea water to Bu Hasa, Bab, NEB & SE for injection.
- Building and commissioning new sea water injection pump station and injection network
- Building a pipe network to distribute sea water to existing injector wells
- Full conversion (except PWRI) of existing aquifer water to sea water injection, including decommissioning and P&A of associated water supply well, decommissioning of surface pump and associated chemical treatment, etc.
- Produced water re-injection clusters will remain as it is.
- Field de-congestion by demolition of existing water injection clusters and OHLs.

2. COST ESTIMATE (+/-40%)

Refer to Appendix-2 for Concept Selection Report (Doc. No. 30.99.91.0621) Section 13.

3. PROJECT ECONOMICS

Project Economics are available Decision Support Package.

4. PRODUCTION PROFILES AND MECHANISMS

Refer to Preferred Field Development Plan Deliverable.

5. RESERVOIR MANAGEMENT PHILOSOPHY

Refer to Preferred Field Development Plan Deliverable.

6. WELL BASIS OF DESIGN

This section is not applicable. This project will not have any new wells to be drilled and will focus on surface facilities and supply treatment of water with tie-ins to existing injection wells.

7. DRILLING AND COMPLETION PROGRAM

This section is not applicable. This project will not have any new wells to be drilled and will focus on surface facilities and supply treatment of water with tie-ins to existing injection wells.

8. WELL EXECUTION PLAN

This section is not applicable. This project will not have any new wells to be drilled and will focus on surface facilities and supply treatment of water with tie-ins to existing injection wells.

9. SUMMARY OF DATA AND DESIGN CRITERIA

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621).

10. FIELD DEVELOPMENT ARCHITECTURE

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621).

11. ENERGY EFFICIENCY REPORT

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621).

12. PROCESS ENGINEERING REPORT

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621).

13. UTILITIES ENGINEERING REPORT

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621)

14. CIVIL AND STRUCTURAL ENGINEERING REPORT

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621)

15. PIPING ENGINEERING REPORT

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621)

16. MECHANICAL, ELECTRICAL, AND INSTRUMENTATION (MEI) ENGINEERING REPORT

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621)

17. MAIN EQUIPMENT LIST

Refer to Appendix-2 for Equipment List (Doc. No. 30.99.91.0623)

18. HSE CASE

Refer to Appendix-1 for Concept Selection Report (Doc. No. 30.99.91.0621)

19. OPERATIONS REQUIREMENTS AND ASSESSMENT

Refer to Appendix-3 Project Philosophies (Doc. no. 30.99.91.0622)

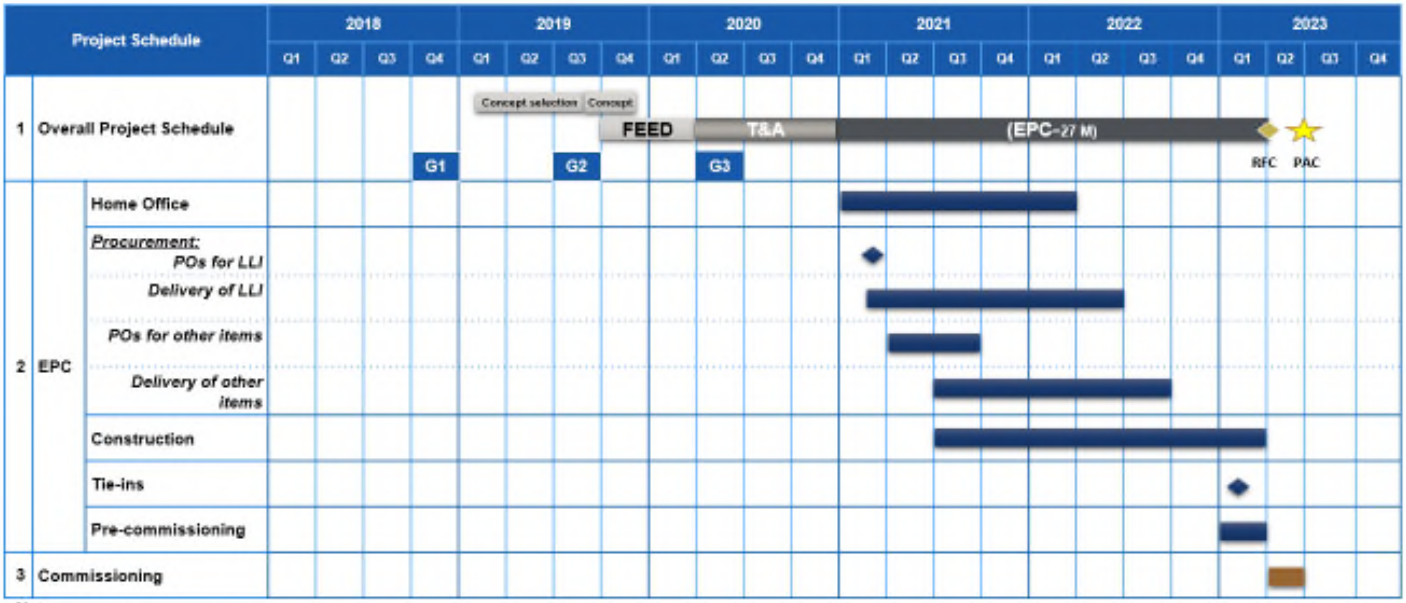
20. PROJECT RISK REGISTER AND MANAGEMENT PLAN

A Project Risk Assessment session will be conducted during concept Design stage. The purpose of this Project Risk Assessment Workshop is to identify any risks to the timely completion of the project and to conduct a qualitative assessment of the same, with reference to cost, schedule and projects' objectives. The assessment will be conducted as per ADNOC EDP Project Risk Management Guideline (Doc ref EDP/TC-PE/GM-0090). Same will be again conducted during FEED stage and Risk register will be updated.

Risk	Description	Mitigation plan
Biofouling	Biofouling/ presence sea grass in Sea Water Intake facilities	During the FEED of intake facilities impact of Biofouling will be studied and taken into consideration through maintenance / operational activities and any design modification.
High waves force against sea water intake	Due to high wave force impact on sea water intake facilities	Marine climate (waves) shall be carefully analysed during FEED Bathymetric Survey and Waves/Tidal Study.

Risk	Description	Mitigation plan
Technology Changes	Design of sea water injection Technology changes to be monitored and potential impact on current scheme evaluated pending timing of Project implementation.	Communication with specialized vendors for water treatment packages are ongoing. Basis of each stage will consider latest vendor's recommendations.
Delay in tender award	Delay in management shareholder approvals will result in impact on the project schedule and not meeting the RFC date	Evaluate potential FEED and EPC schedule adjustment due to delay.
Interfaces with other ongoing projects	Potential delay in schedule due to interface with ongoing projects in existing facilities area	1)Interface management to be established 2) Project Milestones to be assessed and aligned with other projects 3) Potential interfaces to be identified in FEED SOW
Delay activities due to NOC approval	Delay due to NOC approval for proposed facilities	Ensure proper communication of NOC Guidelines
Delay by Sub-Contractor	Delay by Intake FEED sub-contractor will impact project schedule	Ensure during contract stage that sub-contractor is aware of this risk and include contingency margin as part of their schedule.
Integrity of existing facilities during de-commissioning	As part of project scope, decommissioning and P&A of existing water supply well, decommissioning of surface pump and associated chemical treatment, etc considered. Potential for integrity shall be verified for the same.	Same shall be considered as part of FEED SOW. De-commissioning Scope breakup about shall be include in FEED SOW
Scope Creep	Scope of work is constantly changing and water injection requirements is changing from Asset Development Teams. If quantity of water is not confirmed this will cause rework and redesign of intake facilities, entire plant, and supply pipeline and in field distribution network.	Freeze total injection requirements from all Development teams and respective stakeholders at the start of Define stage activities.

21. INTEGRATED PROJECT SCHEDULE (LEVEL 2)



Note:

1. As per agreement with ADNOC considering time constraint, G2 DSP will be submitted based on concept selection. Concept study /FEED will continue after G2.Concept study will be finished by Nov'2019 and FEED will continue. Integrated Schedule is subject to timely Gate approval in one month.
2. Long Lead Items are Line Pipe, SW Lift Pumps, SRP Pumps, SW Booster Supply Pump, SW Supply Pump & Water Treatment Facilities (Filtration, Sulphate Removal Unit).

22. APPENDIX

- **Appendix 1: Concept Selection Report (Doc. no 30.99.91.0621)**
- **Appendix 2: Equipment List (Doc. no 30.99.26.0601)**
- **Appendix 3 Project Philosophies (Doc. no. 30.99.91.0622)**

Appendix 1: Concept Selection Report (Doc. no 30.99.91.0621)

أدنـوك
ADNOC

Conceptual Study

For

PROJECT WAVE

Project No. : **P30280**

Document No. : **30-99-91-0621**

CONCEPT SELECTION REPORT

1	31-08-2019	Project Team	SIA	AQL	Issued for Concept Design
A	15-08-2019	Project Team	SIA/SMA	AQL	Issued for Review
REV.	DATE	ORIGINATOR	REVIEWED	APPROVED	DESCRIPTION

THIS DOCUMENT IS INTENDED FOR THE USE BY ADNOC ONSHORE AND ITS NOMINATED CONTRACTORS, MANUFACTURERS AND SUPPLIERS.

ORIGINATOR: **TECHNICAL CENTER (ENGINEERING)**

ORIGINATOR Document No.: 30-99-91-0621

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Executive Summary

ADNOC Onshore is currently producing around 1.8 MMBOPD of crude oil. With several planned modifications in all ADNOC Onshore fields, ADNOC Onshore is planning to increase the oil production to a sustainable level of approximately 2 MMBOPD by year 2020. ADNOC Onshore future plan (Year 2028) includes increasing the sustainable production by 2.4 MMBOPD.

Figure-1: ADNOC Onshore Fields locations



Project Wave represents ADNOC ++ initiatives for ensuring an additional source of water for injection in ADNOC Onshore fields. The scope of the project looks to utilize treated seawater as an alternative for all ADNOC Onshore fields (BAB, Bu Hasa, NEB and South East).

The main objective is to assess and evaluate a techno-economical alternative to aquifer water for feeding BAB, NEB, Bu Hasa and South East injection demands as affirmed in the 2019-2023 business plans and the current conceptual development outlook.

For concept study of Project Wave, the project has been broken down to three components:

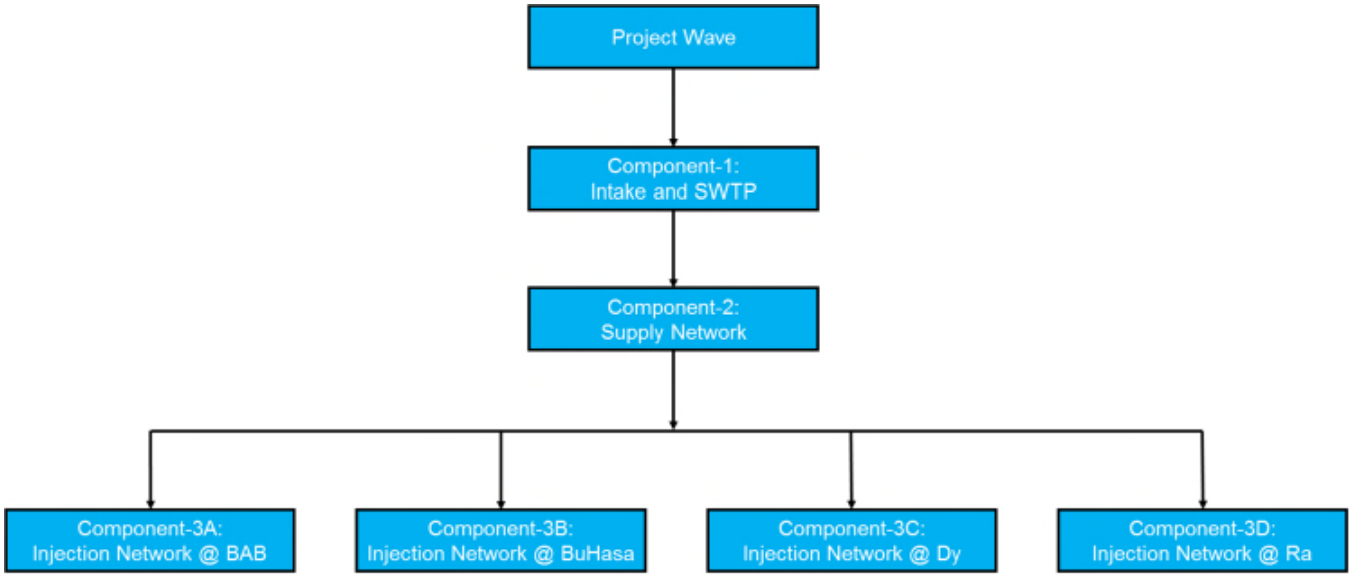
a- Component-1: caters for the selection of the sea water supply intake source as well as the location of the seawater treatment plant.

b- Component-2: caters for the selection of the supply pipeline network scheme with respect to number of pipelines, intermediate pumping as well as pipeline's metallurgy.

c- Component-3: caters for the design of the seawater injection pumping and injection pipeline distribution network.

Below Figure-2 illustrates the Concept Selection breakdown:

Figure-2: Project Wave Concept Selection Breakdown



All options considered in the components and their subsequent elements are based on G1 comments received from ADNOC Onshore Shareholders.

Note: Initially Project Wave considered the replacement of aquifer water with seawater for only NEB, BAB and Bu Hasa Fields. South East was included at a later stage of the project to give a holistic view for Seawater Injection in ADNOC Onshore fields. South East was not considered in the evaluation of all Components however, subsequent evaluation was conducted based on the concluded options.

Component-1 Intake and STP:

The options considered for Component-1 are listed below and were subject to an Option Screening Workshop with relevant stakeholders:

1. Central Plant
   a. Central Plant at Ruwais
   b. Central Plant at Mirfa
   c. Central Plant at Dabbiya
2. Split Plant
   a. Plant at Ruwais for Bab and Bu Hasa and Plant at Dabbiya for Dabbiya and Rumaitha
   b. Plant at Mirfa for Bab and Bu Hasa and Plant at Dabbiya for Dabbiya and Rumaitha
3. Split Plant with Sulphate Reduction Plant (SRP) installed at field
   a. Filtration Plant at Ruwais for Bab and Bu Hasa (SRP at field-BAB) and Plant at Dabbiya for Dabbiya and Rumaitha (SRP at Dy)
   b. Plant at Mirfa for Bab and Bu Hasa (SRP at BAB) and Plant at Dabbiya for Dabbiya and Rumaitha (SRP at Dy)

Component-1 Screening:

Based on the evaluation of CAPEX, OPEX, Operability and other factors, following options were selected for further study:

a. Sea Water Treatment Plant at Mirfa for Bab and Bu Hasa and

b. Sea Water Treatment Plant at Dabbiya for Dabbiya and Rumaitha

Component-1 Selection:

The Seawater Treatment Plant Plant (SWTP) will have pre-filtration and Sulphate Reduction Plant. Prefiltration includes Coarse filtration and Ultra Filtration. After Sulphate removal, the treated water will be deoxiginated in Vacuum Dearator Tower and chemical dearation to reach to a level of 20 ppb. Sulphates are removed to a level of 800 mg/l.

Below is the capacity requirements for both plants:

Table 1: Seawater Treatment Plant Capacity

Location	Capacity BWPD		
	Maximum	Minimum	Turndown
At Mirfa / Ruwais	3,004,000	1,895,000	50%
Dabbiya	1,242,000	464,000	50%

Below is the estimated CAPEX (EPC Cost) and OPEX (Energy Cost):

Table 2: CAPEX & OPEX Comparison, MMUSD

Item Description	Mirfa / Dy	Ruwais / Dy
Intake & SWTP	1,648	1,677
Pipelines (C2)	227	354
Total – EPC Cost	**1,875**	**2,031**
30 Year Energy Cost	543	704

Note: Pipeline (C2) is the estimated cost of the associated supply lines for both options, which is part of Component 2.

Based on relevant options drivers and criteria the selected option for Concept Design is:

Split Plant at Mirfa (catering for Bab & Bu Hasa) and Dabbiya (catering for Dabbiya & Rumaitha).

Component-2 Supply Network:

The identified options for the supply network considered different Materials of Construction (MOC) with different configuration with/without Intermediate Pumping Stations and Single/Double supply lines.

Different MOCs considered are listed below:

1. Metallic:
    a. Carbon Steel (CS)
    b. Carbon Steel with CRA Lining
2. Non-Metallic:
    a. RTP
    b. GRE
3. Metallic with non-metallic lining
    a. HDPE lined Carbon Steel
    b. FBE lined Carbon Steel
    c. Cement Lined Carbon Steel

Component-2 Screening:

All relevent options were studied with respective vendors on size, pressure and design limitations of all MOCs and agreed upon with relevent stakeholders during screening. The following was the outcome of Option Screening for the identified options:

1. Carbon Steel with its pipeline and pump configuration
2. FBE coated Carbon Steel with its pipeline and pump configuration
3. HDPE Lined Carbon Steel
4. GRE Pipeline – a sensitivity case was studied with GRE where number of pipelines will be increased in order to reduce the operating pressure to remain within the available design pressure limits.

Component-2 Selection:

The detailed study was conducted with each material and multiple arrangements and the selected option for both plants are as follows:

- 64'' CS pipeline without IPS is selected to supply from Mirfa Treatment Plant to Bab and 48" CS pipeline to supply to BuHasa.
- 42" Supply Pipeline from DY SWTP to Dy CPP and 30" Supply Pipeline from Dy CPP to Ra CPP is slectected.

Component-3 Injection Network at the Fields

For both Option Identification & Selection, a meeting was arranged with all relevant stakeholders including Field Operations. For all field distribution networks, as per objectives of the project to de-congest the existing fields and demolish existing Aquifer Water Injection Clusters, the following options were considered:

- Centralized Pumping Station
- Split Pumping Stations

Component-3 BAB Field Option Selection

For Bab Field, current arrangement is Water Injection Clusters scattered across the field. Based on the technical and economical merits, Centralized Pumping Station was selected and its location was at the field periphery (Near Cluster-9) close to the supply pipeline approach from Mirfa to Bab Field.

Since Bab has High Pressure Injection and Low Pressure Injectors, therefore, Bab has two set of pumps i.e. High Pressure Injection Pumps and Low Pressure Injection Pumps and respective Headers that supply the water injection demand for the entire field. Details of the major equipment involved are provided in below table:

Table 3: BAB Seawater Injection Network Summary

Description	Single Pumping Station at the Edge of BAB Field CL-9
Peak Injection Rate	1700 MBPD
Injection Pressure	3000 psig for Th-B, Th-C, Th-G, Hb-2 3500 psig for Th-A, Th-H, HB-1
Pipelines	LP Header: 24” – 206 km HP Header: 20“ – 81 km
Total Pipeline	287 km
No. of Pumps	13 W + 3 S (96 MW)
OHL	15km
Substation	New substation

The Injection Network consists of High Pressure Inner Loop, Low Pressure Inner Loop and Low Pressure Outer Loop. These Loops are the main headers. From each of the main header there are several sub headers. The flow lines are connected from subheaders and supply to the injectors.

The main headers are underground and piggable. Subheaders are above grade and non piggable.

Component-3 – Bu Hasa Field Option Selection

For Bu Hasa Field, current arrangement is Water Injection Clusters scattered across the field. Based on the technical and economical merits, Centralized Pumping Station was selected at the field periphery (Near Cluster-49) close to the supply pipeline approach from Bab Field.

Details of the major equipment involved are provided in below table:

Table 4: Bu Hasa Seawater Injection Network Summary

Description	Centralized Pumping at the Edge of Buhasa field
Peak Injection Rate	15000 MBPD
Injection Pressure	2500 psig
Total Pipeline	79 km
No. of Pumps	10W+2S 75 MW
OHL	30km
Substation	220 kV Compound 33 kV Substation

The injection network consists of three main headers North Header, South Header and Central Header. From each of the main header there are several sub headers. The flow lines are connected from subheaders and supply to the injectors.

The main headers are underground and piggable. Subheaders are above grade and non piggable.

Component-3 – Dabbiya Field Injection Network

For Dabbiya Field, current arrangement is a Centralized Pumping Station that supply Aquifer water across the field for Injection. Based on the technical and economical merits, it was concluded that the current system will be extended and upgraded to suit the increased requirement.

Details of the major equipment involved are provided in below table:

Table 5: Dabbiya Seawater Injection Network Summary

Description	Fully Centralized at CPP
Peak Injection Rate	914MBPD
Injection Pressure	2000 psig
No. of Pumps	7 W + 3 S (29 MW)
OHL	-
Substation	New substation

New Injection Pumps are insalled in Dy CPP with fence extension. Existing installed Pumps are being utilized. The network requires debottlenecking by addition loop lines. For Cluster R and Cluster C new pipelines will be required. The main headers are underground and piggable.

Component-3 – Rumaitha Field Injection Network

For Rumaitha Field, current arrangement is a Centralized Pumping Station that supply Aquifer water across the field for Injection. Based on the technical and economical merits, it was concluded that the current system will be extended and upgraded to suit the increased requirement.

Details of the major equipment involved are provided in below table:

Table 6: Rumaitha Seawater Injection Network Summary

Description	Fully Centralized at CPP
Peak Injection Rate	341 MBPD
Injection Pressure	2500 psig
No. of Pumps	3 W + 1 S (11 MW)
OHL	-
Substation	Modification of existing Substation at CPP

New Injection Pumps are insalled in Ra CPP in a plot space assigned for future injection pumps. Existing installed Pumps are being utilized. The network requires debottlenecking by addition loop lines. The main headers are underground and piggable.

South East (SE) Fields Requirements

South East fields, which includes, Asab, Sahil, Shah, Qusahwaira and Mender were included late on during Concept Selection. For SE fields supply from Mirfa or Dabbiya is studied and concluded that CAPEX and OPEX for Dabbiya SWTP supplying to these fields is more attaractive and accordingly Dabbiya is selected to supply treated seawater to SE fields. This is based on the Supply Pipeline Length envisoned:

Table 7: Supply pipeline length to SE

	Supply from Dabbiya	Supply from Mirfa
Total Pipeline Length	309 km	357 km

Due to the accomodation of south east within the Dabbiya sea water treatment plant, the capacity of the plant will have to be increased from 1242 MBWPD to 2700 MBWPD at the outlet of the package's battery limit.

Table 8: Dabbiya Seawater Treatment Plant Capacity

Location	Capacity BWPD		
	Maximum	Minimum	Turndown
Dabbiya (Note-1)	1,242,000	464,000	50%
Dabbiya (Note-2)	2,696,000	1,348,000	50%

Note-1: Considering NEB seawater injection demand
Note-2: Considering NEB+ SE seawater injection demand.

Component 2 and 3 concluded options were applied to South East Field. Below is the summary of the envisoned equipment for all SE Fields:

Table 9: SE Fields Seawater Injection Network Summary

	Asab Major Items	Sahil Major Items	Shah – Major Items	Qusahwira Major Items	Mender Major Items
	Single Pumping Station at the Edge	Single Pumping Station at the Edge	Single Pumping Station at the Edge	Single Pumping Station at the Edge	Single Pumping Station at the Edge
Peak Injection Rate	1200 MBPD	260 MBPD	265 MBPD	150 MBPD	100 MBPD
Injection Pressure	2200 psig	2500 psig	2000 psig	2000 psig	2200 psig
Pipelines	Headers: 16" – 90 km Headers: 14" – 40 km	Header: 12" – 78 km	Header: 12'' – 11.7 km Header: 14'' – 17.9 km	Header: 12'' – 36 km	Header: 10" – 10.3 km Header: 8" – 6.5 km
No. of Pumps	1010 m3/h @ 185 Bar, 7.5 MW (8W + 2S) (60MW)	680 m3/h @ 170 Bar, 4.6 MW (2W + 1S) (9.2 MW)	912 m3/h @ 170 Bar, 6.2 MW (2W + 1S) (12.4 MW)	900 m3/h @ 165 Bar, 5.9 MW (1W + 1S) (5.9 MW)	570 m3/h @ 165 Bar, 3.7 MW (1W + 1S) (3.7 MW)
OHL	30 km	32 km	18 km	6 km	1 km
Substation	Modification in existing Substation	Modification in existing Substation	New Substation	New Substation	New Substation

Cost Estimate Summary

Final Project Cost Estimate based on updated offers from SWTP Specialized Vendors are shown below to an accuracy of ±40%.

Table 10 - Estimated CAPEX (MMUSD)

Mirfa Plant (BAB & Bu Hasa)	CAPEX (MMUSD)
Component 1 (Intake & Plant)	1,102
Component 2 (Supply Pipeline)	350
Component 3 (In-Field Distribution)	1,727
EPC Cost	**3,179**
ADNOC Onshore Engineering & Management Cost:	230
Project Overall Contingency	156
Total Installed Cost	**3,565**

Dabbiya Plant (NEB)	CAPEX (MMUSD)
Component 1 (Intake & Plant)	774
Component 2 (Supply Pipeline)	125
Component 3 (In-Field Distribution)	292
EPC Cost	**1,191**
ADNOC Onshore Engineering & Management Cost:	85
Project Overall Contingency	58
Total Installed Cost	**1,334**

Dabbiya Plant (NEB+SE)	CAPEX (MMUSD)
Component 1 (Intake & Plant)	1,183
Component 2 (Supply Pipeline)	956
Component 3 (In-Field Distribution)	1,278
EPC Cost	**3,417**
ADNOC Onshore Engineering & Management Cost:	246
Project Overall Contingency	166
Total Installed Cost	**3,829**

Table–2 Demolition Cost (MMUSD)

Description	CAPEX (MMUSD)
Demolition cost (BAB, Buhasa & NEB)	180
Demolition cost (SE)	84
EPC Cost	**264**
ADNOC Onshore Engineering & Management Cost	18
Project Overall Contingency	12
Total Demolition Cost	**294**

Cost Estimate Exclusions:

- Any modification works at existing Clusters
- Cost Estimate excludes Drilling Cost

List of HOLDs

HOLD #	Section	Description
1	6.2	Mirfa Reject water composition
2		
3		
4		
5		
6		
7		

Abbreviations

Barg	Bar gauge
BWPD	Barrels of Water per Day
CAPEX	Capital Expenditure
CEB	Chemically Enhanced Backwash
CIP	Cleaning-In-Place
CLS	Cluster
CPP	Central Processing Plant
CRA	Corrosion Resistant Alloy
CS	Carbon Steel
Dy	Dabbiya
EPC	Engineering, Procurement & Construction
FEED	Front End Engineering Design
FBE	Fusion Bonded Epoxy
GRE	Glass Re-inforced Epoxy
HDPE	High Definition Polyethylene
HP	High Pressure
HSE	Health Safety & Environment
ILI	In-Line Inspection
IPS	Intermediate Pumping Station
LP	Low Pressure
LS	Lift Station
MMBOPD	Million Barrels of Oil per Day
NEB	North East BAB
NF	Nano-Filtration
NM	Non-Metallic
OHL	Over-Head Line
OPEX	Operating Expenditure
ppm	Parts per Million
PWRI	Produced Water Re-Injection
Qw	Qusahwira
Ra	Rumaitha
RAS	Ruwais Area Service
RTP	Re-inforced Thermo Plastic
RRE	Ruwais Refinery East
RRW	Ruwais Refinery West
SE	South East
SRP	Sulphate Reduction Plant
SW	Seawater
SWTP	Seawater Treatment Plant
UF	Ultra-Filtration
UG	Underground
WIC	Water Injection Cluster

1.0 Introduction

ADNOC Onshore operates crude production facilities at Asab, Sahil, Shah, Qusahwaira, Mender, BAB, Bu Hasa and NEB (Dy/Ra). The crude production from these stations is routed to MP-21, and from there to the export terminals at Jebel Dhanna and Fujairah. Provisions exist for supply of crude to refineries at Umm Al Nar (Abu Dhabi) and Ruwais.

ADNOC Onshore is currently producing around 1.8 MMBOPD of crude oil. With several planned modifications in all the ADNOC Onshore fields, ADNOC Onshore is planning to increase the oil production to a sustainable level of approximately 2 MMBOPD by year 2020. ADNOC Onshore future plans (Year 2028) includes increasing the sustainable production by 2.4 MMBOPD.

Figure 1.1: ADNOC Onshore Fields locations



As part of pressure maintenance, aquifer water injection and produced water re-injections are being employed. Project Wave represent ADNOC ++ initiatives for ensuring an additional source of water for injection in ADNOC Onshore fields. The scope of the project looks to utilize treated seawater as an alternative for all ADNOC Onshore fields (BAB, Bu Hasa, NEB and South East).

NEB Field Description

The NEB development comprises of three major fields namely Al Dabbiya, Rumaitha and Shanayel. Within these fields, there are two main Hydrocarbon reservoirs; Thamama zones ‘B’ and ‘C’ together with additional thinner reservoirs Thamama zones ‘F’ & ‘G’ and other zones ‘A’, ‘D’ & ‘E’. The Al Dabbiya field lies on a coastal/shallow marine area while the Rumaitha/Shanayel fields are onshore close to the coast line South West of Abu Dhabi.

The NEB fields are located in one of the most environmentally sensitive areas of all ADNOC Onshore licenses and as such, the current development addresses the many challenges associated with such areas through application of state of the art engineering concepts and technologies. Future development within the NEB fields will continue to follow and build upon this strategy to minimize environmental impact.

BAB Field Description

The Bab field is located in a desert area, approximately 160 km southwest of Abu Dhabi city. The field covers an area of approximately 45 km by 25 km. The main processing facilities are located around Bab Habshan.

The field is sour with high H_2S content. The wells to the northeast of Bab field exhibit generally higher H_2S content than wells to the southwest.

Currently, Bab injects aquifer water into the producing zones as the pressure maintenance strategy. Existing clusters 15 & 16 are PWRI clusters. Associated gas separated at BCDS is delivered to ADNOC Gas Processing for processing and processed Crude Oil is pumped to ADNOC Onshore export network.

Bu Hasa Field Description

Bu-Hasa field is located 200 kilometers south west of Abu Dhabi. It is ADNOC Onshore's most western producing field. It was discovered in 1962 and was put on production in May 1965. In Bu-Hasa currently there are three Remote Degassing Stations (RDS-1/2/3) and two satellite stations BQ & HW.

Production from oil wells completed in Shuaiba, Thamama B, Thamama F, BQ & HW is routed through individual flow lines to three Gathering stations (RDS-1, RDS-2, RDS-3), BQ and HW stations in various parts of the field. The combined production from the wells at each these stations is routed to Central Degassing Stations (CDS) via transfer lines ranging in sizes from 16" to 26". In addition, some wells in the central part of the field are connected directly to the CDS.

South East Field Description

Asab Field is located in the desert area approximately 160 KM south of Abu Dhabi city being managed & operated by ADNOC Onshore. Sahil, Shah, and Qusahwira & Mender are considered as satellite fields to Asab and are located approximately 160, 200, 220 and 250 km south of Abu Dhabi respectively. Mender field is recently commissioned and the oil is flowing to Asab CDS along with Qusahwira production.

2.0 Project Objective

Potential benefits of utilizing seawater as a complimentary source of water for injection demand includes:

- Sustainable source for water injection
- Contain aquifer depletion and adverse impacts of pressure decline
- Improve Infectivity in marginal, low permeability reservoirs
- Conceptually reduce stimulation cost of injectors due to lower TSS
- Reduce future CAPEX & OPEX by reducing the number of Water Injection Clusters, ESP's pulling hoist, manpower, power consumption, etc.
- Improve operational efficiency, reduce injection downtime and improve system efficiency through centralization of treatment facility

3.0 Project Scope

The project's scope mainly involves the following:

- Building a seawater filtration plant and Sulphate Reduction Plant (SRP) with a network of pipelines to bring treated filtered, low-sulphate seawater to NEB, BAB, Bu Hasa and South East fields.
- Building and commissioning new sea water injection pump station and injection network
- Building a pipeline network to distribute such sea water to existing or new injector wells
- Full conversion of existing aquifer water to seawater injection, including decommissioning and P&A of associated water supply well, decommissioning of surface pump and associated chemical treatment, etc.
- Produced water re-injection clusters will remain as it is.
- Field de-congestion of existing water injection clusters.

4.0 Document Objectives

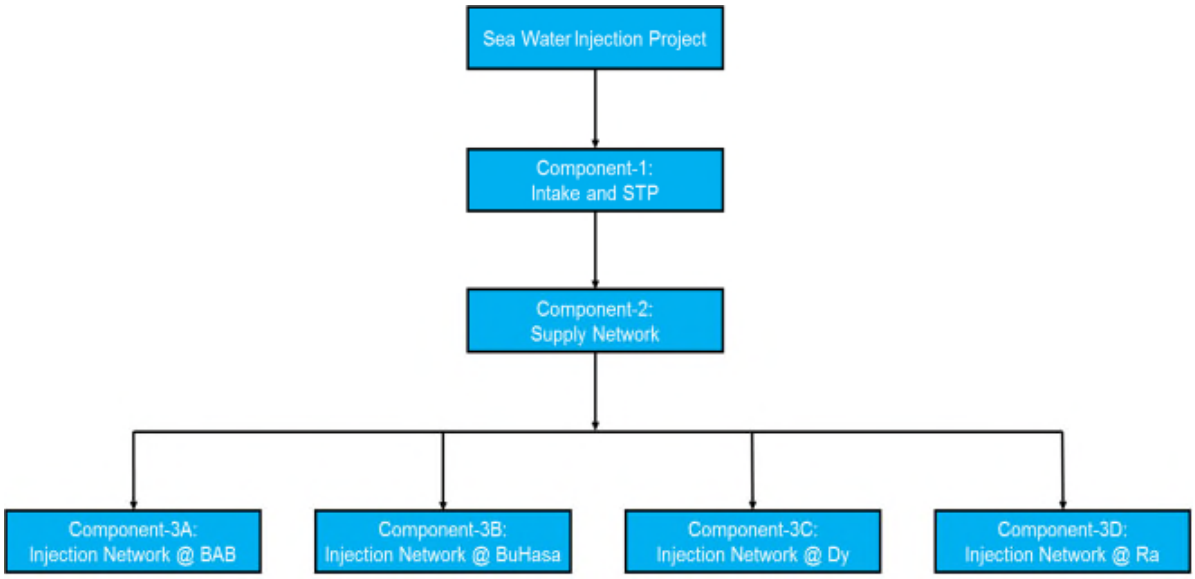
The objective of this document is to report the concept methodology and selection, which includes option identification, evaluation of all options and selection of the optimum option.

5.0 Project Description

5.1 Project's Breakdown Structure

Considering the wide extent of project's scope and the multiple items to be covered under project's conceptual design, the project has been broken down into components; each component caters for a specific design area, which requires individual assessment, analysis and selection. Refer to figure 5.1.1 below for project's components:

Figure 5.1-1: Seawater project components breakdown



Note: Initially Project Wave considered the replacement of aquifer water with seawater for only NEB, BAB and Bu Hasa Fields. South East was included at a later stage of the project to give a holistic view for Seawater Injection in ADNOC Onshore fields.

Project's design components are described as follows:

a- Component-1: caters for the selection of the sea water supply intake source as well as the location of the seawater treatment plant. The distribution from the seawater treatment plant to the individual fields is captured as part of component-2. The battery limit of this component starts from the seawater / reject water intake source and terminates at the seawater treatment plant's outlet.

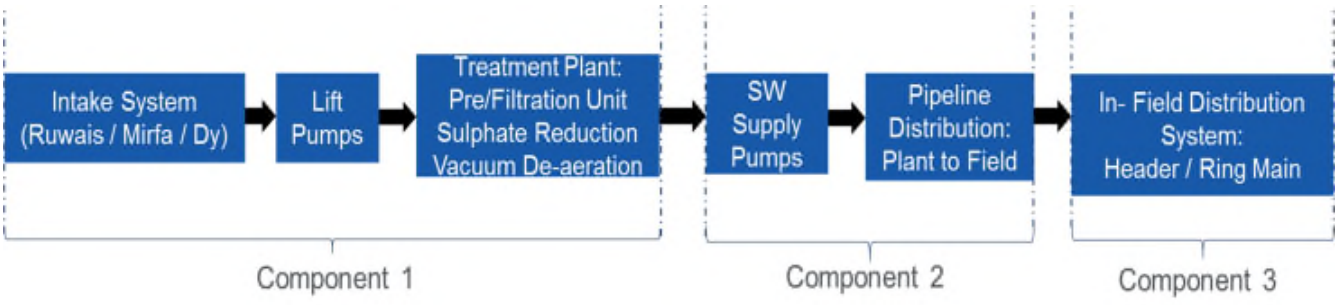
b- Component-2: caters for the selection of the supply pipeline network scheme with respect to number of pipelines, intermediate pumping as well as pipeline's metallurgy. The battery limit of this component starts from the outlet of the seawater treatment plant and terminates at the inlet of the receiving fields.

c- Component-3: caters for the design of the seawater injection pumping and injection pipeline distribution network. The battery limit of this component starts from the tie-in with the seawater supply pipeline and seawater injection network distributing the injection water to the wells/pads/clusters.

Known future developments are catered in the design. De-congesting the existing water injection clusters and associated facilities (by demolition) is also considered, where applicable.

Refer to figure 5.1-2 below for the overall segregation of each component's definitions:

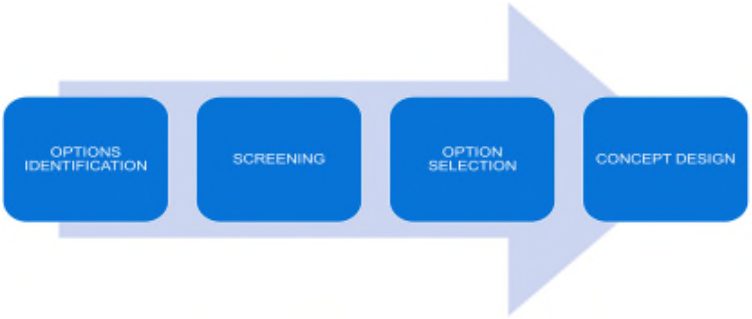
Figure 5.1-2: Components limits definition



5.2 Project's workflow

Each component will have options identification, screening and selection as per the workflow shown in figure 5.2-1 below:

Figure 5.2-1: Component individual workflow



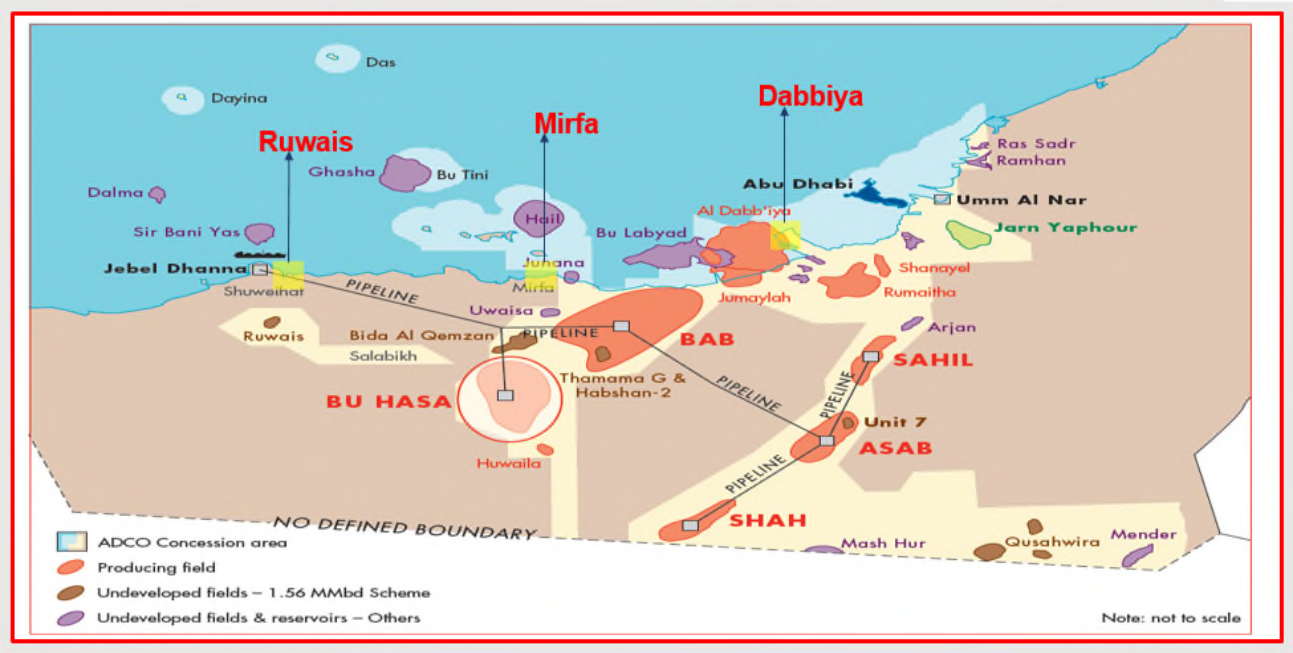
Each component will have option identification, screening and option selection, followed by concept design. All of these concept stages have the workshop assessment as required. In Option identification, all possible options are listed. An Option Identification Workshop is arranged to ensure the involvement of all stakeholders. All identified options were screened out based on feasibility / criteria, as required. Screening out unfeasible options reduces the efforts in option evaluation. Evaluation of available options is performed against design constraints, CAPEX, OPEX and other necessary parameters. Eventually one option is selected based on the Option Selection criteria.

Below is a description of the identified options for each component.

5.2.1 Component-1: Location and Sea Water Treatment Plant

Several potential locations were evaluated for the sea water supply; Ruwais, Mirfa and Dabbiya. Potential utilization of reject water discharged from existing desalination plants is also evaluated in this component.

Figure 5.2-1: Component-1 potential seawater supply sources



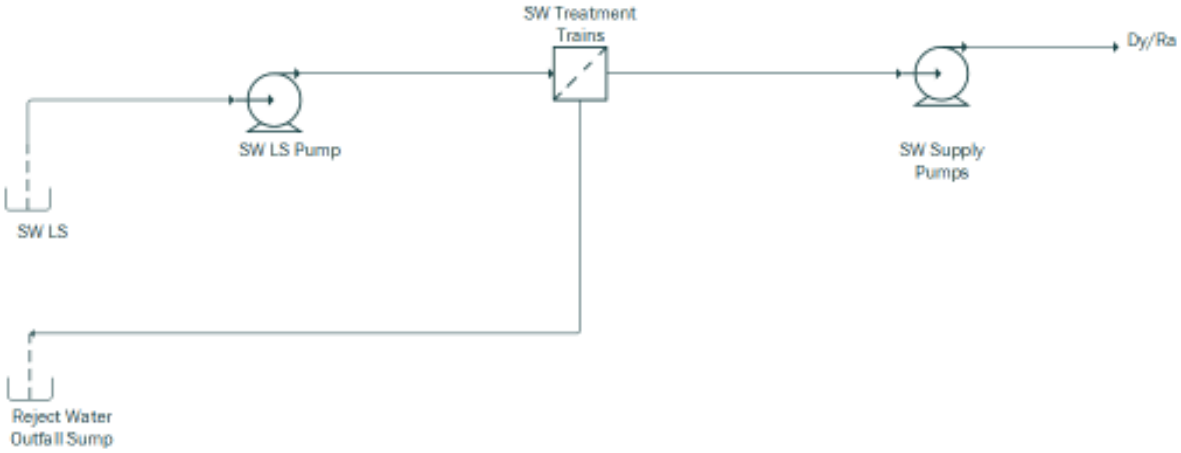
Seawater Intake System can be with channels or with intake pipes. Typically, seawater enters the facility through a set of inlet screen channels from where it emerges into a large Lift Station, where Sea Water Lift Pumps are provided to boost the pressure to the inlet of the seawater treatment plant.

Seawater treatment plant is envisaged to be consisting of the following main processing units:

1) Sea water intake system
2) Sea water/Reject Water lifting stations
3) Seawater lift pumps.
4) Filtration unit: which coarse cartridge filtration followed by Ultra-filtration units.
5) Sulphur Reduction Unit (SRU): consists of Nano-filtration membranes for sulphur removal
6) Vacuum deaeration for 99.9% oxygen removal.
7) Chemical Injection Packages (biocide, coagulants, flocculants, oxygen scavengers and corrosion inhibitor, etc)
8) Associated systems for back wash (CIP, CEB, etc)
9) Electro chlorinator package
10) Seawater supply pumps.

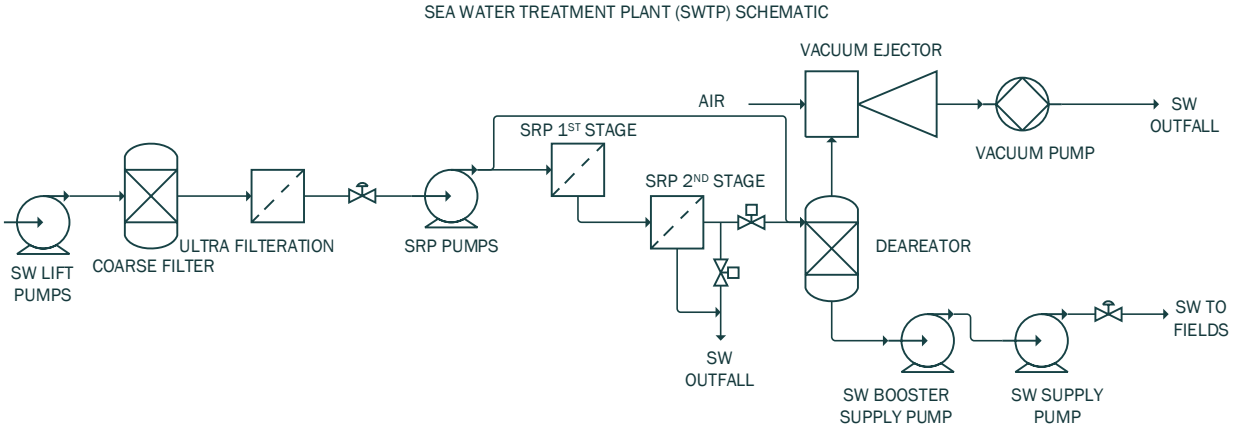
Figure 5.2.2 below provides a pictorial view of component-1 process flow:

Figure 5.2-2: Component-1 Seawater system process flow



Refer to figure 5.2-3 below for a pictorial view of seawater treatment plant and its components:

Figure 5.2-3: Seawater treatment plant overall scheme



Sulphate removal from seawater is important for maintaining the stability of the formation clays and for preventing the formation of barium and strontium sulphates due to interaction between formation water and seawater. Such sulphate components can be hard to remove and they tend to accumulate and deposit in wellbore tubings and production piping internals.

Reject discharge from the sulphur removal plant shall be directed to an outfall sump. Accordingly, the demand intake capacity to the inlet of the treatment plant shall consider a 35% margin on the demand seawater at plant's outlet battery limit.

5.2.2 Component-2: Supply Network

This component looks into the supply of the treated seawater from the treatment plant to the individual field. The following items are studied in this component:

1) Supply with single or parallel pipelines.
2) Intermediate pumping station to supply to the fields.
3) The material of construction of the supply pipeline.

5.2.3 Component-3: Field Injection Network

This component studies the network of the seawater injection from injection pumps up to the injectors. In general, Component-3 consists of Injection Pumping Station(s), Injection Main Headers, Sub-headers and flowlines.

Existing water injection clusters facilities will be demolished for the purpose of de-congestion. Concept stage considers new seawater injection networks for BAB, Bu Hasa & South East fields including the flowlines up to the injection wells. Any optimizations to utilize existing pipeline network or equipment will be evaluated during FEED stage. However, since NEB fields already have a centralized injection network, therefore, utilization of existing network has been considered for NEB fields.

6.0 Project Design Basis

6.1 Key Basis and Assumptions

The following assumptions formulate the key basis of the concept selection study for Project Wave:

- Seawater requirement covers all existing, ongoing and future developments up to and including P5 development.
- All existing water injection clusters and their OHL will be demolished to de-congest the fields.
- New seawater injection pipeline network is considered for BAB, Bu Hasa & South East fields. Any utilization of existing pipeline and existing equipment will be evaluated during FEED stage.
- NEB fields' aquifer water injection will be fully converted to seawater injection. For Bab and BuHasa current PWRI plans (BuHasa: PWRI-1/2/3/4 and BAB: Cls-15/16) will be considered as per the approved plans and accordingly PWRI load will be subtracted from the total water injection volumes to get the seawater profile.
- Only sustainable sea water injection rates are considered i.e. no technical margin applied to sustainable injection rates.
- NEB Profiles provided during Project 5.0 are being utilized
- Latest profiles provided by BuHasa for Project Wave are being utilized
- For BAB, seawater injection profiles are used as provided by BAB Development in June 2019. The profiles consider all BAB existing and upcoming developments.
- SE fields were included late in the concept selection therefore; the available aquifer water injection profiles (inclusive of project 5 requirements) are to be used for seawater injection requirements.

6.2 Sea Water Composition

The following locations have been considered for the sea water supply source:

- Ruwais
- Mirfa
- Dhabb'iya

Accordingly, seawater compositions for these locations are provided below:

Mirfa / Dabbiya Seawater Composition:

For Mirfa/Dy seawater composition is shown in table 6.2-1 below.

Table 6.2-1A: Sea Water particle distribution (Reference: ADNOC Offshore)

Sea Water composition counts according to P7531-DS-2317-F-0002-B1							
Particle Size (Micro-meter)	0.5-1	2-1	2-3	3-4	4-5	5-10	>10
Particles/ml	NA	50,000-120,000	4,000-8,000	500-2,000	100-700	70-400	5-40

Table 6.2-1B: Sea Water particle composition (Reference: ADNOC Offshore)

Sea Water Quality @ Sea Water Filtration Package Inlet		
Parameter	Value	Design Value
PH	8.0-8.5	8.5
Free chlorine as Cl2 (ppm)	1.2	5 (shock)
Total dissolved Solids , mg/l	39000-44000	55000
Sodium , mg/l	12300-13900	17375
Calcium, mg/l	460-520	650
Magnesium, mg/l	1430-1615	2019
Barium, mg/l	0	0
Strontium, mg/l	0	0
Total iron , mg/l	0.5	0.625
Carbonate , mg/l	0	51
Bicarbonate , mg/l	146-164	205
Chloride , mg/l	21700-24400	30340
Bromide, mg/l	49-55.5	69
Sulphate , mg/l	2965-3345	4400
Specific Gravity	1.025-1.026	1.027
Total Suspended Solids , mg/l	0.4-5	10
Hydrocarbons , mg/l	0.1-0.2	2

This composition is to be used for Mirfa and Dabbiya Plant until seawater samples and tests are conducted for these sites by ADNOC Onshore.

Design values have margins over the inlet concentrations to ensure the plant performance over 30 years life. However, this may require to be updated based on the inputs from vendor at the next stage of engineering.

Mirfa Reject Water:

This project will review to reuse reject water as an environmentally better solution. Mirfa has potentially reject water availability, however, this is pending confirmation from MIPCO and EWEC and will be considered during Concept Design upon receiving their response.

Ruwais Seawater Composition:

Ruwais seawater inlet composition is provided in Table-6.2-2.

Table 6.2-2: Ruwais Sea Water Composition

Description	Unit	Value	Description	Unit	Value
Specific Gravity		1.032	Phenolphthalein Alkalinity	mg/l CaCo3	25
Total Hardness	mg/l CaCo3	8300	Sillica	[mg/l siO2]	0.07
Calcium	mg/l CaCo3	1410	Iron	[mg/l Fe]	0.03
Magnesium	mg/l CaCo3	6791	Organic matter (P.V)	[mg/l KMnO4]	8
Sodium	mg/l CaCo3	28301	Salinity	-	44214
Potassium	mg/l CaCo3	691	pH at 20 degC	-	8.24
Total cations	mg/l CaCo3	37193	TDS at 180 degC	[mg/l]	45410
Bicarbonates	mg/l CaCo3	75	Phosphate	[mg/l P205]	<0.05
Carbonates	mg/l CaCo3	50	Particle Size	mm	max 1
Chlorides	mg/l CaCo3	33514	Residual Chlorine	-	-
Sulfates	mg/l CaCo3	3490	-for short times	Ppmw	max 2
Nitrates	mg/l CaCo3	0.032	-after shock treatment	Ppmw	max 5
Total Anions	mg/l CaCo3	37129	Total Suspended solid	[mg/l]	5 to 15
Methyl- Orange Alkalinity	mg/l CaCo3	125			

Ruwais Reject Water Composition:

Ruwais has indicated availability of reject water, which is currently disposed to the sea. This project will review to reuse this reject water as an environmentally better solution. Data from Ruwais Refinery shows that reject water quantity is maximum 6,200 m³/h and minimum 5,300 m³/h. Accordingly, 5,300 m³/h will be assumed as available all the time (minimum) and balance requirement is to be provided by fresh sea water.
Ruwais reject water composition is provided in Table 6.2-3;

Table 6.2-3: Ruwais Reject Water Composition

Sample Point		RRW MSF #A	CBDC MSF #A	RAS MSF #1
Sampled Water		**Brine Blow Down**	**Brine Blow Down**	**Brine Blow Down**
Sampled Date		2019/1/16	2019/1/16	2019/1/17
Sampled Time		15:08	16:16	11:38
Temperature of Samples		32.7	40.1	37
Sample Description		B-1	B-2	B-3
pH Value @ 20 Deg C	ph Units	8..8	8..8	8.7
Electrical Conductivity @ 25 Deg C	mS/cm	97	103	100
Total Suspended Solids	mg/L	<5.0	<5.0	<5.0
Total Dissolved Solids	mg/L	82,400	89,700	86,100
Dissolved & Emulsified Oil	mg/L	<10	<10	<10
Free Oil	mg/L	<0.01	<0.01	<0.01
Turbidity	mg/L	1.7	4.2	3.2
Nitrogen (Ammonia)	mg/L	<0.05	<0.05	<0.05
Ammonia	mg/L	<0.06	<0.06	<0.06
Ammonium	mg/L	<0.064	<0.064	<0.064
Bicarbonate	mg/L	102	102	132
Carbonate	mg/L	77	86	72
Hydroxide	mg/L	<1.0	<1.0	<1.0
p-Alkanity	mg/L	64	72	60
m-Alkanity	mg/L	212	228	228
Total Alkanity	mg/L	212	228	228
Bromide	mg/L	130	140	130
Fluoride	mg/L	2.2	2.1	2
Nitrate	mg/L	9.3	11.1	10.8
Orthosulphate	mg/L	0.06	0.06	0.06
Sulphate	mg/L	5890	6090	5610
Chloride	mg/L	40400	44000	42500
Chemical Oxygen Demand	mg/L	32	36	40

Sample Point		RRW MSF #A	CBDC MSF #A	RAS MSF #1
Sampled Water		**Brine Blow Down**	**Brine Blow Down**	**Brine Blow Down**
Total Organic Carbon	mg/L	3	3.4	3.6
Aluminium (A)	mg/L	<0.060	<0.060	<0.060
Barium (Ba)	mg/L	0.021	0.026	0.026
Boron (B)	mg/L	11.4	11.2	11.1
Calcium (Ca)	mg/L	920	890	890
Iron (Fe)	mg/L	<0.060	<0.060	<0.060
Magnesium (Mg)	mg/L	2600	2610	2630
Magnesium (Mn)	mg/L	<0.01	<0.01	<0.01
Potassium (K)	mg/L	801	808	819
Sodium (Na)	mg/L	21700	23200	22000
Strontium (Sr)	mg/L	21.4	20.2	20.6
Silica	mg/L	0.05	0.07	0.09

6.3 Treated Sea Water Specifications

The required specification of the treated seawater is provided below:

- Sulphate content 600 mg/l for Dabbiya & Rumaitha fields
- Sulphate content 800 mg/l for Bu Hasa field
- Sulphate content 1200 mg/l for BAB field
- TDS 0.1 mg/L (particle size: 95% separation > 2 microns)
- Oxygen 20 ppb

Note that if a central plant is installed then stringent criteria of the above shall be used i.e. sulphate content to be equal or less than 600 mg/l. For split plant, sulphate content for NEB and Mirfa/Ruwais is 600 mg/l and 800 mg/l respectively to suit the most stringent fields' requirement.

6.4 Sea Water Injection Profile

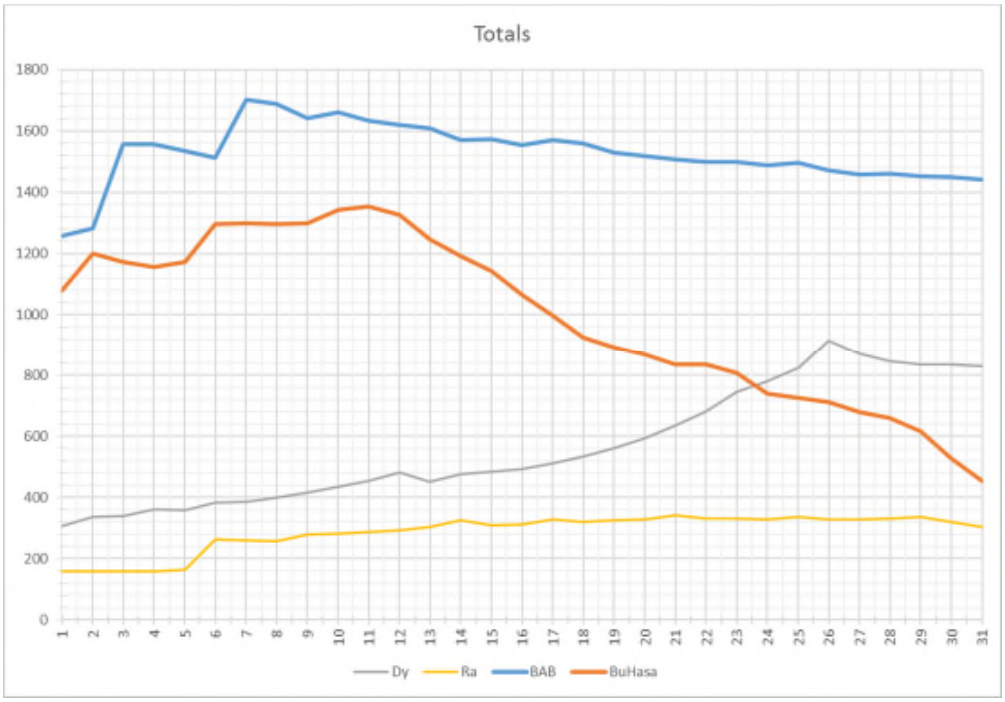
All the injection profiles provided in this section are inclusive of Project 5.0.

Following to be noted for asset injection profiles:

- NEB Profiles provided during Project 5.0 are being utilized
- Latest profiles provided by BuHasa are being utilized
- Latest profiles provided by BAB are being utilized
- Current PWRI plans will be considered to be proceeded and accordingly PWRI load will be subtracted from the total water injection volumes to get the seawater profile.

Figure 6.4.1 provides an overall estimation of the individual field's injection demand:

Figure 6.4-1: Sea Water injection requirement per field



6.5 Reservoir & Wellhead Conditions

Based on the latest received subsurface data for each field, table 6.5-1 below provides the minimum wellhead injection pressure values to be considered for the design of the main supply and field located injection pumps:

Table 6.5-1: Wellhead injection pressure summary

Field	Minimum Wellhead Injection Pressure
Bu Hasa	2500 Psig (500 Psig increment over the aquifer minimum WHIP)
BAB	Low Pressure Zones : Th-B,Th-C,Th-G & HB-2 with WHIP of maximum 3000 Psi. High Pressure Zones: Th-A, Th-H & HB-1 with WHIP of maximum 3500 Psi.
NEB-Dabbiya	2000 Psig
NEB- Rumaitha	2500 Psig
ASAB	2200 Psig
Mender	2200 Psig
Shah	2000 Psig
Qusawaira	2000 Psig
Sahil	2500 Psig

Design Life

A design life of 30 years is considered for seawater injection facilities design.

Service Water System

Service Seawater System consists of supply from Sea Water Lift Pumps and seawater filtration package. Major users of seawater are considered to be Potable Water System, firewater header pressurization, Sea Water Intake Filter back-wash and Electro chlorination Package.

Potable Water System

Requirement for Potable water system will be established during FEED.

7.0 Component-1: Location & Treatment Plant

7.1 Option Identification and Screening

Component-1 mainly deals with location of seawater intake and treatment plant. The potential locations for the seawater treatment plant are Ruwais, Mirfa and Dabbiya. It is important to note that Gate-1 (base case) considered Mirfa as the intake and plant location to supply the injection water to all the assets.

Note: Initially Project Wave considered the replacement of aquifer water with seawater for only NEB, BAB and Bu Hasa Fields. South East was included at a later stage of the project to give a holistic view for Seawater Injection in ADNOC Onshore fields. South East was not considered in the evaluation of this Component however, subsequent evaluation was conducted based on the concluded options. This is available in Section 12.

Options considered for Component-1 are:

1. Central Plant
   a. Central Plant at Ruwais
   b. Central Plant at Mirfa
   c. Central Plant at Dabbiya

2. Split Plant
   a. Plant at Ruwais for Bab and BuHasa and Plant at Dabbiya for Dabbiya and Rumaitha
   b. Plant at Mirfa for Bab and BuHasa and Plant at Dabbiya for Dabbiya and Rumaitha

3. Split Plant with Sulphate Reduction Plant (SRP) installed at field
   a. Filtration Plant at Ruwais for Bab and BuHasa (SRP at BAB) and Plant at Dabbiya for Dabbiya and Rumaitha (SRP at Dy)
   b. Plant at Mirfa for Bab and BuHasa (SRP at BAB) and Plant at Dabbiya for Dabbiya and Rumaitha (SRP at Dy)

For Central Plant option full injection water volume is to be treated and pumped to BAB, BuHasa and NEB from a central location. For Split Plants, Mirfa/ Ruwais Plants to process and supply injection water quantities for Bab and BuHasa. Whereas Dabbiya plant to supply the injection water requirements of Dy and Ra.

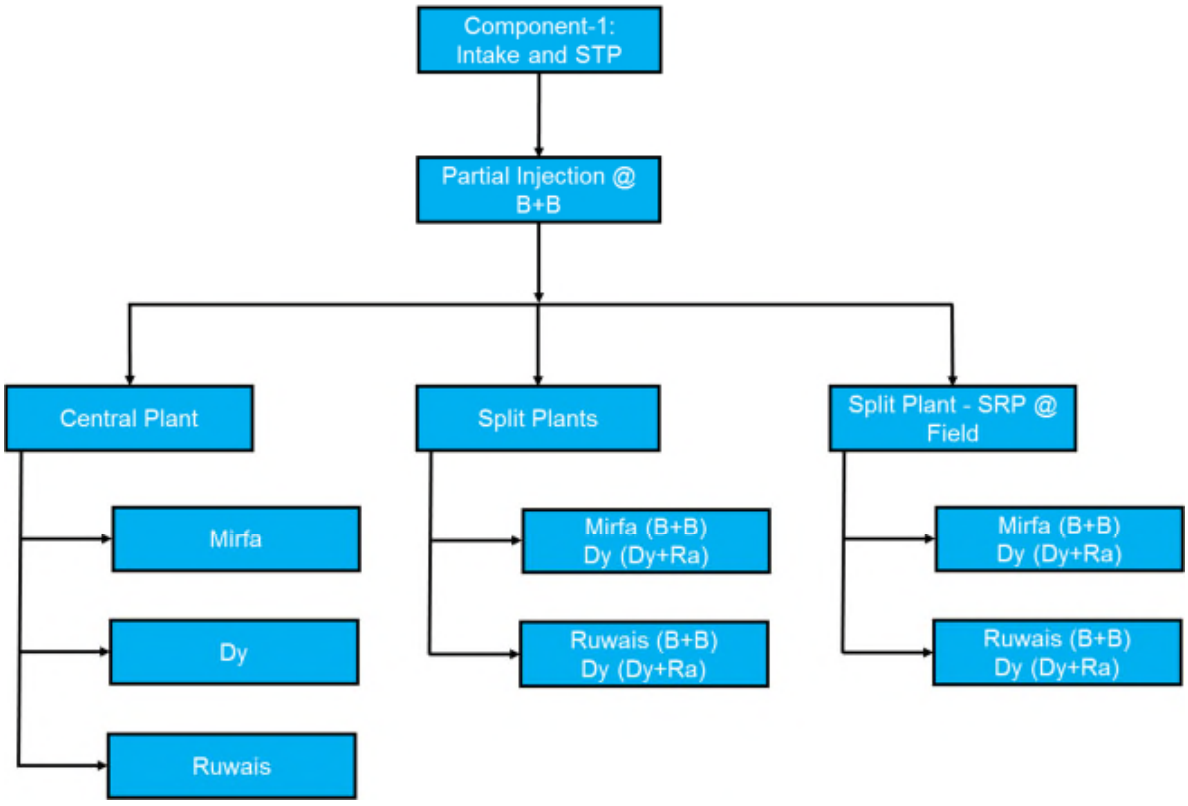
It is important to note that Ruwais option was included to process the reject water quantities as an environmentally driven option. Also, the intent of SRP installation at the field is also to dispose the reject water into aquifer instead of sea.

It must be noted that Ruwais team has clarified that Ruwais Intake system has limited capacity and cannot accommodate ADNOC Onshore injection requirements. Therefore, a new intake system has been considered for Ruwais options to top up to meet the total water injection requirements.

For Mirfa concept selection, an independent intake and outfall has been considered.

Component-1 option tree is given below:

Figure 7.1-1: Option tree for Component-1



7.1.1 Central Treatment Plant Options

Mirfa Site:

As part of the study, comparison analysis has been made between central vs split plant. Below schematic describes central plant study at Mirfa location.

Mirfa is identified as the potential location for the central plant considering its proximity to the fields as well as to the sea. A location beside ADNOC Industrial Gases is considered for the sulphate removal plant whereas intake required to be routed from sea via lift station to the plant. This central plant requires a total pipeline length of approximately 225 km.

Figure: 7.1-2: Field layout for Mirfa central plant

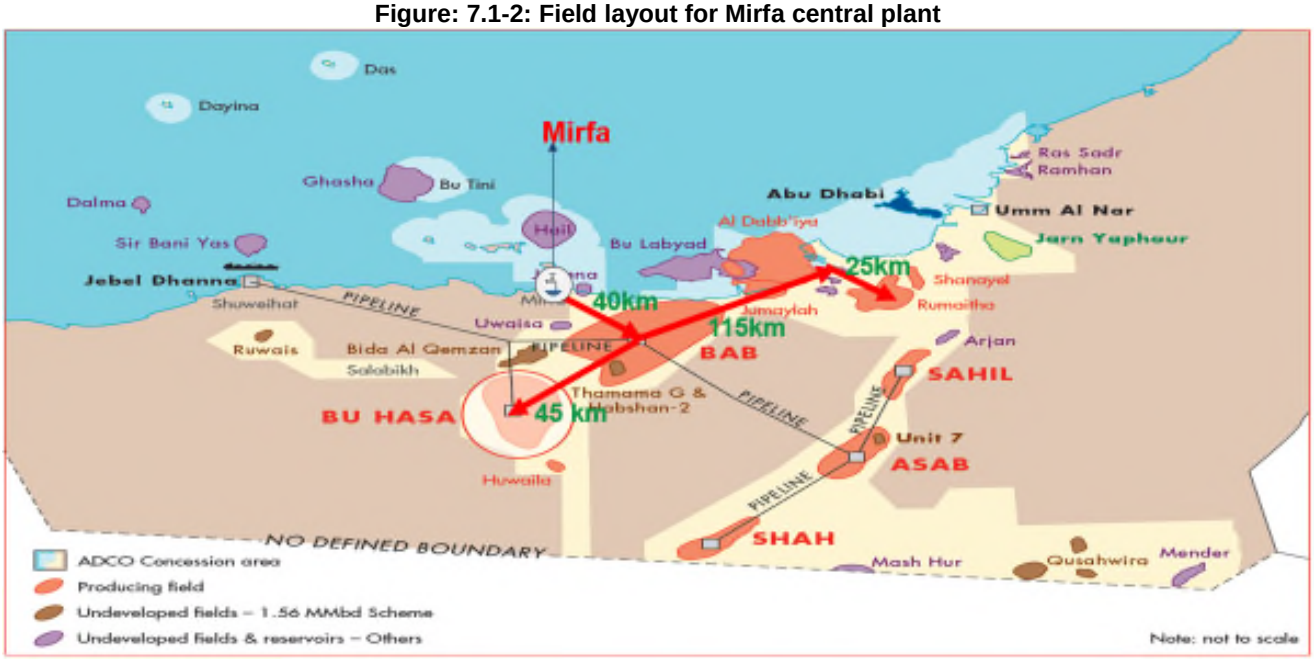
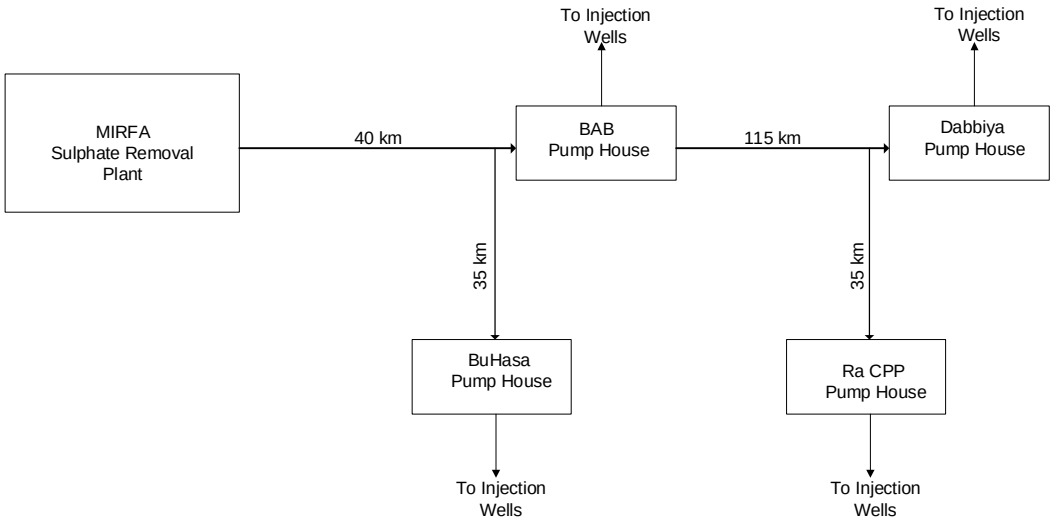


Figure-7.1-3: Mirfa Central Plant Sketch



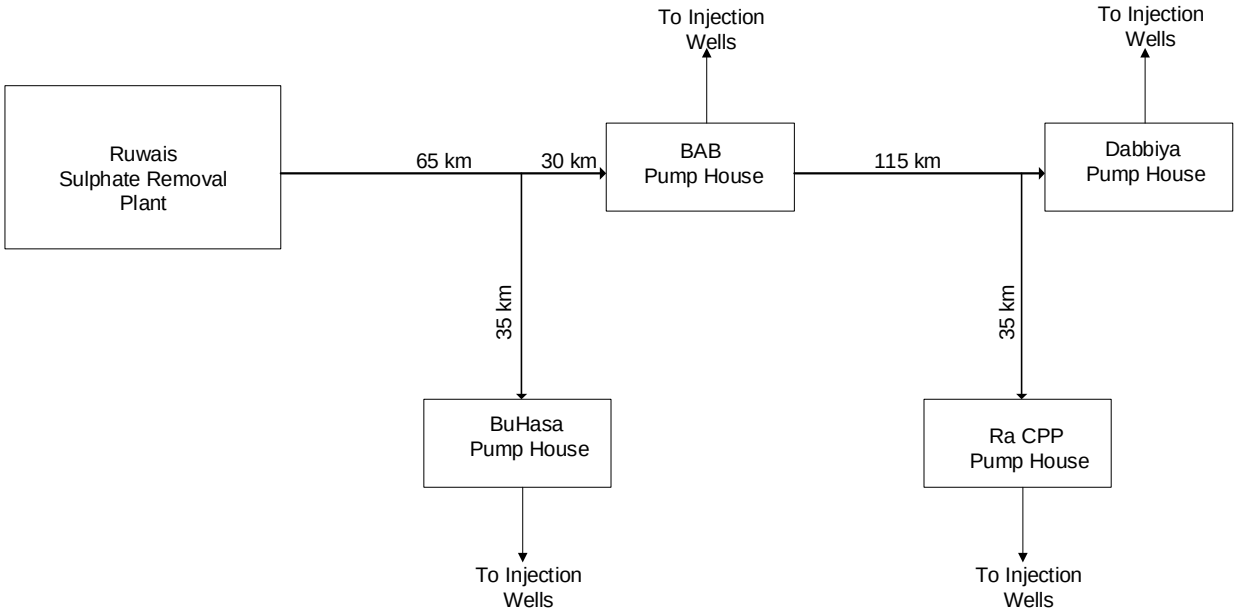
Ruwais Site:

3rd potential option, where the plan is to locate central plant at Ruwais location, has been studied. Intial findings state requirements of longer pipeline for supplying water to the fields compare with the other two potential locations stated above. In case central plant is considered at Ruwais, 280 km supply pipeline will be required to feed the fields. Below schematic illustrates an overall view for this option.

Figure: 7.1-4: Field layout for Ruwais central plant



Figure-7.1-5: Ruwais Central Plant Sketch



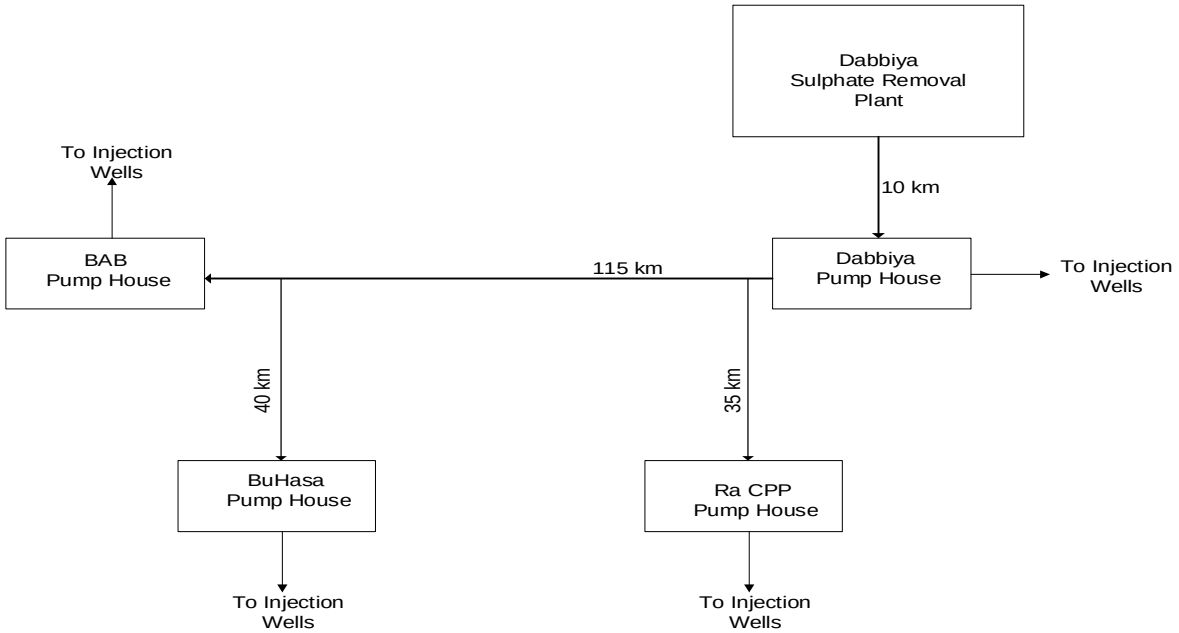
Dabbiya Site:

Dabbiya is considered as the 2nd potential location. Dabbiya is under ADNOC-Onshore concession, located beside sea. Hence, considered feasible for the sea water intake system and treatment plant facilities. As part of option screening study dicates a requirement of 200 km long pipeline for the supply of water when considering Dabbiya as Central. Below schematic presents overall arrangement for this case study.

Figure: 7.1-6: Field layout for Dabbiya central plant



Figure-7.1-7: Dabbiya Central Plant Sketch



7.1.2 Split Treatment Plants Options

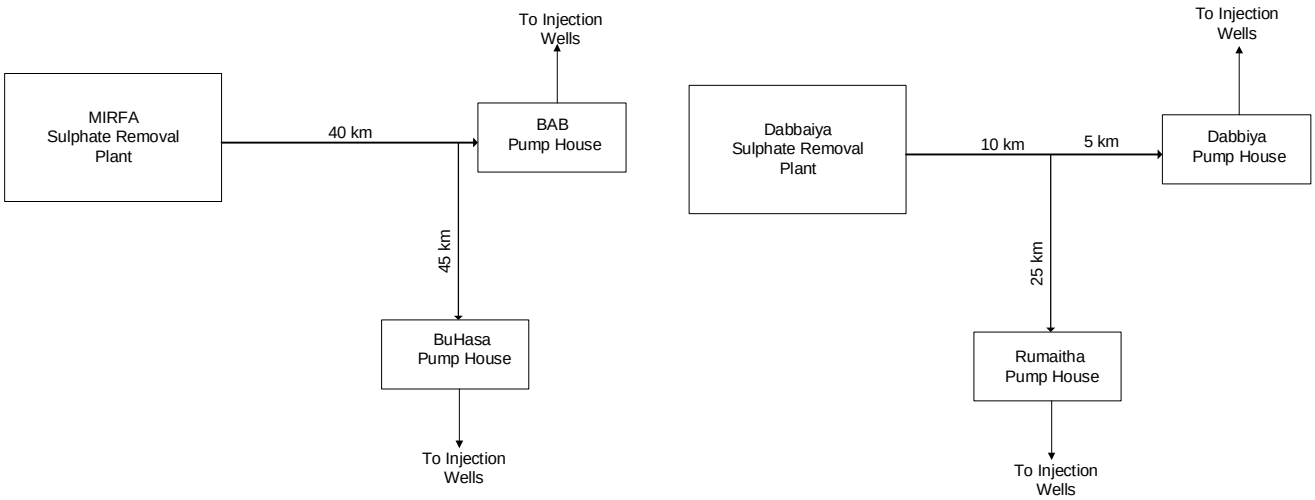
Mirfa and Dhabbiya Split Treatment Plants:

As an option screening study, alternative proposal to locate treatment plants in two different locations have also been studied. Plants are considered feasible at Mirfa & Dabbiya locations, major drivers are water intake and field location. Below schematic shows plants location and supply pipeline arrangement. In this option supply pipeline length will be 125 km long. This option also provides flexibility over central plant.

Figure: 7.1-8: Field layout for Mirfa and Dabbiya as split plant option



Figure-7.1-9: Mirfa and Dy Split Plant Sketch



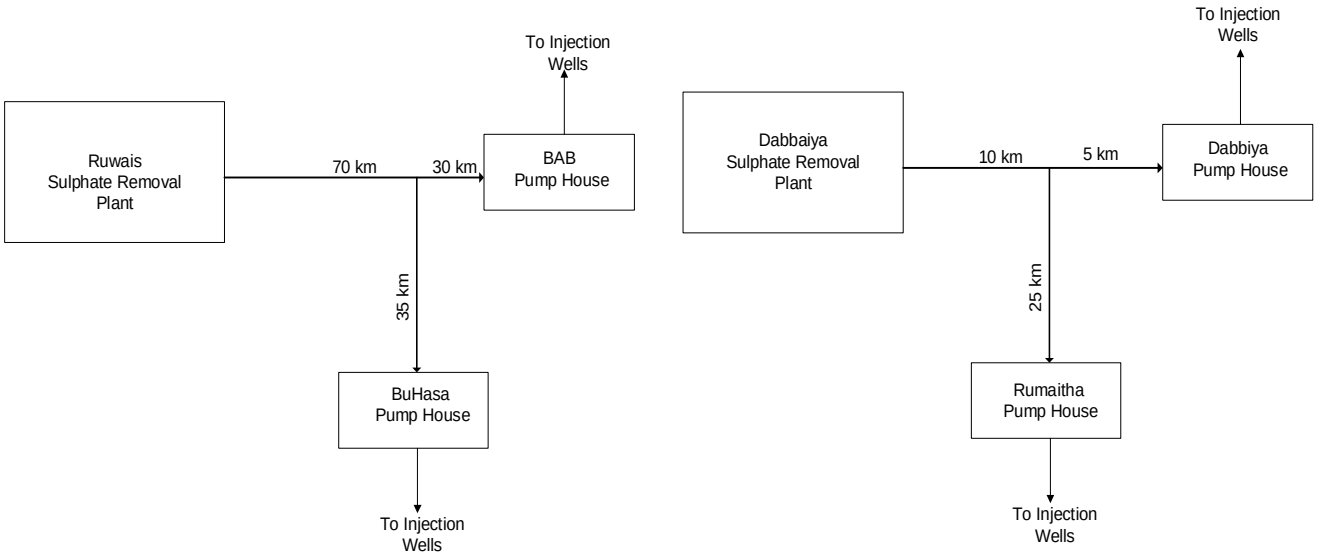
Split Plants Ruwais & Dabbiya

Plants are considered feasible at Ruwais & Dabbiya locations. Ruwais plant will supply to Bab and BuHasa, and Dy Plant will supply to NEB Fields. Below figures shows plants location and supply pipeline arrangement. These potential locations demand supply pipeline length of 175 km approx. Below schematic identfies plant location and pipeline route.

Figure 7.1-10: Field layout for Ruwais and Dabbiya Split Plant



Figure-7.1-11: Ruwais and Dy Split Plant Sketch



Comparison of all the options is given in table 7.1.1 below:

Table 7.1-1: Pipeline comparison for all location options

Plant	Supply Network
Central Plant in Mirfa	225 km
Central Plant in Dy	200 km
Central Plant in Ruwais	280 km
Split Plant in Mirfa & Dy	125 km
Split Plant in Ruwais & Dy	175 km

Based on above analysis it can be seen that the split plants options are more favorable since they have lower pipeline length which implies that their CAPEX and OPEX will be lower.

As a part of the study, Concept level feasibility for Seawater intake facilities, i.e. intake channel/Pipeline (offshore) and lift station are checked for space availability and distance to deep waters for each of the locations. Associated Civil quantities for each option are provided for CAPEX based on the location and accessibility to the deep sea.

Channel lengths are based on the existing intake facilities at Mirfa. Studies are conducted on eMAPs for space availability and the same shall be further developed during FEED after conducting the Bathymetric Survey at each of the final selected locations.

Further to that, for SRP plant locations, each location is studied on eMAP for plot availability, access to site, and grading requirements. Civil inputs for split plants and Central plants are worked out and provided for CAPEX estimation. During FEED, actual surveys (Topographic, Underground detection, Geotechnical etc.) shall be undertaken at all locations of selected option to complete the FEED level of engineering

With all above identified options, a screening workshop was conducted. Options drivers / criteria were defined and weightage for each criteria was agreed with the forum members. Option drivers / criteria definitions are given in below table:

Table-7.1-2: Component-1 Drivers / Criteria definitions

Drivers / Criteria	Definitions
CAPEX	CAPEX includes Pipeline length, intake channels, reject outfall, Treatment plant, etc
OPEX Energy consumption	OPEX includes energy consumption due to different lengths and different loads (SRP @ field is pumping 25%-30% additional water to the field). Further, maintenance of single or multiple facilities are also weighed in this criteria.
HSE (Health, Safety and Environment	This includes improvement in environmental impact due to decrease in reject discharge, NORM (for SRP at Field)
Plot Availability	for current phase and future extensions
Scaling	Scaling in the pipeline or disposal well (as in SRP @ field)
Sea / Reject Water Availability	Ruwais and Mirfa are potentially utilizing reject water and therefore its reject water continuous availability is a factor
Risks	including utilities, interface with other organisations, available reject water possible quantity and quality variations, etc
Availability	Impact of operating single facility to handle all fields vs multiple (split) facilities.

These drivers were weighed against each option for the purposes of screening during the workshop and is given in below in table 7.1-3.

Table 7.1-3: Options Ratings

Driver/Criteria	%	Central Ruwais			Central Mirfa			Central Dy			Split Ruwais/Dy			Split Mirfa/Dy			Split -SRP Ruwais/Dy			Split - SRP Mirfa/Dy		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
HSE	20	🟢	5	20	🟢	4	16	🟡	3	12	🟡	3	12	🟡	3	12	🔴	0	0	🔴	0	0
(CAPEX)	15	🔴	1	3	🔴	2	6	🔴	2	6	🟢	4	12	🟢	5	15	🟢	4	12	🟢	5	15
(OPEX)	25	🔴	1	5	🔴	1	5	🔴	1	5	🟡	3	15	🟢	4	20	🔴	2	10	🟡	3	15
Risks (Utility, interface, quality)	15	🟡	3	6	🟢	4	12	🟢	5	15	🟡	3	9	🟢	4	12	🟡	3	9	🟢	4	12
Plot Availability	5	🟡	3	3	🟢	4	4	🟢	5	5	🟡	3	3	🟢	4	4	🔴	4	4	🟢	4	4
Sea/Reject Water Availability	5	🟡	3	3	🟢	4	4	🟢	5	5	🟡	3	3	🟢	4	4	🟡	3	3	🟢	4	4
Scaling	5	🟢	5	5	🟢	5	5	🟢	5	5	🟢	5	5	🟢	5	5	🔴	1	1	🔴	1	1
Availability	10	🟡	3	6	🟡	3	6	🟡	3	6	🟢	5	10	🟢	5	10	🟢	5	10	🟢	5	10
Ranking	100	🔴	51		🔴	58		🔴	59		🟢	69		🟢	82		🔴	39		🔴	51	
Ratings		**0** Unacceptable			**1** Very Poor			**2** Poor			**3** Average			**4** Good			**5** Very Good					

It is important to note that there is potential of Naturally Occurring Radioactive Materials (NORMs) formation due to the high content of sulphur in the seawater and the potential reaction of this compounds creating potential NORM scale deposition in the flow lines, well head injection tubing and other elements.

Based on similar seawater treatment experience in ADNOC offshore concurrent with long term sea water injection, NORM formation creates an environmental and health concern. In order to control this potential NORMs formation, the location of the SRU shall be taken into consideration. From an environmental point of view, it is not acceptable to re-inject the outfall brine in other reservoirs at the field where further transportation and disposal is mandated. On the other hand, it is acceptable to discharge the SRU outfall into the sea considering proper dispersion of the brine in appropriated area as per the environmental emission limits. If SRU is installed at the fields additional transfer lines back to the sea or complex waste management system shall be required and therefore option of installing SRP at field is not acceptable and accordingly rejected by CHSE.

During the workshop, an additional option to pump the reject water from Ruwais to Mirfa was identified. With the remaining injection requirement to be met by fresh seawater taken from Mirfa. The treatment plant will be located at Mirfa and then it will be pumped to fields (BAB and BuHasa). This option was dropped due to the additional 100km of pipeline (from Ruwais to Mirfa) and the envisioned very high OPEX. Further, when Intake and Treatment Plant can be built at Ruwais, therefore the additional 100 km pipeline and pumping is not justified. A separate rating was performed and following results in Table 7.1.4 were found.

However, vendors feedback on the utilization of reject water from Ruwais reject water is being communicated in order to evaluate the merits and de-merits of utilizing highly saline reject water in the design of the ADNOC Onshore SWTP. Received Vendor feedback is that a pilot is required to test the impact of using reject water due to its high level of hardness which may cause scaling the SRU membranes.

Table 7.1-4: Ruwais reject water to Mirfa option evaluation

Driver/Criteria	%	Split - Ruwais/Mirfa/Dy		
			Rating	Wtage
HSE	20	🔴	5	20
(CAPEX)	15	🟢	1	3
(OPEX)	25	🟡	1	5
Risks (Utility, interface, quality)	15	🟢	3	9
Plot Availability	5	🟢	3	3
Sea/Reject Water Availability	5	🟢	4	4
Scaling	5	🔴	5	5
Availability	10	🟢	5	10
Ranking	100	🔴	49	

Component-1 Screening Results

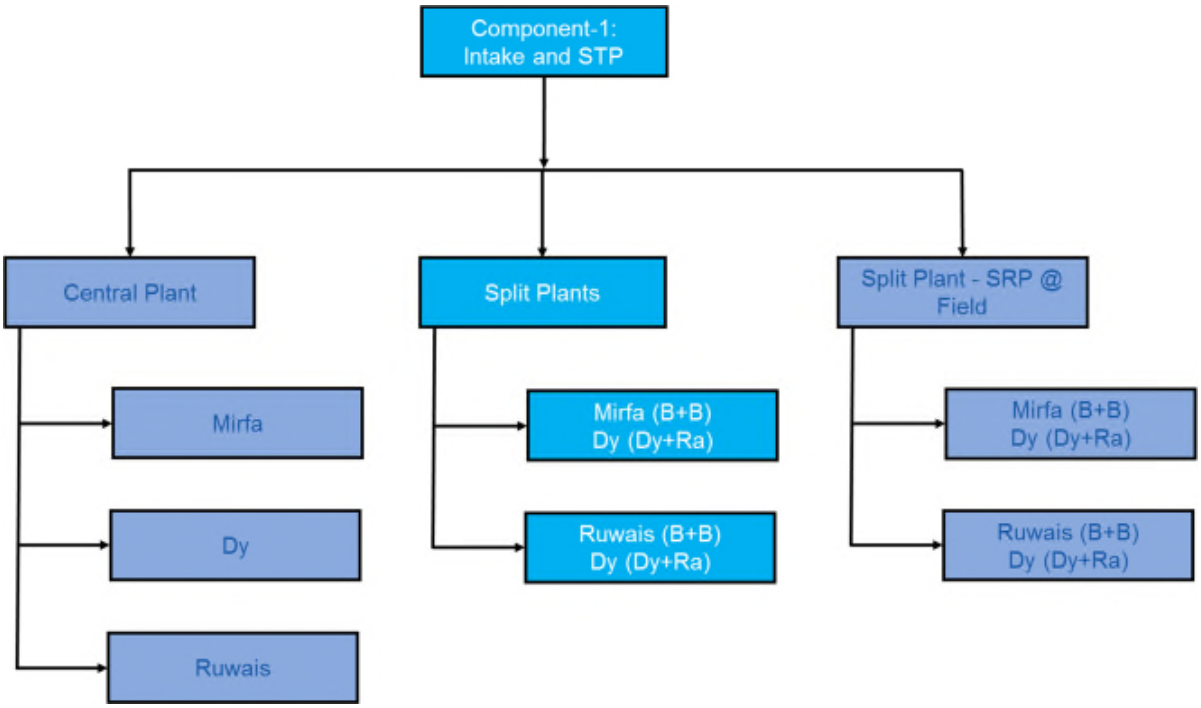
Based on the criteria in table 7.1-2, the following has been concluded:

- Based on the above evaluation, Central Plant Options and Split Plant with Sulphate Reduction Plant (SRP) at field are screened out.
- Split plant with SRP near inlet will move forward to the concept selection stage. Split Plants options to be studied further are listed below;
    - Split Mirfa/Dy – Mirfa Sea Water Treatment Plant for Bab and BuHasa fields injection requirements and Dabbiya Sea Water Treatment Plant for Dabbiya and Rumaitha fields injection requirements
    - Split Ruwais/Dy – Ruwais Sea Water Treatment Plant for Bab and BuHasa fields injection requirements and Dabbiya Sea Water Treatment Plant for Dabbiya and Rumaitha fields injection requirements

7.2 Component-1 – Location & Treatment Plant: Option Selection

Based on the option screening workshop, the following are the options for further evaluation and selection;

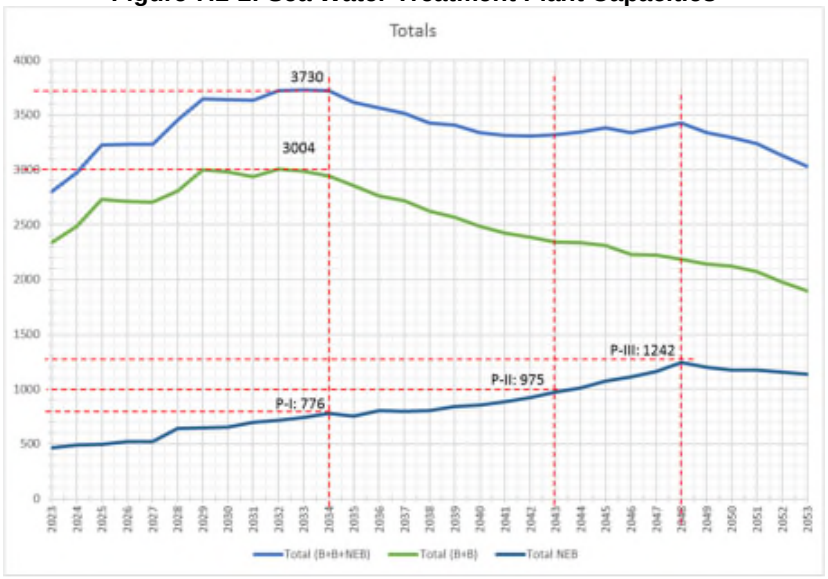
Figure 7.2-1: Options for Selection Stage



Seawater Treatment Plant

The seawater treatment plant looks to treat intake seawater whilst meeting the TSS, sulphates removal and de-aeration requirements. The required capacity of the plants is given in below graph:

Figure 7.2-2: Sea Water Treatment Plant Capacities



Accordingly, the capacity requirement for both plants are given below:

Table 7.2-1: Seawater Treatment Plant Capacity

Location	Capacity BWPD		
	Maximum	Minimum	Turndown
At Mirfa / Ruwais	3,004,000	1,895,000	50%
Dabbiya (Note-1)	1,242,000	464,000	50%

Note-1: Considering NEB sea water injection demand

Seawater is pumped using the Seawater Lift Pumps and directed to the seawater treatment system. The raw seawater is chlorinated via the electrochlorination package and introduced into the seawater lift pump suction lines. Sodium hypochlorite is used to limit the potential of biological activity in the downstream processes.

Each of the seawater treatment packages will have dedicated auxiliary equipment (Cleaning-In-Place and dosing system). Feed from Lift Pumps is sent to automatic back-washable seawater coarse strainers to remove larger particulate matter. This stream is directed to Ultrafiltration (UF) pre-treatment. The UF Membrane System treats the Sulphate Reduction Plant (SRP) feed water to remove the majority of particles.

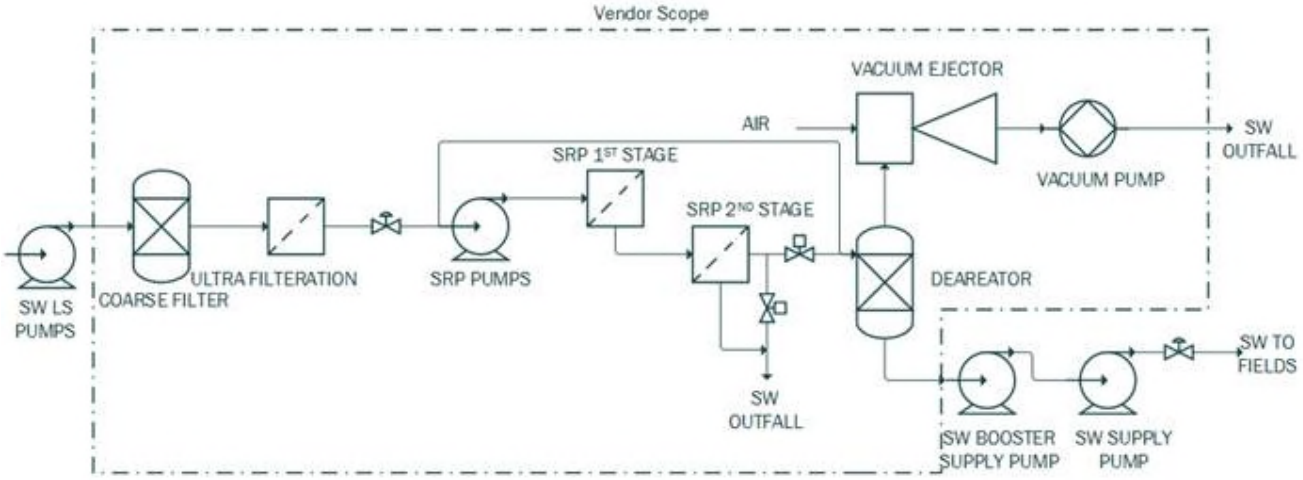
This UF-filtered seawater is routed to the suction of the SRP Feed Pumps to boost the conditioned water to the required feed pressure for the membranes. The SRP Feed Pumps operate in parallel. Anti-scalant is dosed into the common suction piping of the SRP Feed Pumps, decreasing the scaling tendency by limiting the formation of sparingly soluble salts in the membrane system. A non-oxidizing biocide for treating the sulphate membranes is also periodically batch dosed into the common suction piping of the SRP Feed Pumps. Finally, Sodium Bisulfite [SBS] is also dosed into the common suction piping of the SRP Feed Pumps to remove the residual chlorine present in the seawater to prevent irreparable damage to the Sulphate Membranes.

The seawater flows to parallel operated SRPs. The feed pressure to each SRP is controlled based on the permeate flow set point. The SRP produces 75% of the feed flow as low sulphate permeate Seawater. The low sulphate SW from each SRP is merged and then directed to the deaerator. The remaining 35% of the feed flow ends up as high sulphate content reject seawater and is directed to effluent reject pit to be equipped with effluent pump. A bypass is provided across the SRP pumps and trains to provide a blending line in order to achieve the required Sulphate levels in the product seawater.

The treated seawater then enters the Vacuum Deaerator to remove dissolved oxygen from the water. Oxygen scavenger is dosed to the sump of the deaerator to chemically reduce the remaining oxygen further to the required levels.

Deaerated, low sulphate injection water from the deaerator is routed to the Supply Pumps. Figure 7.2-3 shows the typical process flow for the seawater treatment plant.

Figure 7.2-3: Sea Water Treatment Plant schematic



There is a membrane Cleaning-In-Place (CIP) system for the SRP (NF) and UF trains. The CIP Tanks capacity shall be minimum designed for the 1st stage of SRP membranes or 1 train of UF membranes wash (if applicable). CIP Pumps and cartridge filter shall be minimum designed for cleaning of 1st stage of 1 SRP train. One CIP Heater is provided for each CIP tank and shall be sized to heat up cleaning solution volume within 2 hours. Each CIP tank volume shall be sufficient to wash 1 membrane train (largest consumption - UF or SRP). Chemically Enhanced Backwash (CEB) can also be provided for the automatic cleaning of the ultrafiltration membranes and SRP nano-filter membranes.

It should be noted that ADNOC Offshore West Island Project has been used as basis for preliminary plot plan, equipment sizes and other details. Additional details have been obtained from specialized seawater treatment package vendors. Further optimization will be performed during the FEED stage. Various vendors were contacted for obtaining technical proposals on the design scheme of the seawater treatment plant. Various criteria are considered for the evaluation and comparison of the various vendor technical offers:

a. Fulfilment of design specifications
b. Vendor Experience and installed references
c. Thorough technical proposal and description of the treatment technologies with submission of key documents (PFDs, GA, equipment list, etc).
d. Compliance with reject disposal requirements.
e. Sparing philosophy of trains.
f. CAPEX
g. OPEX of various elements (manpower, electrical power, maintenance, chemicals, spare parts) in $/BBL of treated seawater.
h. Installation and operating philosophy.
i. Compliance with Shell Design DEP 39.01.40.30-Gen.
j. Plot plan and space requirements
k. Downtime and replacement frequency of equipment
l. Specific reject water treatment requirements.

A comprehensive comparison has been conducted for the inputs of various treatment package vendors' technical aspects and compliance with the above-mentioned criteria. Refer to Appendix-C for the comparison matrix.

For option selection of Component-1, it is important to understand that the supply network (Component-2) has a significant impact on Component-1 option selection, therefore, following assumptions are made for the supply pipelines:

- Carbon Steel as MOC for supply pipelines
- Single Pipeline for total flow
- No intermediate pumping
- Fixed speed pumps

Note that these assumptions are made to facilitate the selection of Component-1. Supply network (Component 2) will have its own option screening and selection.

Dabbiya Sea Water Treatment Plant

As described earlier, Dabbiya is located at shore-edge; a footprint allocation study has been established for the intake and plant location. The location for proposed seawater intake structure and Seawater Treatment Plant (SWTP) are studied with stakeholders including Engineering, Development and Operations and following is agreed:

- The Intake structure and lift station shall be on reclaimed land.
- SWTP plant and its future expansions a will be around 500 m away from the intake and shall be on the mainland.

Below schematics indicates seawater intake system and plant location at Dabbiya.

Figure 7.2-4: Dabbiya Plant schematic

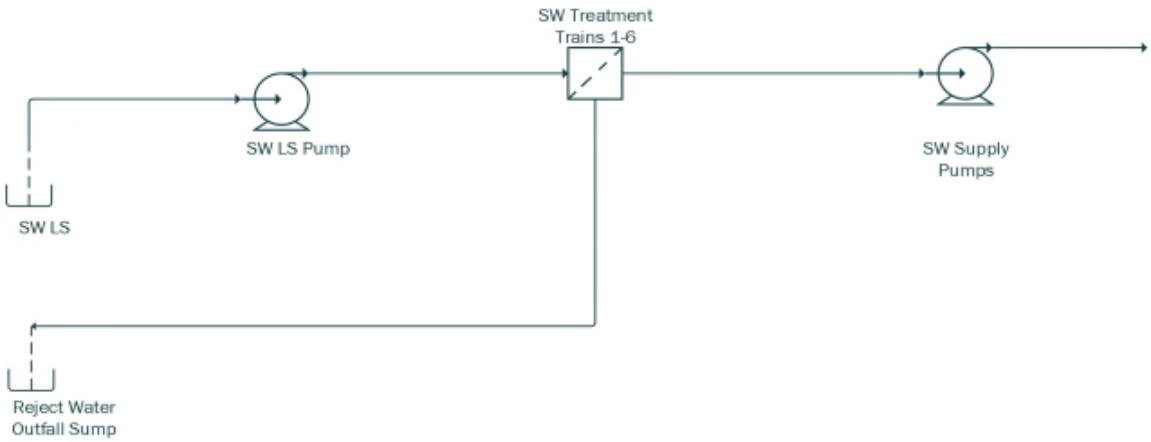


Figure 7.2-4 shows the schematic for Dy Seawater Treatment Plant. The fresh seawater is collected in Seawater Lift Station and pump to the Treatment Trains. The treated water is pumped to Dabbiya and Rumaitha fields via SW Supply Pumps.

Figure 7.2-5: Layout for Dy SWTP



To establish treatment plant sizes, a multidisciplinary study has also been carried out and a plot plan sketch is established. Plot plan sketch is provided in Appendix-B to show the trains' plot arrangement. The design has also considered future footprint requirements for South East facilities.

At this stage, preliminary sizes of equipment's are taken from ADNOC Offshore design, as a reference. However, equipment's are set with ADNOC Onshore design requirements. Vendor's data will be incorporated during Concept Design.

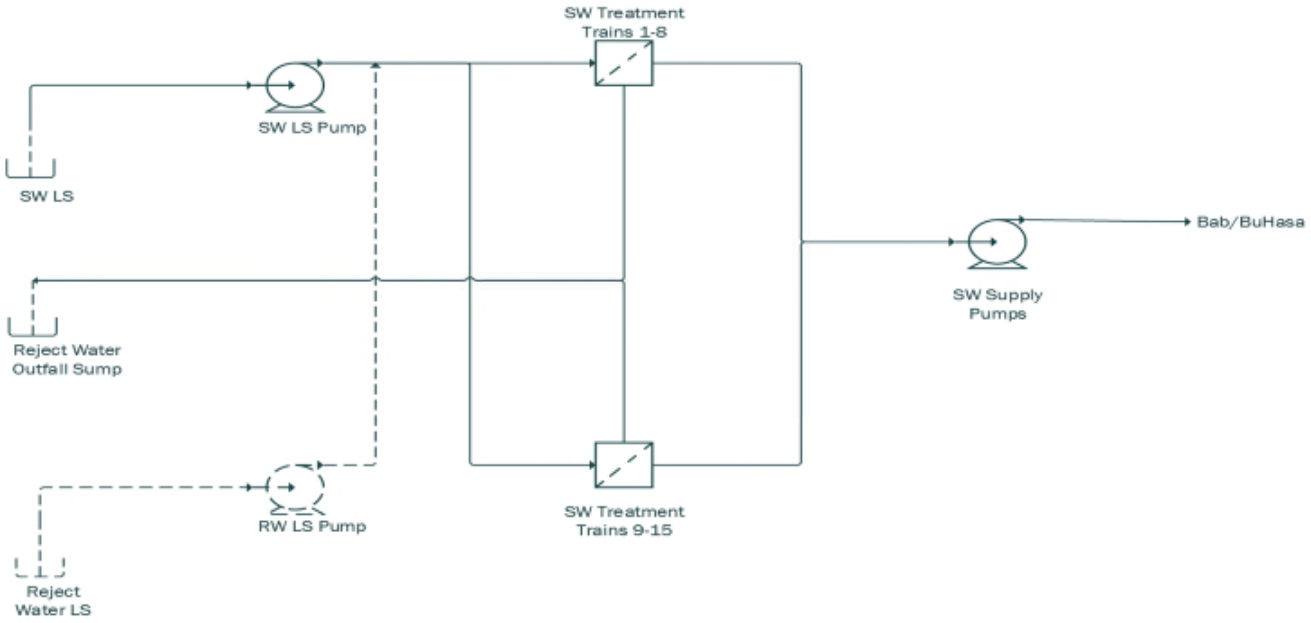
Mirfa Sea Water Treatment Plant

An engineering study has also been done to develop footprint requirements for the treatment plant as well as the intake system etc. at Mirfa. The intake and SWTP will be linked by pipelines as per the site constraints.

Civil works are estimated for CAPEX calculations. Below schematic is an illustration, presenting overall arrangement of intake facilities and treatment plants.

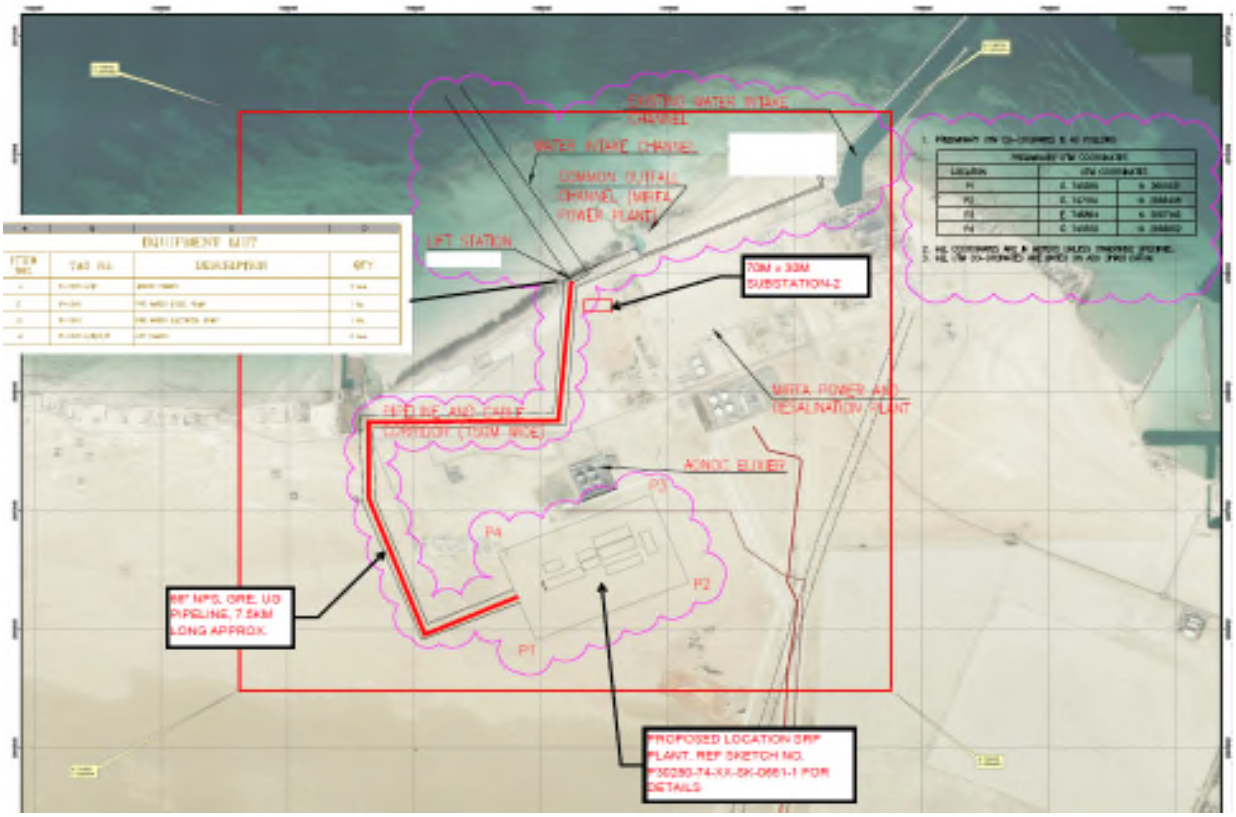
It is important to highlight that Mirfa is located outside ADNOC Onshore concession.

Figure 7.2-6: Mirfa Plant schematic



It can be seen from Figure 7.2-6 that the fresh seawater from Lift Station (LS) is supplied to the treatment trains and will be pumped to fields by Supply Pumps.

Figure 7.2-7: Layout for Mirfa SWTP



After a multidsciplinary study, plot plan sketch has been developed for the SWTP facilities. Appendix-B shows overall facilities arrangements.

Seawater from Intake channel is provided to transport water from intake station to treatmant plant at Mirfa. The required pipeline size is 66" (1 no). The design pressure in this intake supply pipeline will be low, which makes GRE material suitable. Pipeline will be routed under ground from lift station to plant, routing length will be 7.5 km from sea. Pipeline will have buried installation. The route corridor will be outside the existing power plant fence in Mirfa.

Ruwais Sea Water Treatment Plant

Treatment plant facilities requirement at Ruwais is similar to Mirfa except known reject water availability from RRE-GUP (Ruwais refinery east). Below schematic illustrates overall arrangment for the treatment facilities and water intake system from sea & reject water.

Proposed area in Ruwais is not in the ADNOC-Onshore concession. Ruwais plant schematic is given below in figure 7.2-8:

Figure 7.2-8: Ruwais Plant schematic

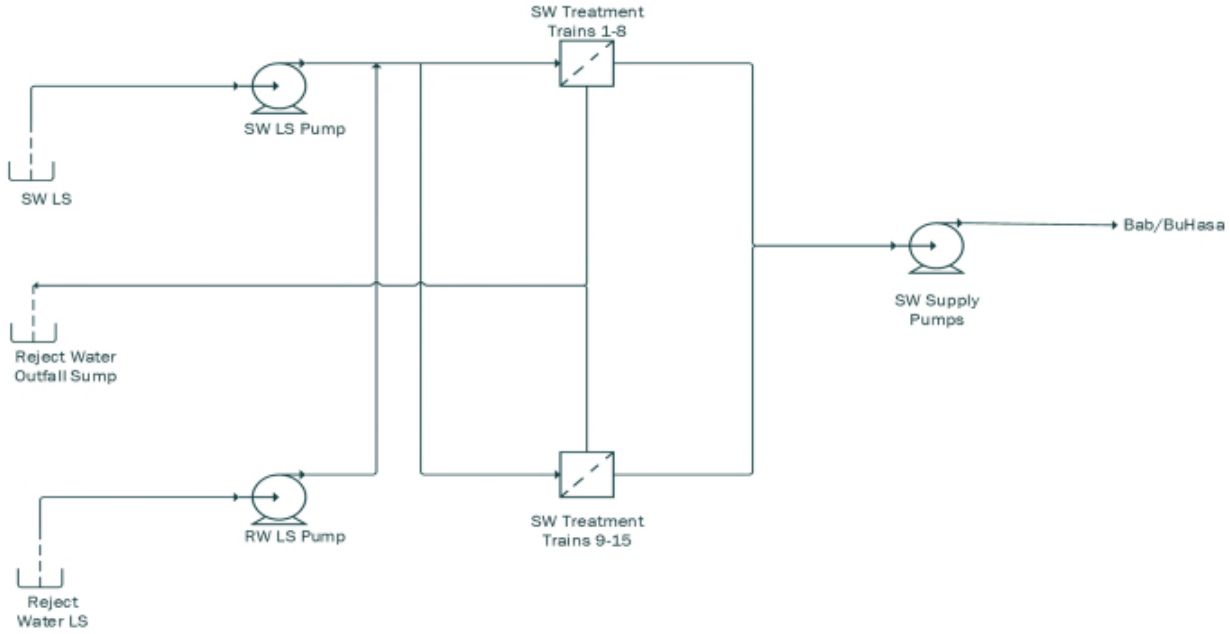
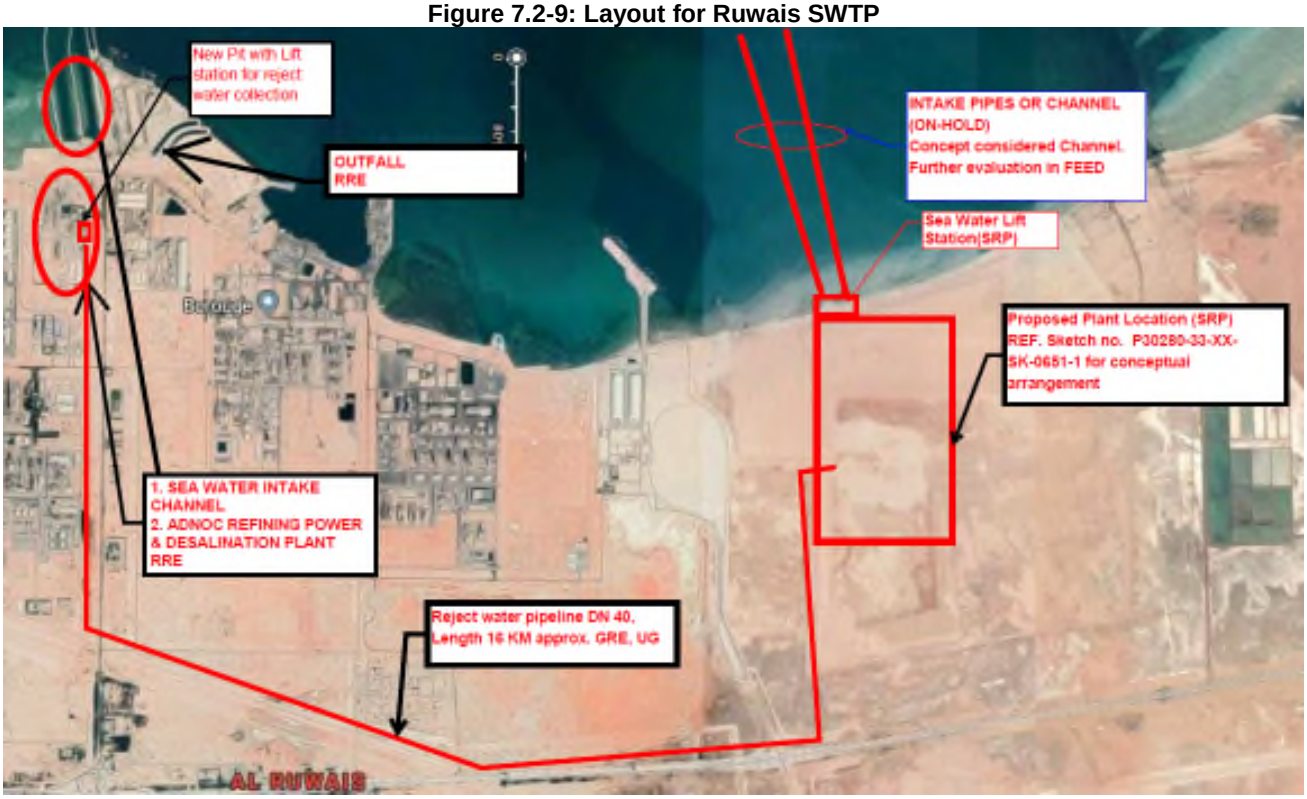


Figure 7.2-8 shows that reject supply is from Ruwais reject water and remaining is from fresh sea water. The reject water will be collected in a new / existing (provided there is space available for new pumps). The fresh sea water from intake is collected in lift station and pumped to the treatment plant via Lift Pumps. The flow from the sources is sent to the treatment trains (consists of filtration and dearation). The treated water is finally sent to the fields via supply pumps.

Figure 7.2-9: Layout for Ruwais SWTP



Same basiss as addressed earlier (for Mirfa & Dabbiya), has been considered to establish footprint sizes for treatment plant facilites. Appendix-B shows overall facilities' arrangements.

The reject water from Ruwais Refinery East (RRE) to proposed treatmant plant at Ruwais is supplied by 16km 40" pipeline. GRE is considered since design pressure of intake supply pipeline is in an acceptable range. GRE Pipeline will be routed burried from RRE to the treatment plant facilities i.e. 16 km long and after processing will be further transported to the respective fields as part of Component-2.

Electrical requirements for both Split Plant Options of Mirfa/Dy and Ruwais/Dy are provided in below table:

Table-7.2-3: Electrical Requirements for Both Split Plant Options

	Mirfa / Dy	Ruwais / Dy
Power Source	Mirfa 220kV substation by TRANSCO through 220kV UG cable / DY – 33kV OHL	Ruwais 220kV substation by TRANSCO through 220kV UG cable / DY – 33kV OHL
Power Demand	Mirfa - 120MVA DY - 60MVA	Ruwais - 120MVA DY - 60MVA
OHL Requirement	Mirfa - 220KV UG cable(1Km) DY - 33KV OHL (18Km)	Ruwais - 220KV UG cable(1Km) DY - 33KV OHL (18Km))
No. & Size of Substations	Mirfa : • 220KV Component (84m*76m • 33KV SS-1 (50m*30 m) • 11KV SS-2 (30m*70m • 11KV SS-3 (30m*70m) • 8 No. of 3.3KV substations (40mx20m) DY : • 33KV SS-1 (45m*30m) • 11KV SS-2 (30m*55 m) • 11KV SS-3 (30m*55m) • 3 No. of 3.3KV substations (40mx20m)	Ruwais : • 220KV Component (84m*76m • 33KV SS-1 (50m*30 m) • 11KV SS-2 (30m*70m • 11KV SS-3 (30m*70m) • 8 No. of 3.3KV substations (40mx20m) DY : • 33KV SS-1 (45m*30m) • 11KV SS-2 (30m*55 m) • 11KV SS-3 (30m*55m) • 3 No. of 3.3KV substations (40mx20m)
Electrical Equipment Required	Mirfa • 220/33KV TR (120MVA) • 33KV HSWG • 2 # 11kV switchgear through 50MVA step down transformer • 4 # 415V switchgear through step down transformer DY : • 33kV Switchgear • 2 # 11kV switchgear through 40MVA • 4 # 415V switchgear through step down transformer	Ruwais • 220/33KV TR (120MVA) • 33KV HSWG • 2 # 11kV switchgear through 50MVA step down transformer • 4 # 415V switchgear through step down transformer DY : • 33kV Switchgear • 2 # 11kV switchgear through 40MVA • 4 # 415V switchgear through step down transformer

For both split plant options, telecommunication systems shall be provided for all new locations and shall comply with ADNOC onshore standards and procedures allowing a reliable communication to establish from central plant in Ruwais, Mirfa and Dabbiya and extended to Component-2 (Supply Line) and Component-3 (In-Field Distribution).

Telecommunication systems selection shall meet the project HSE and other operational requirements which include data, voice and video transfer.

CAPEX and OPEX Cost estimates for both options are presented below in Tables 7.2-4 and 7.2-5:

Table 7.2-4: EPC Costs, MMUSD

Item Description	Mirfa/Dy	Rw/Dy
Intake + STP	1,648	1,677
Pipelines (C2)	227	354
Total	1,875	2,031

Table 7.2-5: Energy Costs

Item Description	Mirfa	Ruwais
30Y Energy Cost	543	704

Similar option drivers / criteria were used for both split plant options with the exception of scaling factor. Scaling is not an applicable as both of the two options have desulphated streams transported to the fields via the supply pipeline.

The rating for each option is provided below in Table 7.2-6:

Table 7.2-6: Options ratings

Driver/Criteria	%	Split Ruwais/Dy			Split Mirfa/Dy		
			Rating	Wtage		Rating	Wtage
HSE	20	🟡	3	12	🟢	4	16
(CAPEX)	20	🟢	4	16	🟢	5	20
(OPEX)	25	🔴	2	10	🟢	4	20
Risks (Utility, interface, quality)	15	🟡	3	9	🟢	4	12
Plot Availability	5	🟢	4	4	🟢	4	4
Sea/Reject Water Availability	5	🟢	4	4	🟢	4	4
Scaling	0	🟢	0	0	🟢	0	0
Availability	10	🟢	5	10	🟢	5	10
Ranking	100	🟢	65		🟢	86	
Ratings		**0** Unacceptable			**1** Very Poor		
		2 Poor			**3** Average		
		4 Good			**5** Very Good		

Component-1 Option Selection Conclusion:

Based on the evaluation, split plant at Mirfa and Dy is selected. Mirfa Sea Water Treatment Plant will supply the treated seawater for Bab and Bu Hasa fields' injection requirements and Dabbiya Sea Water Treatment Plant will supply for Dabbiya and Rumaitha fields injection requirements.

8.0 Component-2: Supply Network

8.1 Component-2 – Supply Network: Option Identification

Note: Initially Project Wave considered the replacement of aquifer water with seawater for only NEB, BAB and Bu Hasa Fields. South East was included at a later stage of the project to give a holistic view for Seawater Injection in ADNOC Onshore fields. South East was not considered in the evaluation of this Component however, subsequent evaluation was conducted based on the concluded options. This is available in Section 12.

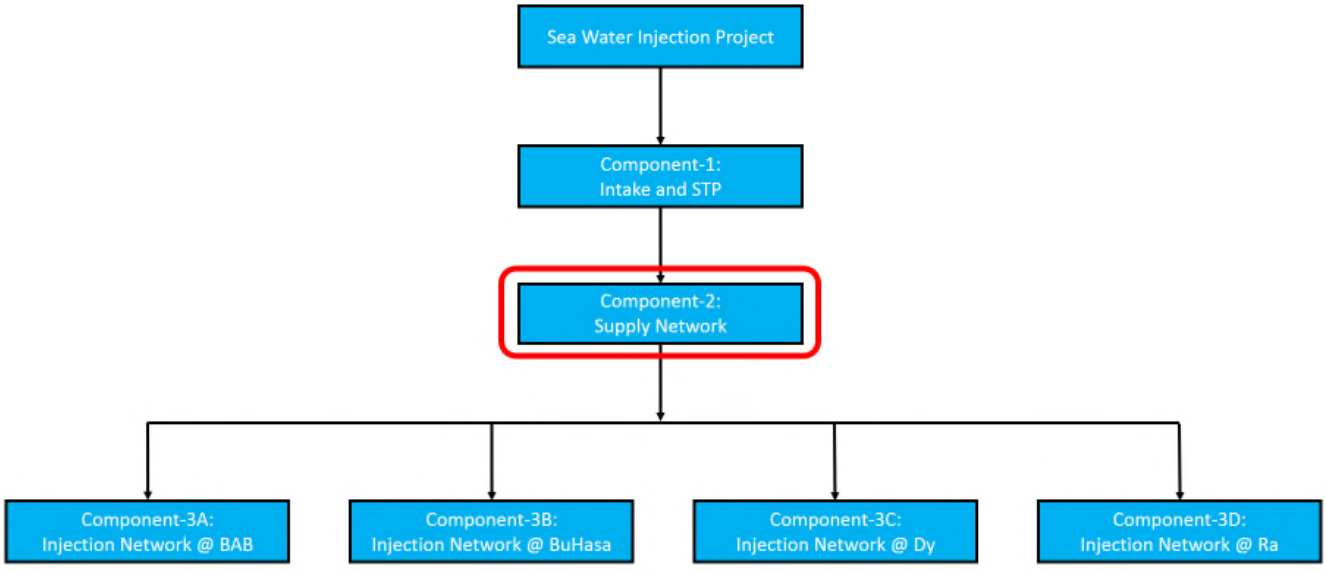
Component-2 mainly deals with pipeline arrangement, boosting pumping station and materials of construction of sea water supply network.

The battery limit of this component starts from the outlet of the seawater treatment plant (downstream the booster and supply pumps) and terminates at the inlet of the receiving fields.

Supply networks under this component are following;

1. Mirfa SWTP supplying to Bab and Bu Hasa
2. Dy SWTP supplying to Dy and Ra

Figure 8.1-1: Project Components

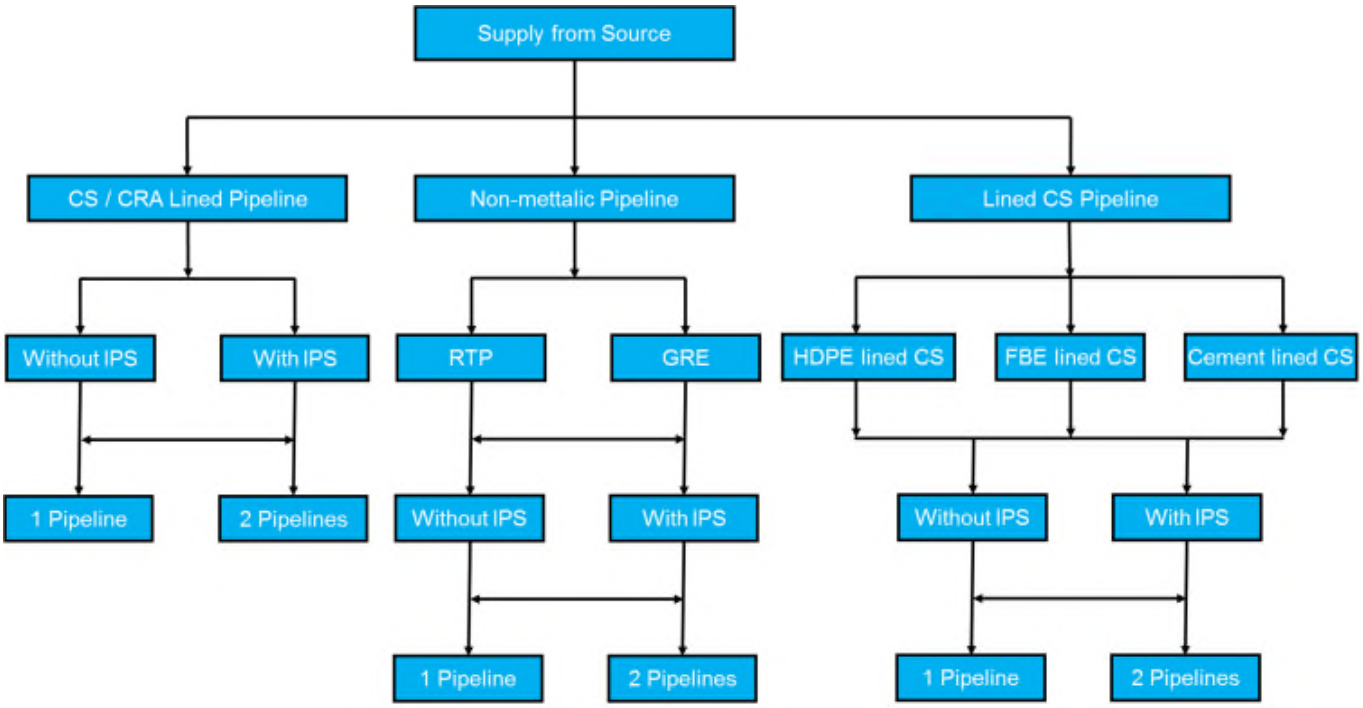


The variables for the supply networks options are listed below:

- Supply with single or parallel pipelines.
- Requirement of Intermediate pumping station to supply to the fields.
- The Material of Construction selection of the supply pipeline, both metallic and non-metallic materials are studied for the supply lines.

Option tree for Component-2 is given below:

Figure 8.1-2: Option Tree for Component-2



The identified options for the supply network are listed as below;

1. MOC without IPS and one pipeline
2. MOC without IPS and two pipelines
3. MOC with IPS and one pipeline
4. MOC with IPS and two pipelines

Similarly, the same options will be driven with different material of construction. Following material construction are identified for the supply network:

1. Metallic:
    a. Carbon Steel (CS)
    b. Carbon Steel with CRA Lining
2. Non-Metallic:
    a. RTP
    b. GRE
3. Metallic with non-metallic lining
    a. HDPE lined Carbon Steel
    b. FBE lined Carbon Steel
    c. Cement Lined Carbon Steel

All material were assessed for the service and requirements and their analysis is presented below in table 8.1-1.

The pipeline will have typical length in all the identified options for supply network from Mirfa and Dabbiya. However, the pipeline size and number will vary according to material of construction, with or without intermediate pumping station and process hydraulics which are driven by the pipeline size limitations and pressure limitations as applicable.

The non-metallic pipeline options will have a greater number of pipelines than carbon steel option, due to pressure limitation of non-metallics. The pressure holding capacity of non-metallic decreases with increase in size.

Table 8.1-1: Comparison table among Component-2 evaluated pipeline configurations

	Parameter Description	Pipeline Material Options							
		Carbon Steel	CS + CRA Lined	RTP	GRE	CS + Internal FBE lined	CS + Internal HDPE lined	CS + Internal Cement lined	Remarks
Market Availability	**Pipeline Size /Pressure availability**	LSAW ≤ 60” DSAW > 60”	Max 26"-28’’, no pressure limitation	Max. 4’’- 140 barg 6’’- 98 barg	52"- 16 barg	Not a concern	56"- 75 barg	Not a concern	Refer vendor catalogue for size vs pressure variance
Design Data	**Project Pipeline Sizes**	64"	64"	64"	30"/40"	64"	52"	64"	
	Temperature limitation	Not a concern	Not a concern	Based on the Structure Layer and Inner liner: SHELL: -30 ~95C	50 Deg.C	120 Deg.C for FBE	65 Deg.C	Not a concern	
	Jointing	Welded	Welded	Butt Joint	Adhesive/ Lamination based on size	Welded	Flanged / Flange less joint (sleeved coupling)	Sleeve Welded	
	Additional Construction requirements	NA	Strict quality control for product & weld construction;	-	Supplier supervision	Internal FBE coating at Joint	Vendor recommends flange joints for higher sizes, for which concrete pit required for buried flanges	Quality control for product and wet surface requirement. Cement erosion concern.	Pipeline constructability challenges increases with increase in sizes (especially at crossings)
	Bends	Conventional	Conventional	Supplier Recommendation	Conventional	Conventional	Manufacturer recommendation	Manufacturer recommendation	
	Biocide	Required (batch/continuous)	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Biocide injection will be required to mitigate: a) DH equipment corrosion, and b) prevent reservoir injectivity problems as well as souring
Operational requirements	**Corrosion Inhibitors requirements**	Required	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	Not for the pipeline portion	CI injection will be required to mitigate DH equipment corrosion
	ILI Pig ability	Feasible	Not applicable	Not applicable	Not applicable	ILI possible. Scrapping not possible.	Not possible for the sizes and pressures in scope.	Not applicable	

8.2 Component-2 – Supply Network: Option Screening

With all above identified options and its analysis, a screening workshop was conducted. Option drivers / criteria definition with their weightage were identified and agreed with the forum members. Option drivers/ criteria's are given in below table;

Table-8.1-2: Component-2 Drivers / Criteria Definitions

Drivers / Criteria	Definitions
CAPEX	Due to material, no. of lines, intermediate pumping stations, chem. inj., disposal wells
OPEX	Costs due to friction factors of diff material, IPS, pigging costs, chemical inj., etc.
Area / Plot Availability	Due to IPS, pigging facility, additional chem inj.
Risks	Specialized Contractors for NM/lining, ADNOC Onshore lack of experience with lined CS, Subsurface requirements during the CS pigging, Leakage, non proven technology
Availability	1 line vs 2 lines (in case of CS pigging), additional IPS may have impact
Inspection	Piggability for integrity check (ILI)
Corrosion / Erosion	
Maintenance	Cleaning pig,
Constructability	Bending limitation for NM,
Other Limitations	Size, pressure, fabrication, lead time, repair/new connection

These drivers were weighed against each option for the purpose of screening during the workshop.

Table 8.1-3 for Metallic Pipeline Screening Rating

		Mettalic Pipeline																							
Driver/Criteria	%	CS W/o IPS + 1 PL			CS W/o IPS + 2 PL			CS W/ IPS + 1 PL			CS W/ IPS + 2 PL			CRA Lined + 1 PL +W/O IPS			CRA Lined + 2 PL + W/O IPS			CRA Lined + 1 PL +W IPS			CRA Lined + 2 PL + W IPS		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	15		3	9		5	15		3	9		4	12		3	9		5	15		3	9		4	12
(CAPEX)	20		5	20		3	12		3	12		2	8		4	16		2	8		2	8		1	4
(OPEX) - Energy	15		1	3		2	6		3	9		4	12		1	3		2	6		3	9		4	12
Maintenance	5		3	3		2	2		3	3		2	2		4	4		3	3		3	3		3	3
Risks	15		4	12		4	12		4	12		4	12		3	9		3	9		3	9		3	9
Area / Plot Availability	5		4	4		3	3		3	3		2	2		4	4		3	3		3	3		2	2
Inspection	5		5	5		5	5		5	5		5	5		5	5		5	5		5	5		5	5
Corrosion / Erosion	5		5	5		5	5		5	5		5	5		5	5		5	5		5	5		5	5
Other Limitation	10		5	10		5	10		5	10		5	10		0	0		0	0		0	0		0	0
Constructibility	5		5	5		5	5		5	5		5	5		3	3		3	3		3	3		3	3
Ranking	100		76			75			73			73			58			57			54			55	
Ratings		0 Unacceptable			1 Very Poor			2 Poor			3 Average			4 Good			5 Very Good								

The CRA lined pipeline has size limitation of maximum 26". Accordingly, this option is ruled out.

Rating evaluation for non-metallic is given in Table 8.1-4 below;

Table 8.1-4 for Non-Metallic Pipeline Screening Rating

		Non-Mettalic Pipeline																					
Driver/Criteria	%	RTP W/o IPS + N PL			RTP W/o IPS + N PL			RTP W/ IPS + 1 PL			RTP W/ IPS + 2 PL			GRE W/o IPS + 1 PL			GRE W/o IPS + 2 PL			GRE W/ IPS + 1 PL			GRE W/ IPS + 2 PL		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	0		3	0		5	0		3	0		4	0		3	0		5	0		3	0		5	0
(CAPEX)	30		0	0		0	0		3	18		2	12		3	18		3	18		3	18		2	12
(OPEX) - Energy	15		4	12		5	1		4	12		4	12		4	12		5	15		4	12		4	12
Maintenance	5		4	4		4	4		3	3		3	3		4	4		4	4		3	3		3	3
Risks	15		4	12		4	12		4	12		4	12		4	12		4	12		4	12		4	12
Area / Plot Availability	5		5	5		4	4		4	4		3	3		5	5		4	4		4	4		3	3
Inspection	5		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0
Corrosion / Erosion	0		5	0		5	0		0	0		5	0		5	0		5	0		5	0		5	0
Other Limitation	20		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0
Constructibility	5		3	3		3	3		3	3		3	3		4	4		4	4		4	4		4	4
Ranking	100		36			24			52			45			55			57			53			46	
Ratings		**0** Unacceptable			**1** Very Poor			**2** Poor			**3** Average			**4** Good			**5** Very Good							

It must be noted that RTP is available in maximum 6” size and hence it is screened out.

Table 8.1-5 for Metallic with Non-Metallic Lining Pipeline Screening Rating

		Lined CS Pipeline																											
Driver/Criteria	%	Lined HDPE W/o IPS + 1 PL			Lined HDPE W/o IPS + 2 PL			Lined HDPE W/ IPS + 1 PL			Lined HDPE W/ IPS + 2 PL			FBE Coated W/o IPS + 1 PL			FBE Coated W/o IPS + 2 PL			FBE Coated W/ IPS + 1 PL			FBE Coated W/ IPS + 2 PL			Lined Cement W/o IPS + 1 PL			Lined Cement W/o IPS + 2 PL			Lined Cement W/ IPS + 1 PL			Lined Cement W/ IPS + 2 PL		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	15		4	12		5	15		3	9		4	12		4	12		5	15		3	9		4	12		4	12		5	15		3	9		4	12
(CAPEX)	20		3	12		2	8		2	8		1	4		3	12		2	8		2	8		1	4		3	12		2	8		2	8		1	4
(OPEX) - Energy	15		2	6		3	9		4	12		5	15		2	6		3	9		4	12		5	15		2	6		2	6		3	9		4	12
Maintenance	5		5	5		5	5		5	5		5	5		5	6		5	5		5	5		5	5		5	5		5	5		5	5		5	5
Risks	15		3	9		3	9		3	9		3	9		3	9		3	9		3	9		3	9		0	0		0	0		0	0		0	0
Area / Plot Availability	5		4	4		3	3		3	3		2	2		4	4		3	3		3	3		2	2		4	4		3	3		3	3		2	2
Inspection	5		0	0		0	0		0	0		0	0		5	5		5	5		5	5		5	5		0	0		0	0		0	0		0	0
Corrosion / Erosion	5		4	4		4	4		4	4		4	4		4	4		4	4		4	4		4	4		4			4			4			4	
Other Limitation	10		4	8		4	8		4	8		4	8		4	8		4	8		4	8		4	8		4			4			4			4	
Constructibility	5		3	3		3	3		3	3		3	3		4	4		4	4		4	4		4	4		4	4		4	4		4	4		4	4
Ranking	100		63			64			61			62			70			70			67			68			43			41			38			39	
Ratings		**0** Unacceptable			**1** Very Poor			**2** Poor			**3** Average			**4** Good			**5** Very Good																			

Cement lined carbon steel is screened out due to possible erosion and subsequently damaging reservoirs. This is as per the experience and known cement lined failures in ADNOC Onshore.

HDPE lined CS is rated low in ‘’Other Limitation’’ since for larger sizes proven references are unavailable and challenges in repair are envisaged due to limitation of In-Line Inspection (ILI) piggability. For HDPE pipeline material, for a large size pipeline of 42’’, maximum pressure cannot exceed 16 barg which doesn’t suit the hydraulic system of Component-2., Refer to Appendix-D for vendor’s feedback on pipeline metallurgy.

For supply pipelines, various material options were identified for application e.g. carbon steel, carbon steel with HDPE lining, carbon steel with internal FBE lining, GRE pipeline etc. For non-metallic pipes, vendors were approached to obtain the pressure/temperature data, joint connection details, piggability limitations and cost data.

Applicable pipeline sizes, material in each identified option were studied and ranked against the criteria described above.

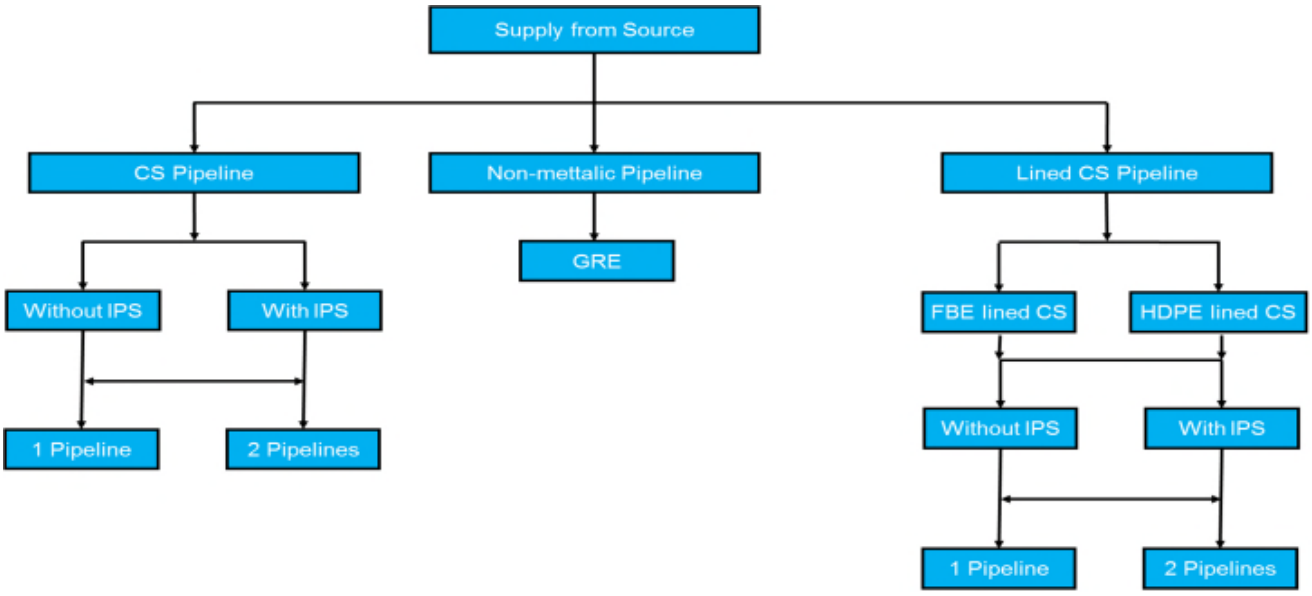
Conclusion of Component-2 Screening:

Following are the filtered concept options, which will be studied further for concept selection:

5. Carbon Steel with its pipeline and pump configuration
6. FBE coated Carbon Steel with its pipeline and pump configuration
7. HDPE Lined Carbon Steel
8. GRE Pipeline – a sensitivity case will be studied with GRE where number of pipelines will be increased in order to reduce the operating pressure to remain within the available design pressure limits. Refer to Appendix-D for GRE sizes versus design pressures.

Accordingly following is the option tree for the Option Selection Stage, which will be subject to further detailed concept study:

Figure-8.1-6: Single Pipeline without Intermediate Pumping

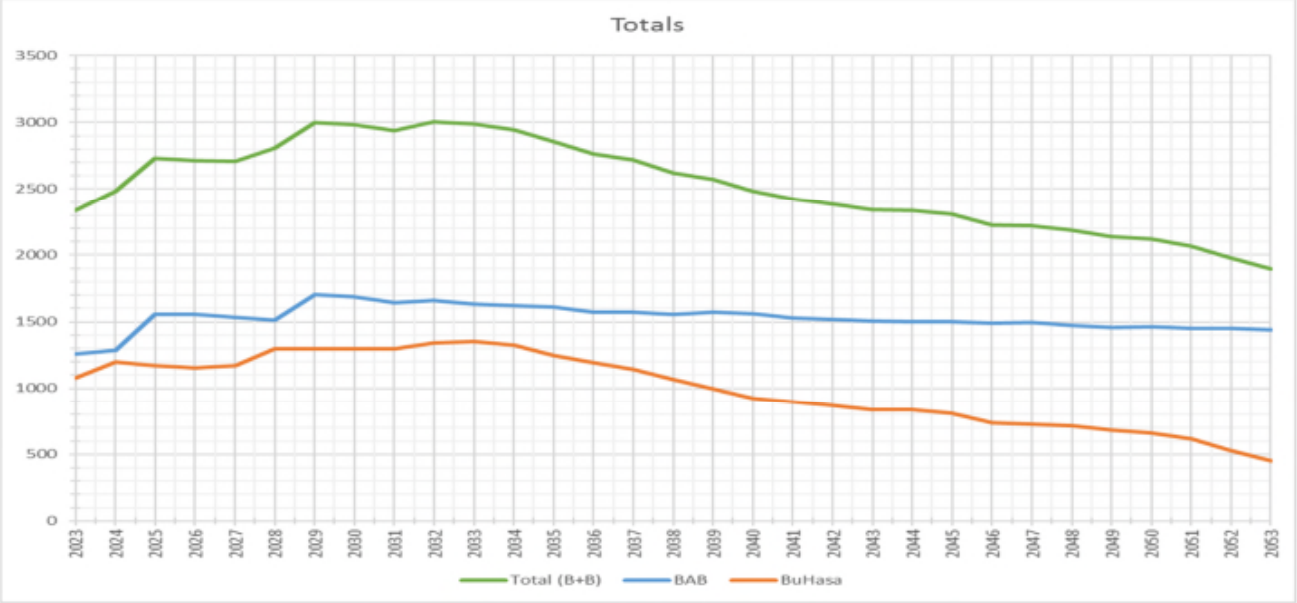


8.3 Component-2 – Supply Network: Option Selection – Mirfa Supply Network

This section describes the Option Selection for Mirfa to Bab and Bab to BuHasa configuration with Options defined in figure 8.1-6.

Mirfa plant capacity requirement, BAB and BuHasa injection profiles are provided in below figure;

Figure-8.2-1: Mirfa SWTP Requirements (BAB and Bu Hasa Injection Profile)



Lengths of pipeline are provided in below table;

Table 8.2-1: Mirfa supply pipelines length

Pipeline (To and From)	Length
Mirfa (STP) to Bab	40 km
Bab to Bu Hasa	45 km

The network configuration from Mirfa to Bab and BuHasa is provided in Figures 8.2-2 to 8.2-5:

Figure-8.2-2: Single Pipeline without Intermediate Pumping

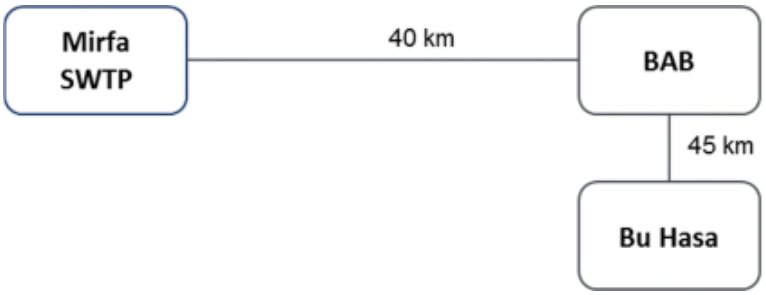


Figure-8.1-3: Multi-Pipeline without Intermediate Pumping

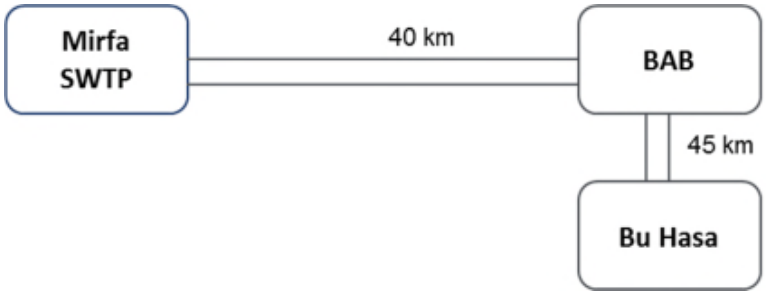


Figure-8.2-4: Single Pipeline with Intermediate Pumping

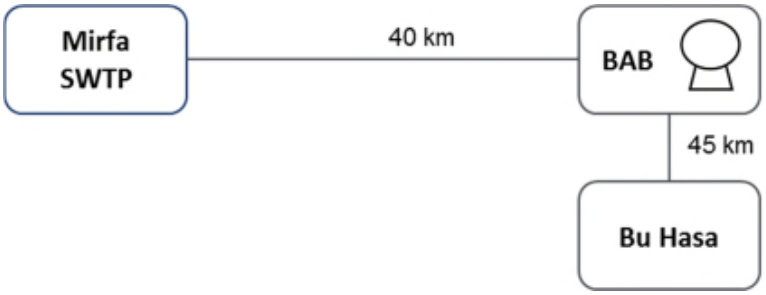
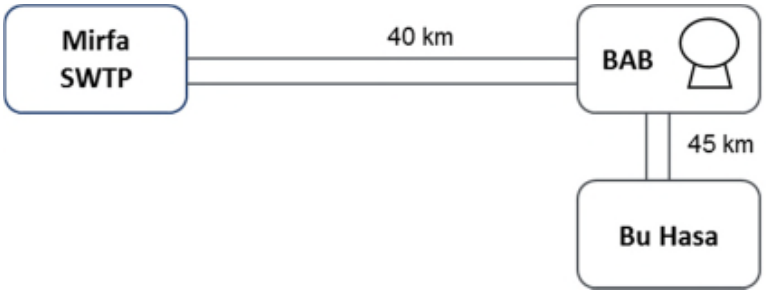


Figure-8.2-5: Multi-Pipeline with Intermediate Pumping



The Civil works associated with each of the option are provided, the major difference in Civil works is for providing intermediate pumping stations and inputs for CAPEX calculations are provided accordingly

Options Identified for Component 2 - Mirfa -Bab – Bu Hasa were subject to CAPEX analysis as well as lifecycle OPEX analysis with respect to chemicals and energy requirements as shown in table 8.2-2 below:

Table 8.2-2: Options Summary with EPC Cost (CAPEX) and OPEX

S.No.	Material	Mirfa to BAB	BAB to BuHasa	IPS	CAPEX MMUSD	% Increase	OPEX (Energy) MMUSD	% Increase	OPEX Chemical MMUSD	OPEX MMUSD	All Costs MMUSD
1	CS	64	48	No	390	7796	399	665	822	1221	1611
2	CS	60	48	No	383	7668	430	717	822	1252	1636
3	CS	60	40	No	506	10122	463	772	822	1285	1792
4	CS	2x48	48	No	428	8560	439	732	822	1261	1689
5	CS	2x42	48	No	410	8196	523	872	822	1345	1755
6	CS	2x48	2x36	No	478	9564	411	685	822	1233	1712
7	CS	64	48	Yes	384	7678	408	680	822	1230	1614
8	CS	60	48	Yes	377	7550	440	733	822	1262	1640
9	CS	2x48	48	Yes	422	8443	416	693	822	1238	1661
10	CS	2x42	48	Yes	404	8078	499	832	822	1321	1725
11	FBE Lined	64	48	No	402	8044	391	652	624	1015	1417
12	FBE Lined	60	48	No	395	7894	420	700	624	1044	1439
13	FBE Lined	2x48	48	No	449	8988	400	667	624	1024	1473
14	FBE Lined	2x42	48	No	466	9315	475	792	624	1099	1565
15	FBE Lined	64	48	Yes	420	8406	401	668	624	1025	1445
16	FBE Lined	60	48	Yes	413	8255	429	715	624	1053	1466
17	FBE Lined	2x48	48	Yes	467	9350	410	683	624	1034	1502
18	FBE Lined	2x42	48	Yes	446	8918	485	808	624	1109	1555
19	HDPE Lined	2x52	48	No	506	10120	390	650	624	1014	1520
20	HDPE Lined	2x48	48	No	482	9640	431	718	624	1055	1537
21	HDPE Lined	2x42	48	No	451	9020	544	907	624	1168	1619
22	HDPE Lined	2x52	48	Yes	524	10480	400	667	624	1024	1548
23	HDPE Lined	2x48	48	Yes	500	10000	440	733	624	1064	1564
24	HDPE Lined	2x42	48	Yes	517	10340	553	922	624	1177	1694
25	GRE	8x30	4x30	No	758	15157	400	667	624	1024	1782
26	GRE	6x30	3x30	Yes	667	13332	400	667	624	1024	1691

For above options:

- CAPEX is EPC cost
- OPEX Energy is pumping costs which is estimated based on the hydraulics of each pipeline category. The estimated energy OPEX figures are based on cumulative costs over project's design life.
- OPEX chemical is chemical consumption costs. For bare carbon steel, it is assumed that 20 ppm of Corrosion inhibitor is being injected at Mirfa and 5 ppm is being injected at each field. However, for non-metallic (lining or otherwise) 20 ppm injection is only performed at field side and no injection is being done at Mirfa plant. Similarly, for Biocide injection, it is assumed that 70 ppm and 25 ppm is injected at Mirfa and at field respectively for carbon steel. Whereas for non-metallic, biocide is only injected at field side. The cost for Corrosion inhibitor and Biocide is taken as 203 $/bbl and 254 $/bbl respectively.

A total of 26 Options were worked out with different metallurgy and configurations. However, these options were shortlisted with the following criteria:

- Low CAPEX options
- Low CAPEX+OPEX options

With above shortlisting following is the summary of selected cases with cost analysis as below:

Table 8.2-3: Shortlisted Options Summary with EPC Cost (CAPEX) and OPEX

S.No.	Material	Mirfa to BAB	BAB to BuHasa	IPS	CAPEX MMUSD	% Increase	OPEX (Energy) MMUSD	OPEX Chemical MMUSD	Total OPEX MMUSD	All Costs MMUSD
1	CS	64	48	No	390	103	399	822	1221	1611
2	CS	60	48	No	383	102	430	822	1252	1636
5	CS	2x42	48	No	410	109	523	822	1345	1755
7	CS	64	48	Yes	384	102	408	822	1230	1614
8	CS	60	48	Yes	377	100	440	822	1262	1640
10	CS	2x42	48	Yes	404	107	499	822	1321	1725
11	FBE Lined	64	48	No	402	107	391	624	1015	1417
12	FBE Lined	60	48	No	395	105	420	624	1044	1439
13	FBE Lined	2x48	48	No	449	119	400	624	1024	1473
15	FBE Lined	64	48	Yes	420	111	401	624	1025	1445
16	FBE Lined	60	48	Yes	413	109	429	624	1053	1466
19	HDPE Lined	2x52	48	No	506	134	390	624	1014	1520

Option selection workshop was arranged with all stakeholders. Table 8.2-4 provides the options' drivers/ criteria definitions:

Table 8.2-4: Option Drivers / Criteria

Drivers / Criteria	Definitions
Availability	1 line vs 2 lines (in case of CS pigging), additional IPS may have impact
CAPEX	Due to material, no. of lines, intermediate pumping stations, chem. inj., disposal wells
OPEX	Costs due to friction factors of diff material, IPS, pigging costs, chemical inj., etc.
Inspection / Maintenance	Piggability for integrity check (ILI), Cleaning pig,
Risks	specialized Contractors for NM/lining, ADNOC Onshore lack of experience with lined CS, Subsurface requirements during the CS pigging, Leakage, non-proven technology
Area / Plot Availability	Due to IPS, pigging facility, additional chemical injection
Constructability	HDPE liner installation and FBE sleeves, logistics and construction for size and number of lines,

The rating for each option is provided in table 8.2-5 below:

Table 8.2-6: Option Ratings Matrix

Case		1			2			5			7			8			10			11			12			13			15			16			19		
Material		CS			CS			CS			CS			CS			CS			FBE Lined			FBE Lined			FBE Lined			FBE Lined			FBE Lined			HDPE Lined		
Mirfa to BAB		64			60			2x42			64			60			2x42			64			60			2x48			64			60			2x52		
BAB to BuHasa		48			48			48			48			48			48			48			48			48			48			48			48		
IPS		No			No			No			Yes			Yes			Yes			No			No			No			Yes			Yes			No		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	10	●	4	8	●	4	8	●	5	10	●	4	8	●	4	8	●	5	10	●	5	10	●	5	10	●	5	10	●	5	10	●	5	10	●	4	8
(CAPEX)	35	●	5	35	●	5	35	●	4	28	●	5	35	●	5	35	●	4	28	●	4	28	●	4	28	●	2	14	●	3	21	●	4	28	●	2	14
(OPEX)	20	●	3	12	●	3	12	●	2	8	●	3	12	●	3	12	●	2	8	●	5	20	●	4	16	●	5	20	●	4	16	●	4	16	●	4	16
Maintenance / Inspection	5	●	5	5	●	5	5	●	5	5	●	4	4	●	4	4	●	4	4	●	4	4	●	4	4	●	4	4	●	4	4	●	4	4	●	1	1
Risks	15	●	4	12	●	4	12	●	5	15	●	4	12	●	4	12	●	5	15	●	4	12	●	4	12	●	4	12	●	4	12	●	4	12	●	2	6
Area / Plot Availability	5	●	5	5	●	5	5	●	4	4	●	5	5	●	5	5	●	4	4	●	5	5	●	5	5	●	4	4	●	5	5	●	5	5	●	4	4
Constructibility	10	●	4	8	●	4	8	●	5	10	●	4	8	●	4	8	●	5	10	●	3	6	●	3	6	●	4	8	●	3	6	●	3	6	●	2	4
Ranking	100	●	85		●	85		●	80		●	84		●	84		●	79		●	85		●	81		●	72		●	74		●	81		●	53	
Ratings	● 0 Unacceptable	● 1 Very Poor	● 2 Poor	● 3 Average	● 4 Good	● 5 Very Good																														

Based on above rating selected Options are as follows:

Table 8.2-7: Selected Options

S.No.	Material	Mirfa to BAB	BAB to BuHasa	IPS	CAPEX MMUSD	% Increase	OPEX (Energy) MMUSD	OPEX Chemical MMUSD	OPEX MMUSD	All Costs MMUSD
1	CS	64	48	No	390	103	399	822	1221	1611
2	CS	60	48	No	383	102	430	822	1252	1636
11	FBE Lined	64	48	No	402	107	391	624	1015	1417

Conclusion for Component-2 (Mirfa Supply Pipelines) Selection:

Based on the evaluation conducted, below are the Concept ideas, which rated highest:

- Carbon Steel
- FBE Coated Carbon Steel

The difference in the selected options is the chemical consumption. Shareholders shared their experience that with provided specifications of sulphate and oxygen, carbon steel doesn't require corrosion inhibitor or biocide injection and chemical consumption should be same as non-metallic. **Therefore, based on this recommendation Carbon Steel is selected. Accordingly, S.No. 1 (64'' one CS pipeline without IPS) is selected because of lower OPEX.**

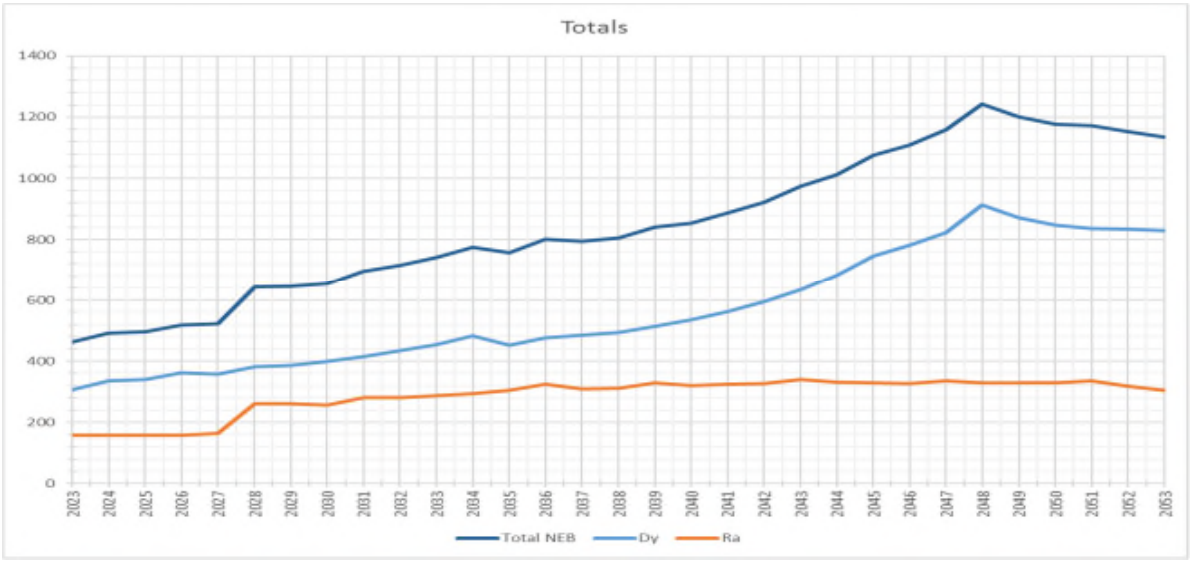
64" Carbon steel pipeline will be laid underground from Mirfa to Bab. Pipeline is DSAW type externally 3LPP coated. The pipeline route will be verified to use the existing corridor. Sections of sabkha portion will be laid above ground with elevated gatch construction. Pipeline will have highway crossing and will be designed as piggable. Launcher will be located in Mirfa, and reciever will be located at the new pumpng station at Bab field.

48” pipeline will be routed from Bab to BuHasa Pipeline and is Carbon steel, LSAW type and will be laid under ground, externally 3LPP coated. The pipeline route will be verified to use the existing Gasco NGL pipeline corridor. Pipeline will have highway crossing and will be designed as piggable. Launcher will be located at the new pump station in BAB, and reciever will be at the new pumping station at Bu hasa field.

8.4 Component-2 – Supply Network: Option Selection – Dy Supply Network

This section describes the option selection for sea water supply network from Dabiyya (SWTP) to Dabiyya CPP and from Dabiyya to Rumaitha. The capacity for Dy Seawater treatment Plant, Dy and Ra fields injection requirements are given in below figure:

Figure-8.3-1: Dy SWTP Requirements (Dy and Ra Injection Profile)



Lengths of pipelines are provided in below table;

Table 8.3-1: Dabbiya SWTP supply pipelines length

Pipeline (To and From)	Length
Dy (SWTP) to Dy CPP	15 km
Dy (SWTP) to Ra	25 km

The network configuration from Dabbiya SWTP to Dy CPP and Ra CPP is provided in figure 8.3-2 and figure 8.3-3. It should be noted that no intermediate pumping is considered for NEB since the length is not significant.

Figure-8.3-2: Single Pipeline without Intermediate Pumping

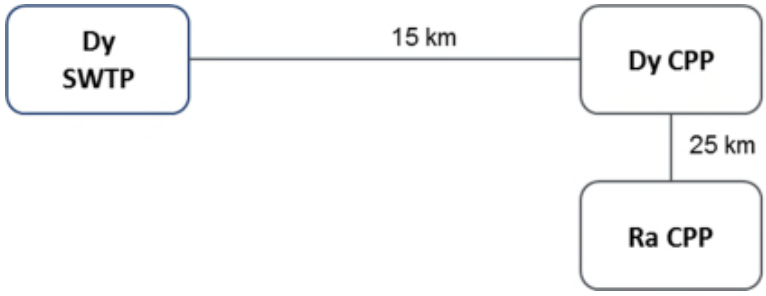
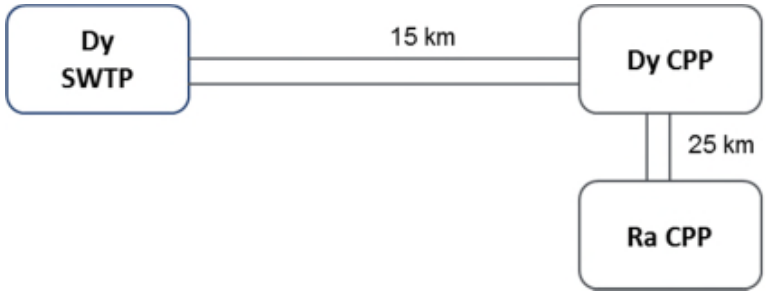


Figure-8.3-3: Multi-Pipeline without Intermediate Pumping



Civil works for existing pumps shed extensions, new pump shed and plot development are considered and the same is provided for CAPEX calculations.

Table 8.3-2: Options Identified

S.No.	Material of Construction	Pipeline (From and to)	Size, Inch
1	Carbon Steel Pipeline	Dy SWTP to DY CPP	42
		Dy-CPP to Ra-CPP	30
2	Carbon Steel Pipeline	Dy SWTP to DY CPP	42
		Dy-CPP to Ra-CPP	24
3	Carbon Steel Pipeline	Dy SWTP to DY CPP	48
		Dy-CPP to Ra-CPP	30
4	Carbon Steel Pipeline 2 Pipeline	Dy SWTP to DY CPP	2x28
		Dy-CPP to Ra-CPP	2x24
5	FBE coated Carbon Steel Pipeline	Dy SWTP to DY CPP	42
		Dy-CPP to Ra-CPP	30
6	HDPE LINED Carbon Steel Pipeline	Dy SWTP to DY CPP	42
		Dy-CPP to Ra-CPP	30
7	GRE Pipeline	Dy SWTP to DY CPP	40
		Dy-CPP to Ra-CPP	30

Note: It should be noted that to make GRE option viable, the arrival pressure is reduced from normal 25 barg to 5 barg, since GRE has a limitation on design pressure. However, in doing so, the existing pumps become inadequate. Accordingly, CAPEX estimation of the GRE lines need to account for the cost of pump's replacement.

In order to compare the GRE options with the other supply pipeline material, the additional power consumption required for achieving arrival pressure of 27 barg and 20 barg at the suction of the injection pumps of Dabbiya and Rumaitha respectively needs to be accounted for.

The Summary of comparisons for selected cases & cost estimates as below:

Table 8.3-3: Summary of Options CAPEX

Options	1	2	3	4	5	6	7
Material	CS	CS	CS	CS	FBE	HDPE	GRE
Dy SWTP to Dy CPP	42	42	48	2x28	42	42	40
Dy CPP to Ra CPP	30	24	30	2x24	30	30	30
IPS	No	No	No	No	No	No	No
CAPEX	**129**	**120**	**133**	**159**	**140**	**138**	**103**
Additional Pumps CAPEX	**-**	**-**	**-**	**-**	**-**	**-**	**62**
Total	**129**	**120**	**133**	**159**	**140**	**138**	**165**

The rating for each option against all criteria is provided in below table:

Table 8.3-4: Option Ratings

Case		1			2			3			4			5			6			7		
Material		CS			CS			CS			CS			FBE			HDPE			GRE		
Dy_SWTP-DY_CPP		42			42			48			2x28			42			42			40		
Dy-CPP-Ra_CPP		30			24			30			2x24			30			30			30		
IPS		No			No			No			No			No			No			No		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	10		4	8		4	8		4	8		5	10		4	8		4	8		4	8
(CAPEX)	35		5	35		5	35		4	28		3	21		4	28		4	28		2	14
(OPEX)	20		3	12		3	12		3	12		2	8		4	16		3	12		5	20
Maintenance / Inspection	5		5	5		5	5		5	5		5	5		4	4		1	1		3	3
Risks	15		5	15		5	15		5	15		5	15		4	12		2	6		3	9
Area / Plot Availability	5		5	5		5	5		5	5		4	4		5	5		5	5		3	3
Constructibility	10		5	10		5	10		5	10		5	10		4	8		2	4		5	10
Ranking	100		90			90			83			73			81			64			67	
Ratings		0 Unacceptable			1 Very Poor			2 Poor			3 Average			4 Good			5 Very Good					

Conclusion for Component-2 (Dy Supply Pipelines) Selection:

Based on the evaluation conducted, Carbon Steel without intermediate pumping has been selected.

9.0 Component-3: In Field Distribution Networks

Note: Initially Project Wave considered the replacement of aquifer water with seawater for only NEB, BAB and Bu Hasa Fields. South East was included at a later stage of the project to give a holistic view for Seawater Injection in ADNOC Onshore fields. South East was not considered in the evaluation of this Component however, subsequent evaluation was conducted based on the concluded options. This is available in Section 12.

Component-3 mainly deals with the design of the seawater injection pumping and pipeline distribution network. It looks into the distribution pipeline network of the seawater injection to the consumer wellhead facilities.

The battery limit of this component starts from the tie-in with the sea water supply pipeline and terminates at the inlet of the injection pumping stations. Additionally, this component involves the greenfield design of the sea water injection network distributing the injection water to the wells/clusters.

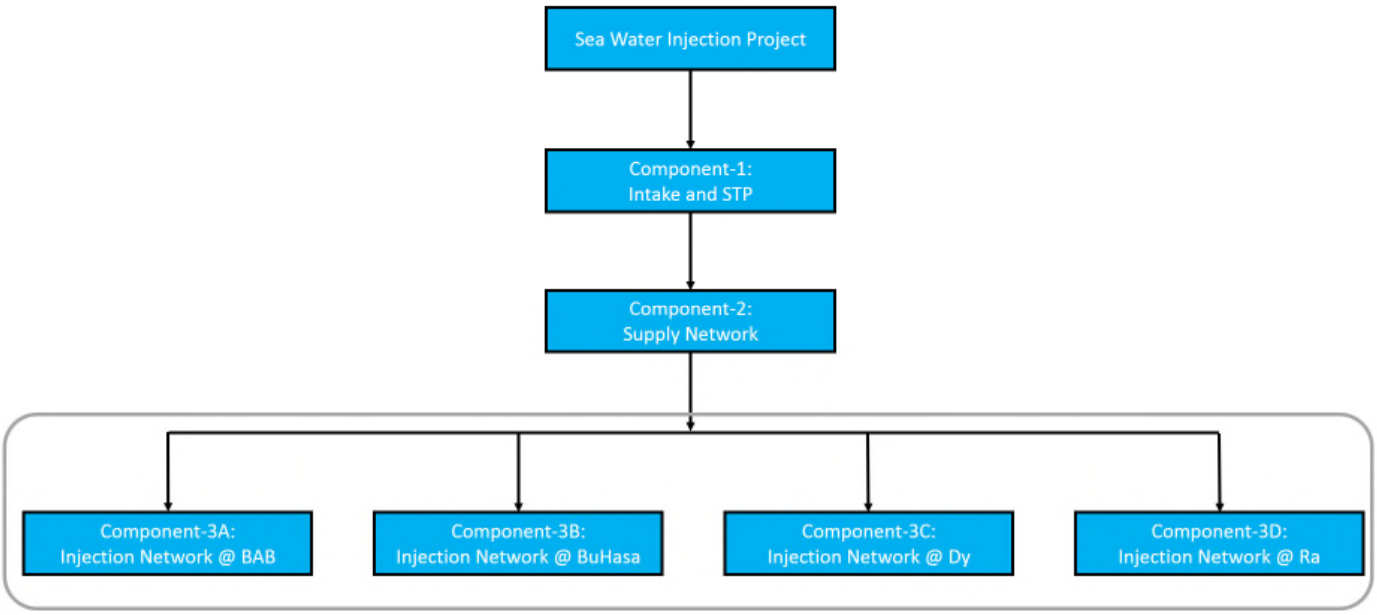
For Bu Hasa and BAB fields, new green field water injection pipeline network is considered and tie-in is made to the existing wells as well as future development locations. This is driven by the requirements of de-congesting the existing water injection clusters and associated facilities. NEB field sea water injection design shall consider green field pipeline network in new areas as well as de-bottlenecking existing brownfield utilized water injection pipeline network where technically feasible.

Existing water injection clusters facilities will be demolished for the purposes of de-congestion. Concept stage consider new greenfield sea water injection network to all BAB & Bu Hasa wellheads. Any optimizations to utilize existing pipeline network or equipment will be evaluated during FEED stage.

This component looks into the merits and de-merits of centralized / split pumping configurations / main injection headers arrangements.Component-3 is split into 4 components;

1. Component-3A: Injection Network at BAB
2. Component-3B: Injection Network at BuHasa
3. Component-3C:Injection Network at Dy
4. Component-3D:Injection Network at Ra

Figure-9-1 Component 3 – In-Field Distribution Network



With all above identified options, a screening workshop was conducted. Option drivers / criteria definition with their weightage were identified and agreed with the forum members. Option drivers/ criterias are given in below table:

Table-9.1.1: Component-3 Drivers / Criteria Definitions

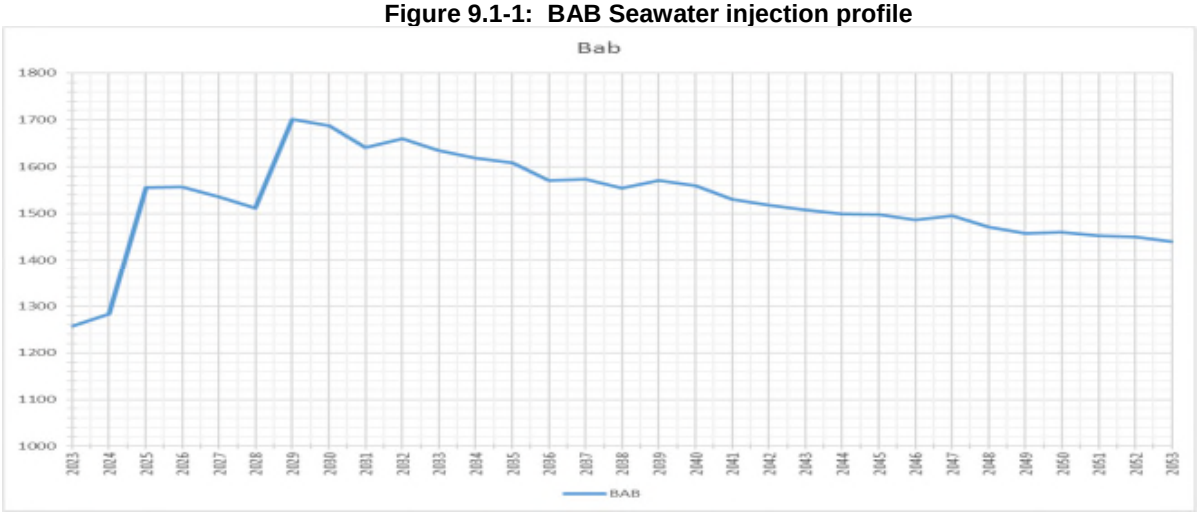
Criteria	Definitions
Availability	Plant availability to supply treated seawater for injection
CAPEX	Capital costs for the injection network and pumping station(s) and any additional spuply pipeline
OPEX	Operating costs of different options (energy consumption)
Maintenance	Issues with maintenance
Risks	Project risks, number of constsruction sites, interfaces, approvals, etc..
Area / Plot Availability	For current phase and any future extensions
Constructability	Capture ease or difficulty of constructability among various options
Operability	Operational flexiblity, access and number of operating sites
Decongestion	One of the main objectives of the project is to de-congest the fields
HSE (as applicable)	HSE risks to operate single or multiple pumping stations (includes travelling), issues during construction, HSE issues related to Operations and Maintenance

9.1 Component-3A: Injection Network at BAB

9.1.1 BAB Injection Network – Design Basis

The full BAB field seawater injection profile including the requirements of P5 and future developments is shown in figure 9.1.1 below:

Figure 9.1-1: BAB Seawater injection profile



The maximum BAB field seawater injection demand is 1.7 MMBLPD, which occurs in year 2029.

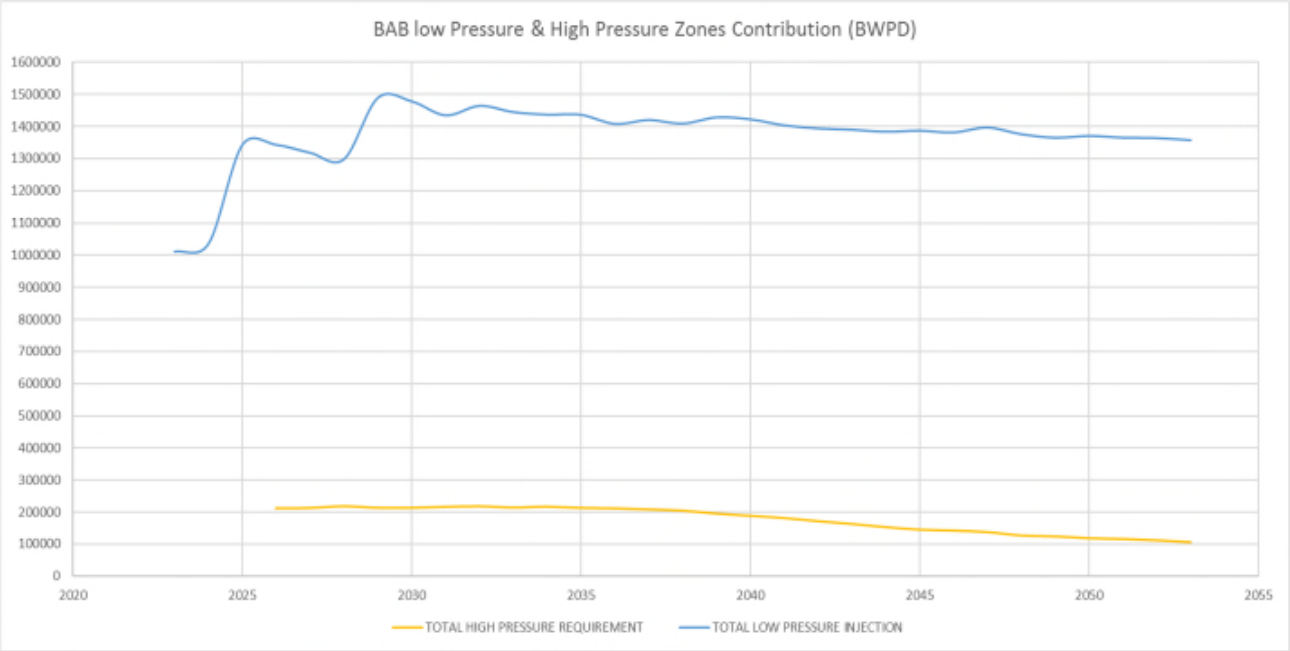
BAB seawater injection development involves various production zones which vary with respect to the required maximum wellhead injection pressure:

a- Low Pressure Zones : Th-B,Th-C,Th-G & HB-2 with a maximum WHIP of 3000 Psi.

b- High Pressure Zones: Th-A, Th-H & HB-1 with WHIP of maximum 3500 Psi.

The hydraulic study for component-3 seawater injection network considers sustainable profile rates and the governing case of maximum demand in year 2029 of 1.7 MMBWPD. The contributions of the low pressure and high-pressure BAB zones are shown in figure 9.1-2 below:

Figure 9.1-2: BAB low pressure and high-pressure zones total seawater injection profile



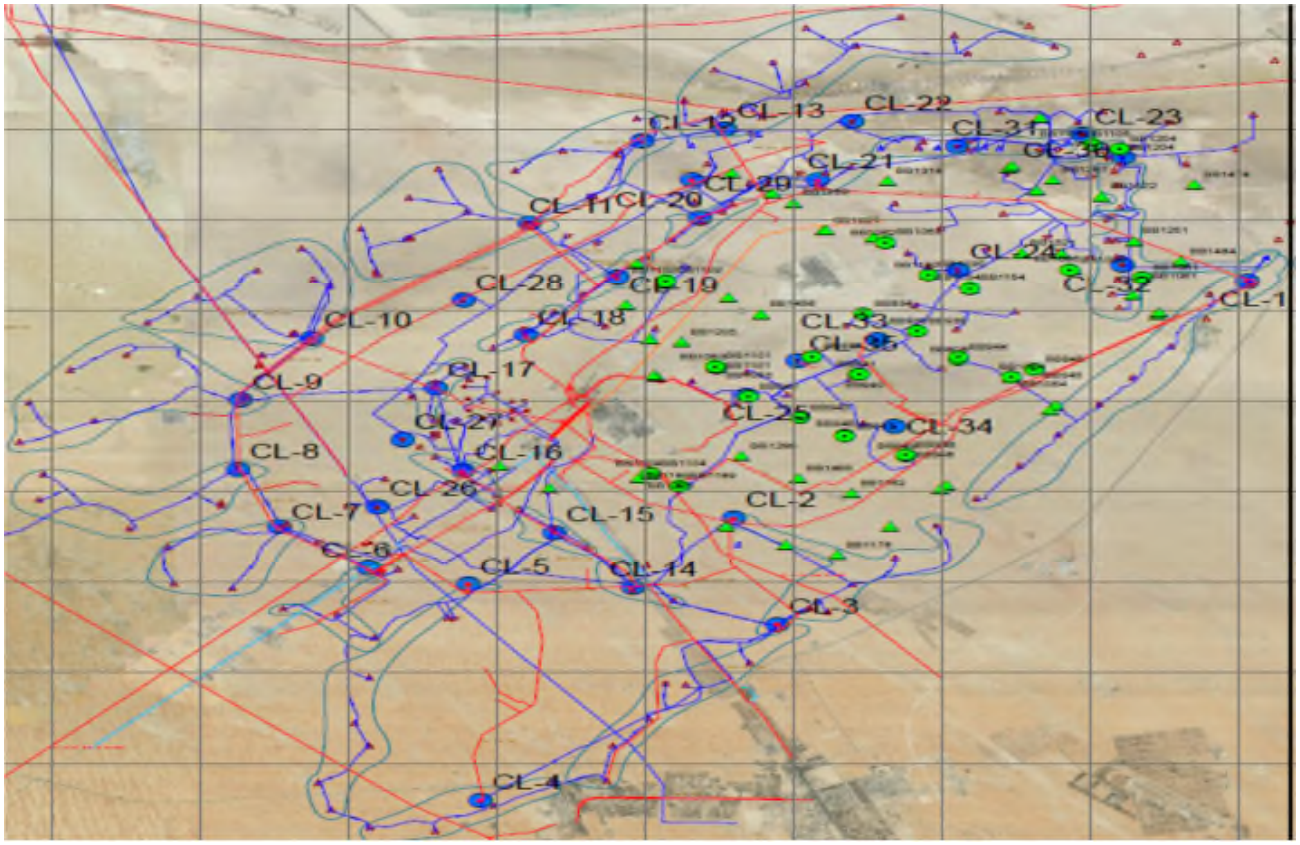
Based on the above profile, it can be see that HP zones contribution is 22% of the total seawater injection demand in comparison to 78% for the LP zones demand. Well-wise yearly injection profile is used to analyze statistically average flow rate per well for each of the low pressure and high pressure wells. Table 9.1.1 below provides the estimate of the number of wells per zone, based on a total BAB field demand of 1.7 MMBWPD and the seawater injection contribution of each zone, an average flow rate per well is estimated as a representative value for each LP and HP zones:

Table 9.1-1: Estimation of representative wells wise injection rate

BAB Zone	*NUMBER OF WELLS*	*Maximum Fraction of Zone Contribution*	*AVERAGE RATE (BWPD)*	*Rounded Up value (BWPD)*
B	714	78%	1419.7	1450
G	100			
HB-2	73			
TH-C	47			
Total LP	***934***	1326000		
HB-1	73	22%	1395.5	1400
TH-A	138			
TH-H	57			
Total HP	***268***	374000		
TOTAL MANDATE BAB PEAK DEMAND (BWPD)		1700000		

The overall field layout for BAB showing the existing water injection cluster is shown in figure 9.1-3 below:

Figure 9.1-3: Existing BAB field layout



As part of project's key strategic objectives, field de-congestion is mandated which includes decongestion of the existing water injection clusters facilities and their associated overhead lines and pumping stations. Concept study design is in-line with project's strategy of de-congesting except Clusters 15 & 16 which will continue their operation under produced water re-injection. New seawater injection network is executed as part of project's scope. Any potential utilization of the existing network will be looked into and studied during FEED stage. Demolition scope included existing Clusters supply and disposal well count is provided in Section 9.1.4.

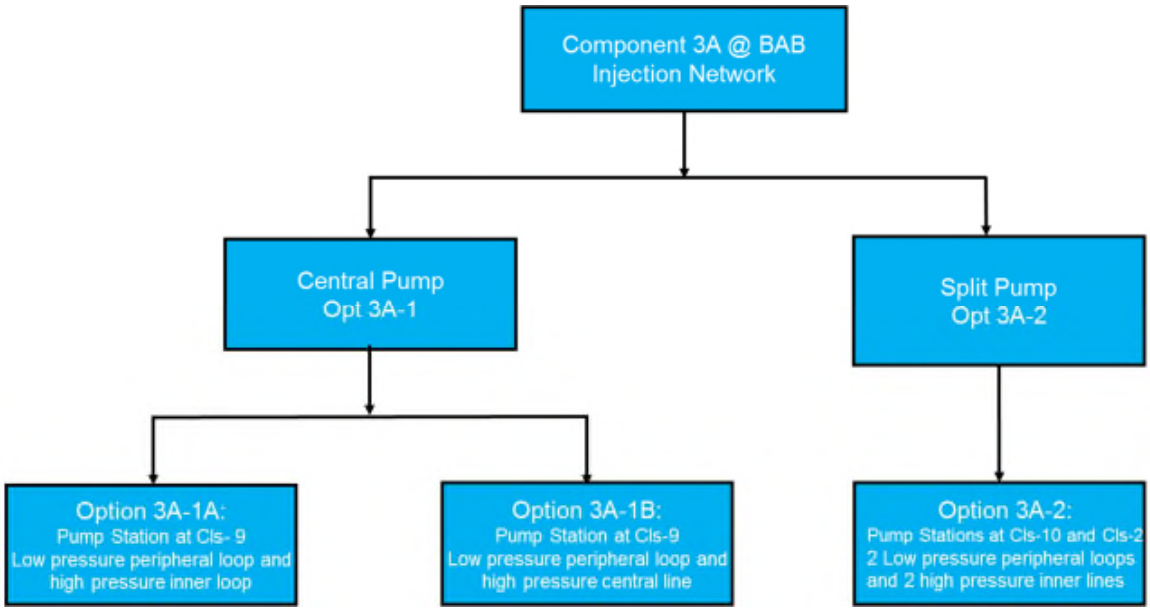
Refer to Appendix-D for the existing water injection cluster's dashboard in BAB field.

9.1.2 Component-3A – Bab Injection Network: Options Identification

New seawater injection network is established for the complete BAB field enabling the distribution of the seawater injection to all existing and future wells, which will be added as part of BAB future expansion projects. Options considered for Bab field are noted below;

1. Centralized Pumping Option 3A-1, which is further splited in below options;
    1. Centralized Pumping station at Cls-9 with Loops, Option 3A-1A
    2. Centralized Pumping station at Cls-9 with Headers, Option 3A-1B
2. Split Options with Pumping Station @ Cls-9 and Cls2, Option 3A-2

Figure 9.1-4: BAB Component-3 Breakdown



Option 3A-1A and Option-3A-1B have central pumps and only difference is in the distribution headers. headers' arrangement and distribution will be studied in detail during FEED in coordination with Bab Master Plan team. Essentially, no difference is foreseen in these two options and therefore Option 3A-1B is screened out at an early stage.

9.1.2.1 BAB Injection Network Option 3A-1A: Central Pump

This option involves centralized pumping at field edge supplying to three injection loops. Due to different injection pressures, the HP and LP rings are provided. There is one LP outer peripheral injection ring, one LP inner water injection ring feeding the central low pressure zones and the third high pressure inner ring feeding the high pressure wells belonging to zones Th-A, Th-H and Habshan-1. The distribution of the water injection wells to be fed by each ring header is designed in a hub scheme following similar existing water injection cluster distribution and optimizing the flowline routings. The identification of the injection hubs for the water injection wells is included in figure 9.1.6. Centralized pumping station located cluster-9 was considered as it is proximate to the seawater pipeline approach from Mirfa to BAB field. The ring scheme is explained below and is shown in figure 9.1.5 below:

a- LP-1 North Header- Outer Ring

b- LP-1 South Header -Outer Ring

c- LP-2 North header- Inner Ring

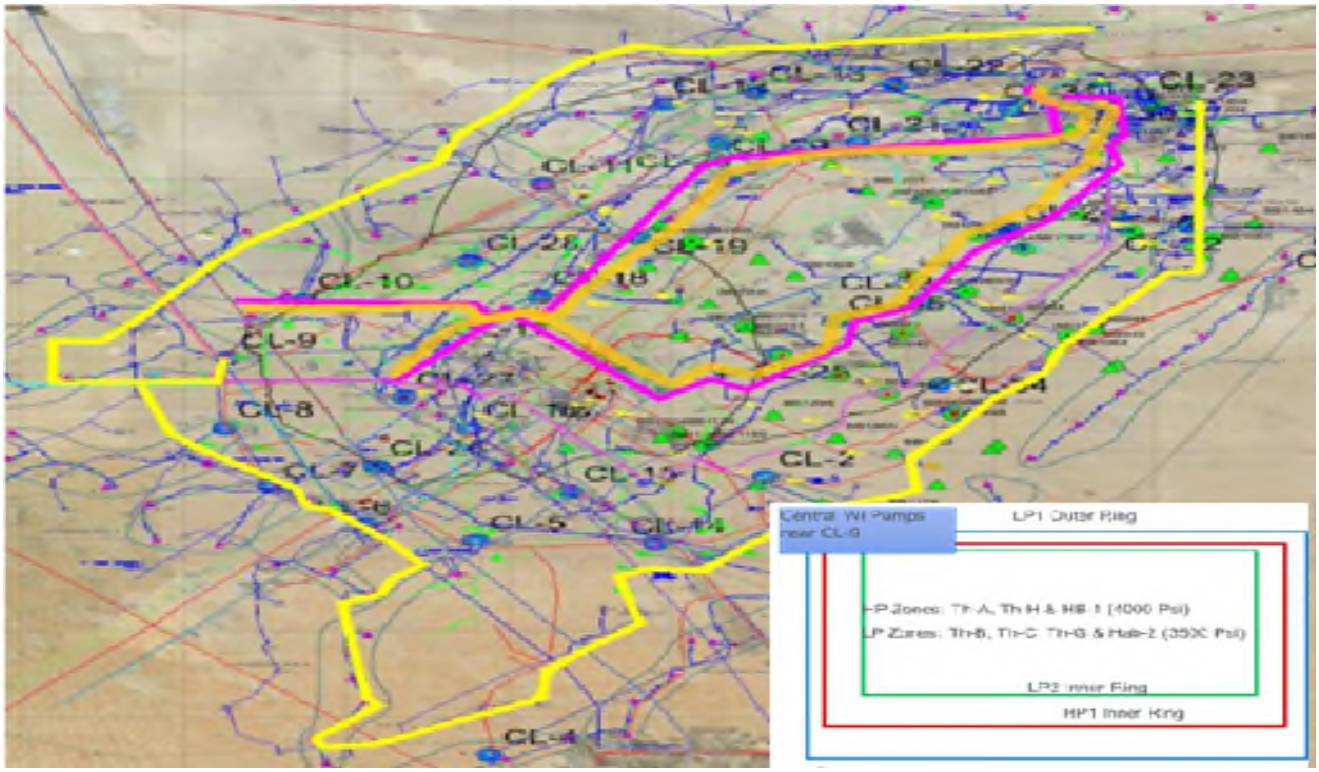
d- LP-2 South Header-Inner Ring

e- HP North Header Inner Ring

f- HP South Header-Inner Ring

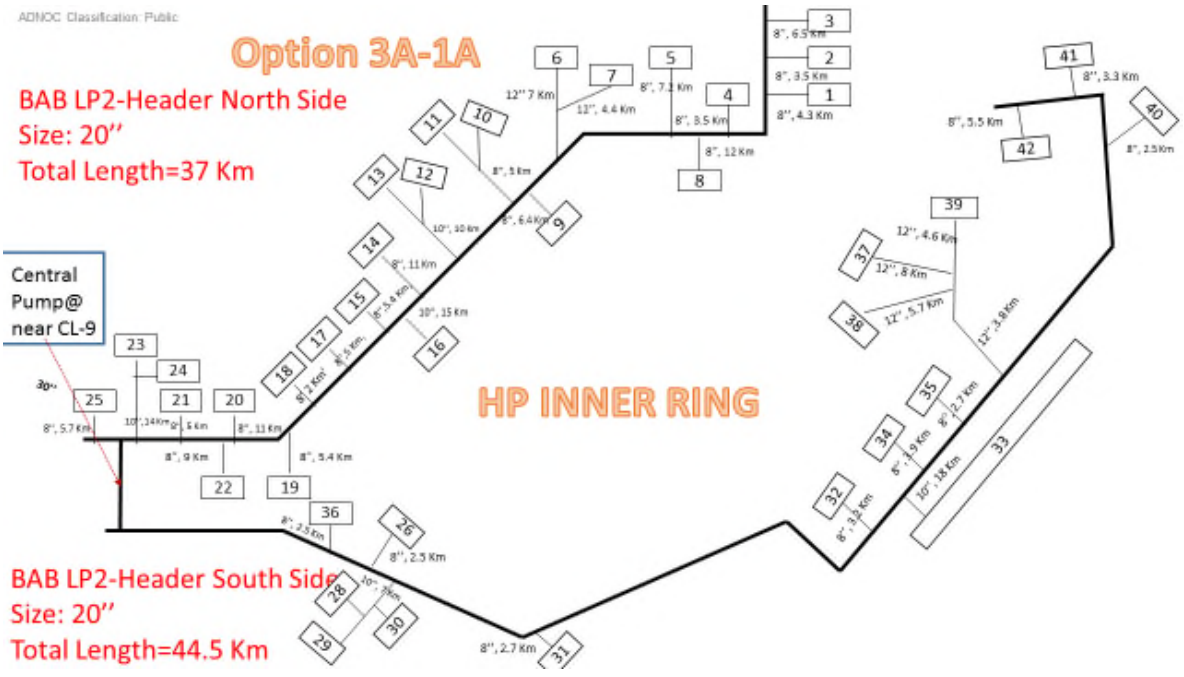
Field layout and configuration is shown in below figure.

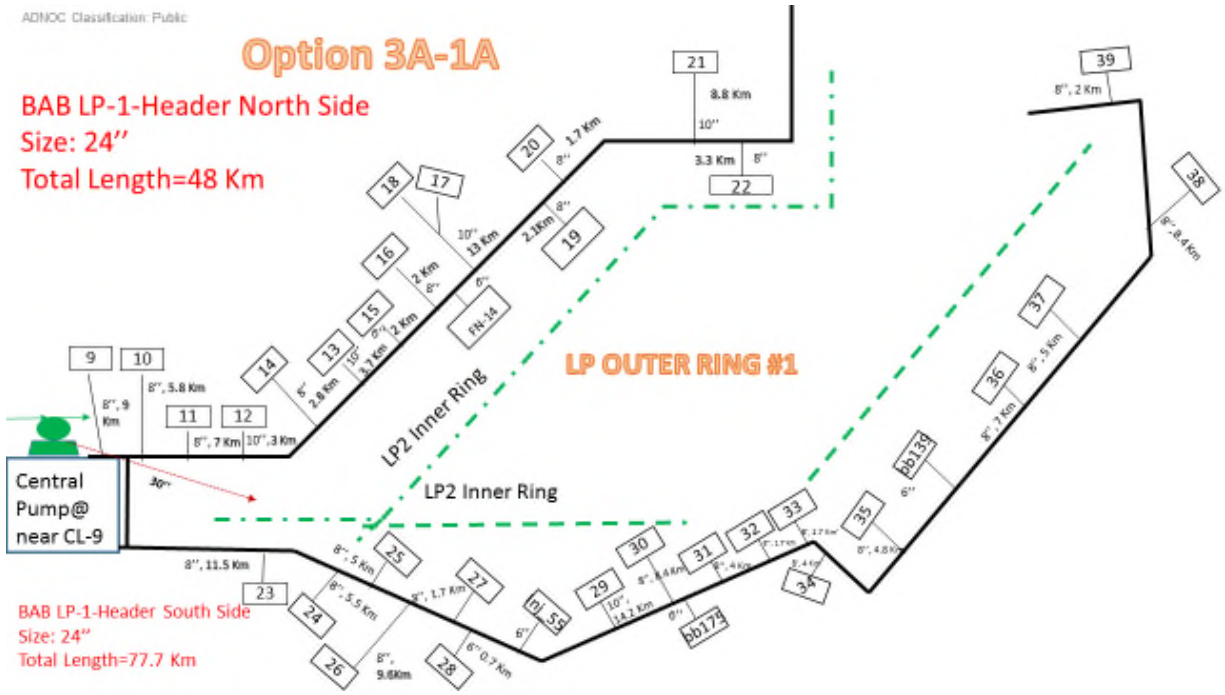
Figure 9.1-5: Field layout and rings configuration for Option 3A-1A

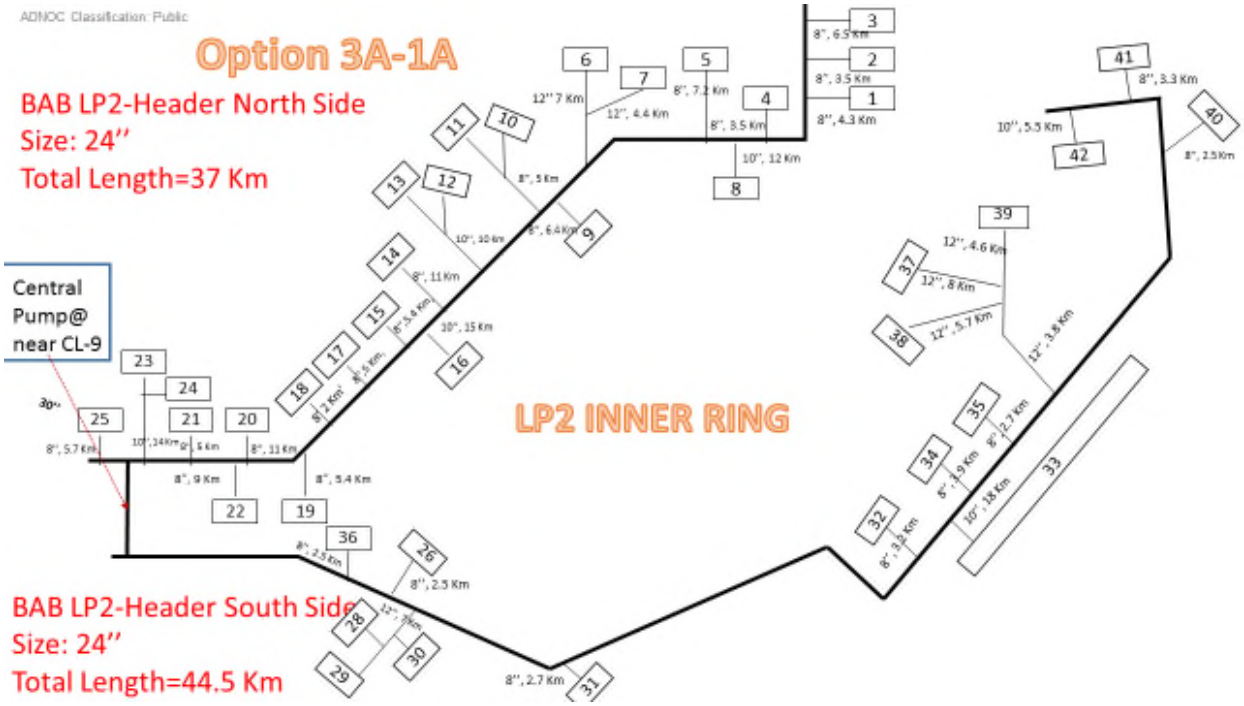


Hydraulic study is performed for option 3A-1A and resulting sizes for headers and subheaders are reported in Figure 9.1-6

Figure-9.1-6: Rings configuration with sizes for centrak pumping station option.







The detailed analysis of the required number of injection pumps for the pumping station at CL-9 is shown in table 9.1.2 below, a total of 16 pumps is required for this option with a total power consumption of 96 MW. New 15 Km OHL and 132 KV substation is required. For this option no additional C-2 supply length is required.

Table-9.1-2: Estimate of number of Pumps and their power requirements

	TOTAL FLOW	NUMBER OF PUMPS	Flow (STB/d)	Flow (m3/h)	SUCTION P	DISCHARGE PRESSURE	Head (m)	Power (MW)	Power for all Pumps(MW)
24'' LP OUTER RING	1326000	9W+2S	150000	994	10	230	2079	7.8	70.6
24'' LP INNER RING									
20'' HP INNER RING	376000	4W+1S	100000	662	10	260	2362	6.3	25.1

The design pressure for the main LP header is 270 barg while for the HP header is 320 barg. Design temperature considering metallic pipeline will be 85 C and 60 C for buried non-metallic pipeline.

9.1.2.2 Bab Injection Network Option 3A-2 : Split Pumping Option

This option involves split pumping stations located at two edge locations of BAB field. In this option, the headers are mainly broken down into North and South sides. The North area is fed by a pumping station located at CL-11 while the south side is fed by a pumping station located at CL-2.

In this option, the same concept of LP & HP loops is adapted, however, each loop is further segregated into two sub-headers for the purpose of distributing the load among the east and west consumers. As seen in figure 7-3 below, there are three main loops classified with respect to pressure requirements:

a- LP1 Outer peripheral North header which is further segregated into:
   i. LP1 North East
   ii. LP1 North West

b- LP2 Outer peripheral South header which is further segregated into:
   i. LP2 South East
   ii. LP2 South West

c- LP 3 Inner North header

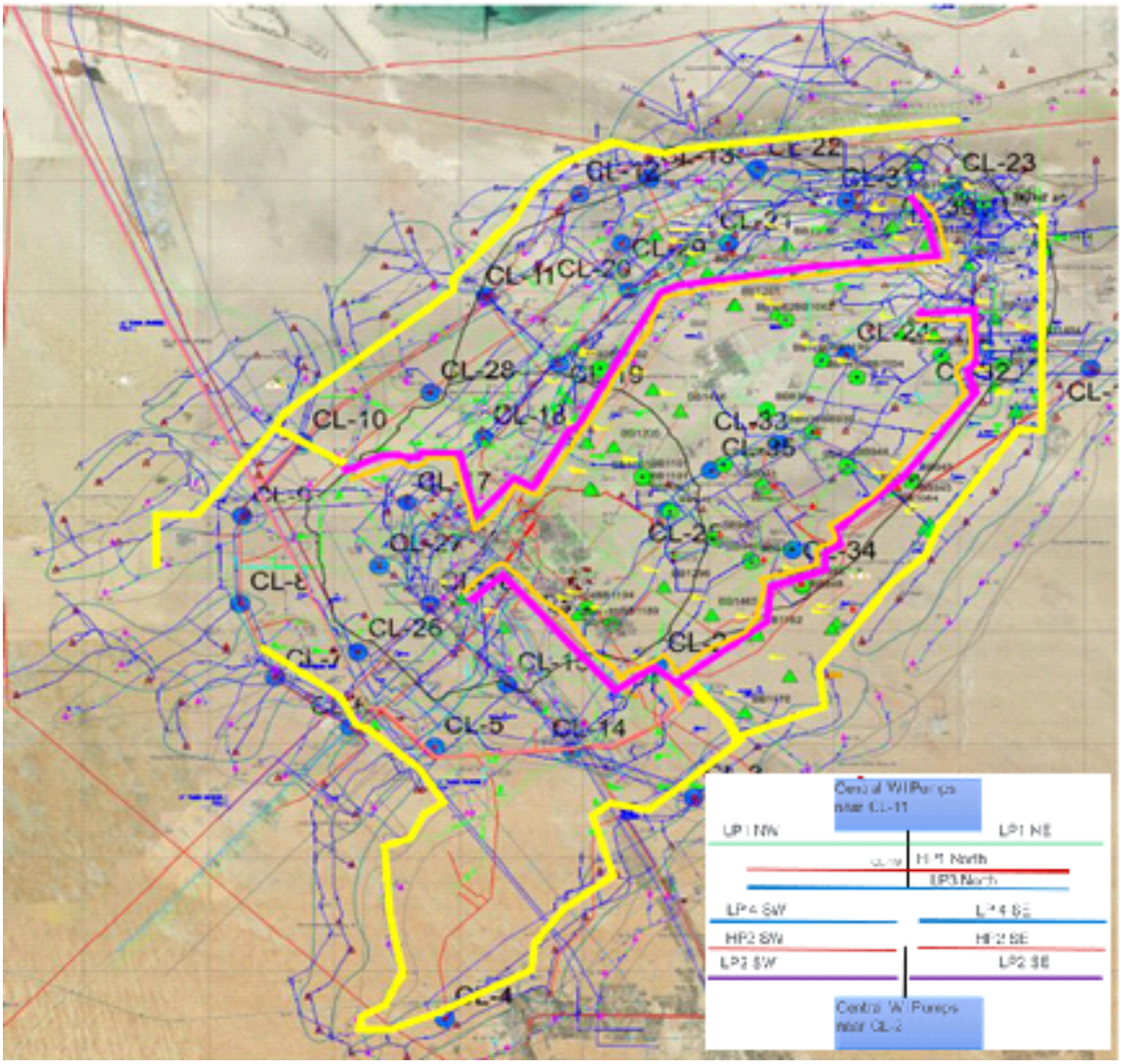
d- LP 4 inner South header which is further segregated into:
   i. LP4 South East
   ii. LP 4 South West

e- HP1 inner North header

f- HP 2 inner south header which is further segregated into:
   i. HP2 South East
   ii. HP2 South West

The distribution of seawater was done with similar approach to Option 3A-1A following the existing routings and grouping of the water injection wells.

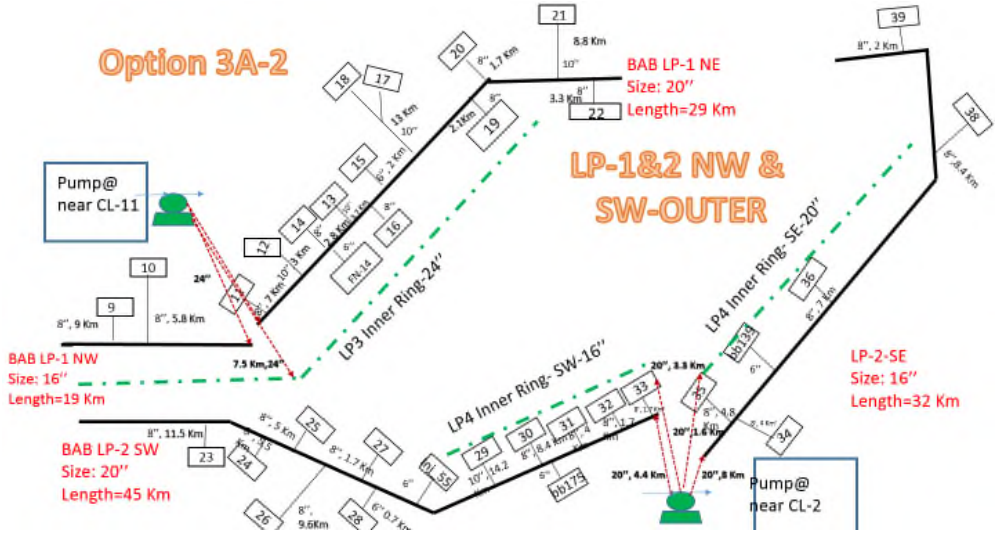
Figure 9.1-7: Field layout and rings configuration for Split Pump Option 3A-2

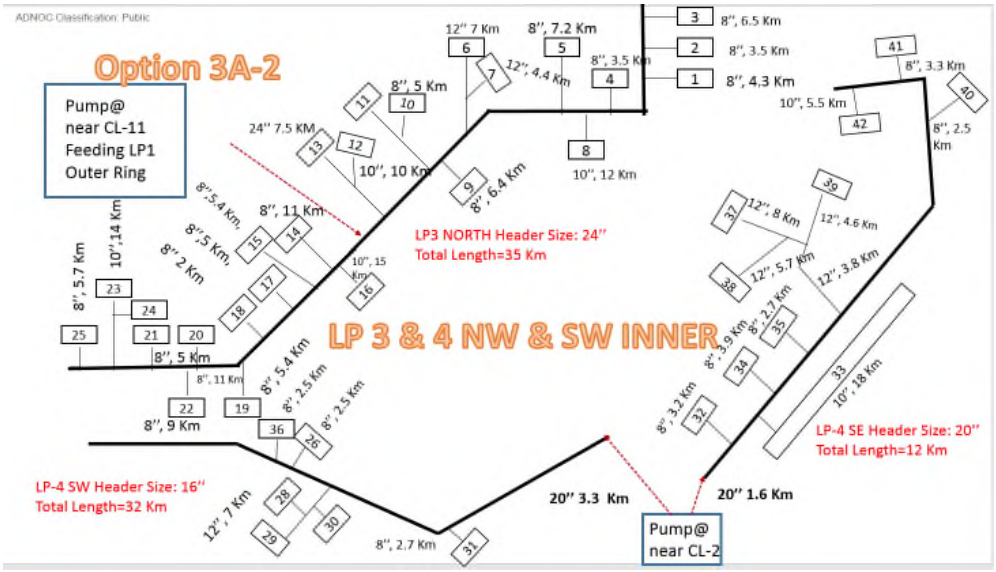


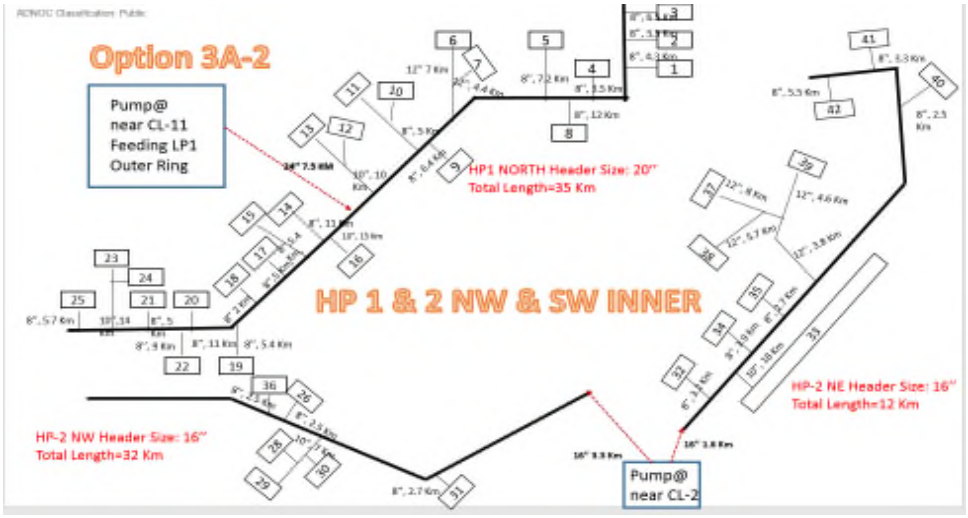
Considering the requirement of locating the south pumping station at cluster-2 and cluster-11, additional length is required as part of component-2 to supply the required seawater injection from Mirfa plant towards the split pumping stations.

Based on the conducted hydraulic study performed for options 3A-2, figures 9.1-8 showcase the selected headers and sub-headers sizes:

Figure 9.1-8: Headers and Sub-headers for Split Pump option 3A-2







The detailed analysis of the required number of injection pumps for the pumping stations at CL-11 & CL-2 for the north and south headers shown above. Based on table 9.1. 3, a total of 17 pumps is required for the two pumping stations with a total power consumption of 96 MW. 12 Km New 132 KV OHL is installed for CL-11 pumping station and another 15 Km new OHL is routed towards the pumping station at CL-2. Nw 132 KV substation is provided at each pumping station. Considering the farther tie-in point location of sea water supply pipeline at clusters 11 & 2 compared to Cluster-9 in option 3A-1A, there is additional 48'' 12 Km towards CL-11 and 48'' 27 Km additional supply pipeline towards cluster-2.

Table 9.1-3: Option 3A-2 Estimate of number of Pumps and their power requirements

OPTION 3A-2- SPLIT PUMPING @ NEAR CL-19 & CL-2										
		TOTAL FLOW	NUMBER OF PUMPS	Flow (STB/d)	Flow (m3/h)	SUCTION P	DISCHARGE PRESSURE	Head (m)	Power (MW)	Power for all Pumps(MW)
PUMP STATION @ CL-11	LP Load	731533	5W+1S	147000	974	10	230	2079	7.7	38.4
PUMP STATION @ CL-2	LP Load	532000	4W+1S	135000	894	10	230	2079	7.4	29.3
PUMP STATION @ CL-11	HP Load	249000	2W+1S	125000	828	10	260	2362	7.8	15.7
PUMP STATION @ CL-2	HP Load	193103	2W+1S	100000	662	10	265	2409	6.4	12.8

Additionally, since the pumping stations discharge shall be extended to the inner LP and HP north and south headers, as seen from figure 9.1-8 above, the following pump discharge pipeline are required:

- 30''- 15 Km pipeline towards each LP 4 & HP 1 North headers (7.5 x 2)
- 20''- 12.4 Km pump discharge pipeline required towards LP 2 south east and south west outer headers
- 20'' 5 Km pump discharge pipeline required towards the south headers LP 4 east and west
- 16'' 5 Km pump discharge pipeline required towards the south headers HP2 east and west

Accordingly, a total length 37 Km pipeline is required for the split pumping discharge lines.

The design pressure for the main LP header is 270 barg while for the HP header is 320 barg. Design temperature considering metallic pipeline will be 85 C and 60 C for buried non-metallic pipeline.

9.1.3 Component-3 Bab Injection Network: Option Selection

Based on the concept study outcomes reflected in above sections for each of the central and split pumping options, table 9.1-4 below provides an overall comparison between the two options with respect to various design aspects:

Table 9.1-4: Options comparison table

	Option 3A-1	Option 3A-2
Description	Single Pumping Station at the Edge of BAB Field CL-9 One Pump station per Ring	Split Pumping @ Central Field for 10 subheaders
Pipelines	LP Ring 1 Outer: 24" 125 km LP Ring 2 Inner: 24" 81 km HP Ring 1 Inner: 20" 81 km	Header-LP1 NE: 20" 29 km Header-LP1 NW: 16" 19 km Header-LP2 SE: 16" 32 km Header-LP2 SW: 20" 45km Header-HP1 North : 20" 35 km Header-HP2 SE: 16" 12 km Header-HP2 SW: 16" 32km Header-LP3 North : 20" 35 km Header-LP4 SE: 16" 12 km Header-LP4 SW: 16" 32km
Additional Pump Discharge Pipeline (Km)	-	37 (7.5 Km towards HP & LP inner north rings each + 10 Km towards the south inner HP & LP rings+ 12.4 Km towards the south outer LP ring)
C-2 Pipeline	NR- Tie-in @ near CL-9 as per C-2 analysis	Additional 48'' 12 Km towards the inner rings near CL-11 Additional 48'' 27 Km towards CL-2
Total Pipeline Length (Km)	289	339
no. of Pumps	13 W + 3 S	13 W + 4 S
Total Pumping Power (MW)	96	96
Plot Space	224m x 18m	1) 126m x 18m @ CL-11 2) 112m x 18m @ CL-2

Both BAB component-3 options 3A-1A and 3A-2 were analysed thoroughly with respect to the below design aspects which are in line with the options drivers explained in section 9:

a- Total Length and required sizes for component-3 pipeline system which directly contributes in CAPEX

b- Additional pipeline required for sea water supply which contributes in CAPEX

c- Field congestion with respect to the associated requirement of more supply pipeline, distribution injection headers and OHL.

Plot availability with respect to accommodate various number of pumping stations and total number of pumps in each station.

Availability of injection system which is a function of the number of pumping stations.

Maintenance requirements which is associated with the required operational load to maintain different number of pumping stations.

Risk associated with operational handling of multiple pumping stations attributed to split pumping option in comparison to central pumping.

The detailed electrical requirements for both options are highlighted in table 9.1-5 below:

Table 9.1-5: Electrical scope requirements for BAB C-3 study

	Option 3A-1A	Option 3A-2
Power source from	New 132kV OHL D/C LINE from existing 132kV GIS S/S (ADBB132S) to New 132kV S/S near CLS-9 (Approx. 15km)	• CLS-2: New 132kV OHL D/C LINE from existing 132kV GIS S/S (ADBB132S) to New 132kV S/S near CLS-2 • CLS-11: New 132kV OHL D/C LINE from existing 132kV GIS S/S (ADBB132S) to New 132kV S/S near CLS-11

Power demand	• 6+1 Pumps x 6.5MW
	• 7+1 Pumps x 6.1MW
	• 4+1 Pumps x 7.85MW
		• CLS-2:
		  • 2+1 Pumps x 6.5MW
		  • 2+1 Pumps near x 8.1MW
		  • 2+1 Pumps near x 9.6MW
		• CLS-11:
		  • 3+1 Pumps x 9.1MW
		  • 2+1 Pumps x 11.8MW
		  • 3+1 Pumps x 9.8MW

OHL requirement	132kV OHL (Approx. 15km)	• CLS-2: 132kV OHL (12 Km) • CLS-11:132KV OHL (15 Km)
Number of substation and size	S/S (140mx50m)	• CLS-2: S/S (80mx45m) • CLS-11: S/S (120mx45m)
Equipment List	• 33KV HSWG through 2x150MVA • 3.3kV HSWG through 10/12.5MVA • 6 Nos. of 415V SWGR with 2.5MVA • 20 Nos. VSD Systems	• CLS-2: • 33KV HSWG through 2x80MVA • 3.3kV HSWG through 10/12.5MVA • 4 Nos. of 415V SWGR with 2.5MVA • 9 Nos. VSD Systems • CLS-11: • 33KV HSWG through 2x140MVA • 3.3kV HSWG through 10/12.5MVA • 4 Nos. of 415V SWGR with 2.5MVA • 11 Nos. VSD Systems

The CAPEX comparison of the two options is shown in table 9.1-6 below:

Table 9.1-6: EPC Cost for the options

	Centralized Pumping Station at near CL-9 (Inner HP/LP rings with outer LP ring)	Split Pumping @ CL-11 & CL-19 for LP/HP North headers & @ CL-2 for HP/LP south headers
Pumping Station	388	443
Pipeline	950	981
Total	1338	1424
Add. C2 Scope	As per Base C-2	91
Grand Total	1338	1515

An option selection workshop was conducted involving the key stakeholders (Engineering, subsurface, Project's team and BAB master plan); each option's driver was jointly assigned a weightage factor and was evaluated subjectively as explained above. Refer to table 9.1.7 below for the Options selection scoring.

Table 9.1-7: Options selection rating matrix

Driver/Criteria	%	Option-3A-1A Central Pump			Option-3A-2 Split Pumping		
			Rating	Wtage		Rating	Wtage
Availability	10	●	4	8	●	5	10
(CAPEX)	20	●	5	20	●	4	16
(OPEX)	15	●	5	15	●	5	15
Maintenance	10	●	5	10	●	4	8
Risks	10	●	5	10	●	4	8
Area / Plot Availability	5	●	5	5	●	4	4
Constructibility	10	●	5	10	●	4	8
Operatibility	10	●	5	10	●	4	8
Decongestion	10	●	5	10	●	4	8
Ranking	**100**	●	**98**		●	**85**	

BAB Injection Network Conclusion:

Based on the above evaluation, it can be seen that central pumping option 3A-1A has higher technical and economical merits than option 3A-2, accordingly, central pumping option is selected for concept design. Detailed network configuration, i.e. header, sub-headers and flowlines, is shown in Appendix-F.

Additionally, following will be considered during Conceptual Design:

- Verification of plot locations, pipeline routing and OHL routings will be studied and confirmed during the next stage.
- Project team to review at next stage of engineering, to have LP headers design pressures same as HP header, so that the pressure in LP header can be increased as required in the future.
- Opportunity to re-utilize existing equipment and pipeline will be reviewed.

9.1.4 BAB C-3 Demolition Scope

As part of the conversion of BAB field to seawater injection with the exception to existing PWRI clusters 15 &16, table 9.1.8 below provides the number of water injection clusters, supply wells and disposal wells to be demolished:

Table 9.1.8: Quantification of demolition scope for Existing BAB water injection system

Cluster Count	Clusters Tags	Supply Wells	Disposal Wells	Remarks
39	001, 002, 003, 005, 006, 007, 008, 009, 010, 011, 012, 013, 014, 017, 018, 019, 020, 021, 022, 023, 024, 025, 026, 027, 028, 029, 030, 031, 032, 033, 034, 035, 036, 038, 039, 041, 042, 043, 044	39	24	• Cls #2 - #21: These are old clusters (20) with 17 supply wells that share 3 disposal wells. Note that Cls #4 is abandoned. This is exclusive of PWRI Clusters. • Cls #22 - #35: These are existing new clusters (14) that built based on each cluster having one supply well and one disposal well (as shown in the map in my earlier email). Hence there are 14 supply wells and 14 disposal wells. Note that Cl #32 is sharing a disposal well with Cl #01. • Cls #36 - #39 & #41 - #44: These are upcoming clusters (7) that will have 7 supply wells and 7 disposal wells.

As per the latest BMP 5.1 well's allocations, 406 injectors will require new flowlines as part of the project's scope. Each flowline is considered as 4'' and 2.5 Km for the purpose of cost estimate.

The demolition of the existing headers and sub-headers for the existing WICs are detailed in Appendix-G.

9.2 Component-3B: Injection Network at Bu Hasa

9.2.1 Bu Hasa Injection Network – Design Basis

Currently Buhasa has 54 aquifer water injection clusters. Out of these 54 water injection clusters 29 shall be converted to seawater injectors. As shown in the figure 9.2-1 the clusters highlighted with yellow colour. Table provides the distinction between the clusters planned for Seawater injection and produced water re-injection.

Figure-9.2-1: BuHasa Field Layout with Sea Water Injection scope

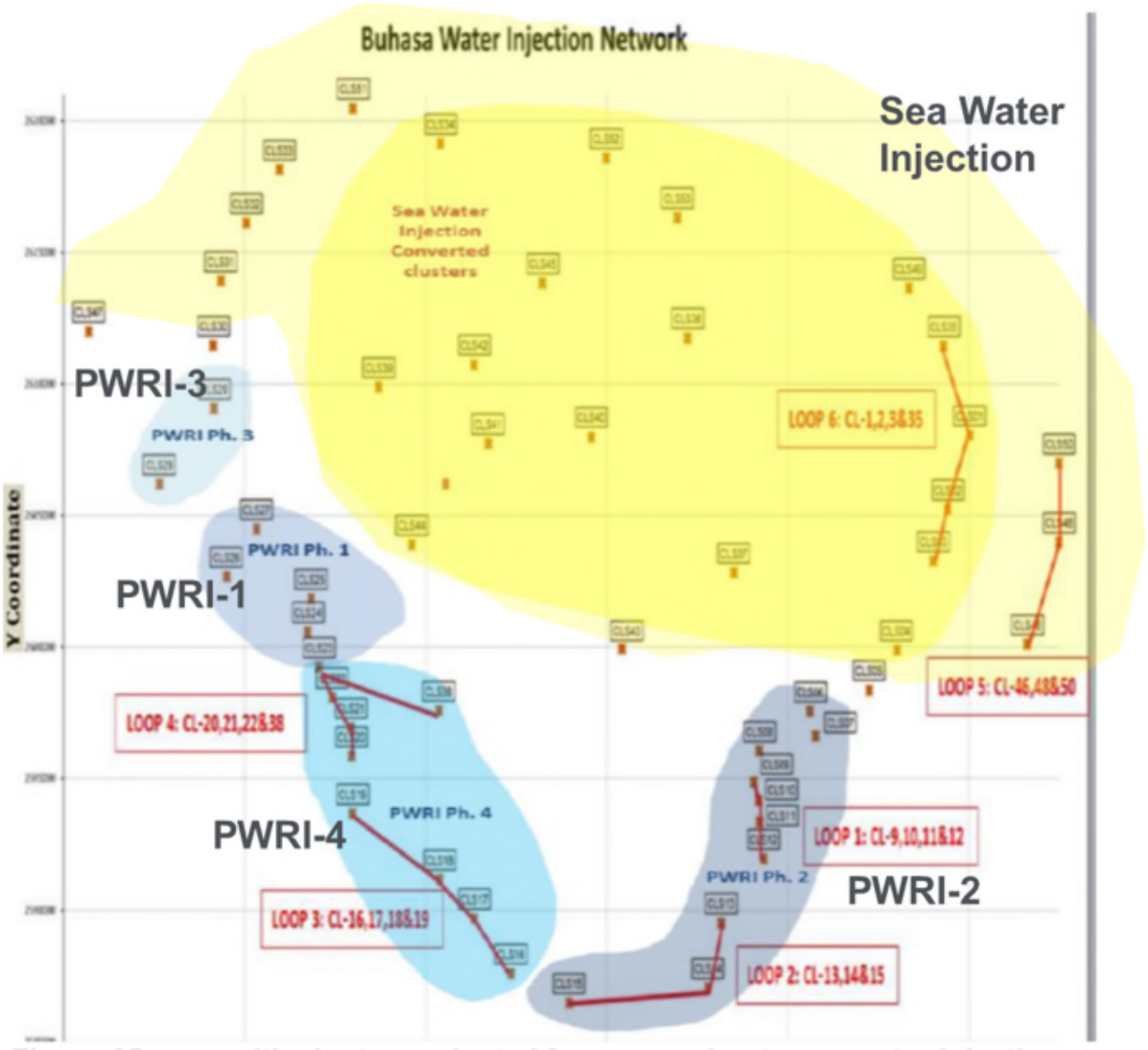


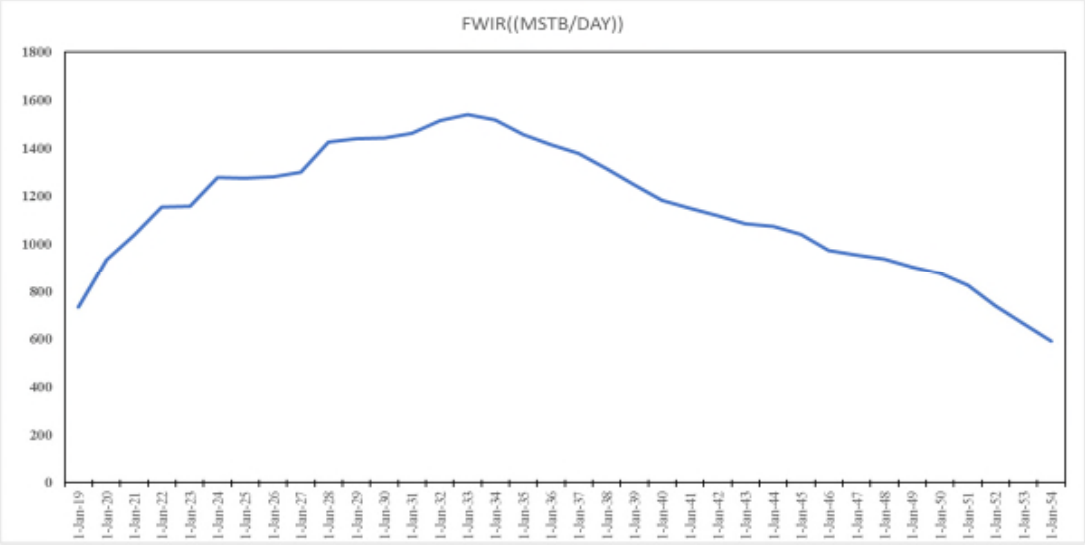
Table 9.2-1: Seawater and PWRI scope distribution

Cluster	PWRI (Phase #)	Peripheral / Non-Pattern	Loop #	SWI	Cluster	PWRI (Phase #)	Peripheral / Non-Pattern	Loop #	SWI
CL-01			6	SWI	CL-28	PWRI 3			
CL-02			6	SWI	CL-29	PWRI 3			
CL-03			6	SWI	CL-30		Peripheral		SWI
CL-04			6	SWI	CL-31		Peripheral		SWI
CL-05		Non-P		SWI	CL-32		Peripheral		SWI
CL-06	PWRI 2				CL-33		Non-P		SWI
CL-07	PWRI 2				CL-34				SWI
CL-08	PWRI 2				CL-35			6	SWI
CL-09	PWRI 2				CL-36				SWI
CL-10	PWRI 2				CL-37				SWI
CL-11	PWRI 2				CL-38	PWRI 4		4	
CL-12	PWRI 2				CL-39				SWI
CL-13	PWRI 2		2		CL-40				SWI
CL-14	PWRI 2		2		CL-41				SWI
CL-15	PWRI 2		2		CL-42				SWI
CL-16	PWRI 4		3		CL-43		(Th-F)		SWI
CL-17	PWRI 4		3		CL-44				SWI
CL-18	PWRI 4		3		CL-45				SWI
CL-19	PWRI 4		3		CL-46		Non-P	5	SWI
CL-20	PWRI 4		4		CL-47		Non-P		SWI
CL-21	PWRI 4		4		CL-48			5	SWI
CL-22	PWRI 4		4		CL-49				SWI
CL-23	PWRI 1				CL-50			5	SWI
CL-24	PWRI 1				CL-51		Peripheral		SWI
CL-25	PWRI 1				CL-52				SWI
CL-26	PWRI 1				CL-53				SWI
CL-27	PWRI 1				CL-54		Peripheral		SWI

The seawater supply pipeline from Mirfa-BAB will terminate at the edge of the Bu Hasa field near Cluster 49 (pipeline landing point). Therefore, any additional pipeline length required to transport the required injection seawater to the pumping station shall be the part of seawater injection network.

The total seawater injection capacity of the network is 1.5 MMBOWPD. As Shown in the figure below the overall injection requirement peaks around to 1.5 MMBOWPD in year 2033. Individual well wise injection profiles are provided in the Process Design Basis.

Figure 9.2-2: Bu Hasa Injection Profile



The low sulphate and de-aerated seawater at around 15 barg will be received at the pumping station. Where its pressure shall be increased to meet the injection pressure requirement at the wellhead. This water shall therefore be distributed across the Bu Hasa field through a fish-bone network comprising of Main headers, sub-headers and flow lines.

The maximum injection pressure of each injector well is 2500 psig. The discharge of seawater injection pumps is distributed into main headers, covering north, central and south portions of the Buhasa field. In addition to the main headers there will be several sub headers. The injection wells will be connected to either main header directly or the sub-header with a flowline.

9.2.2 Component-3B – BuHasa Injection Network: Option Identification

Two seawater injection network schemes were assessed on the basis of number of pumping stations. These are:

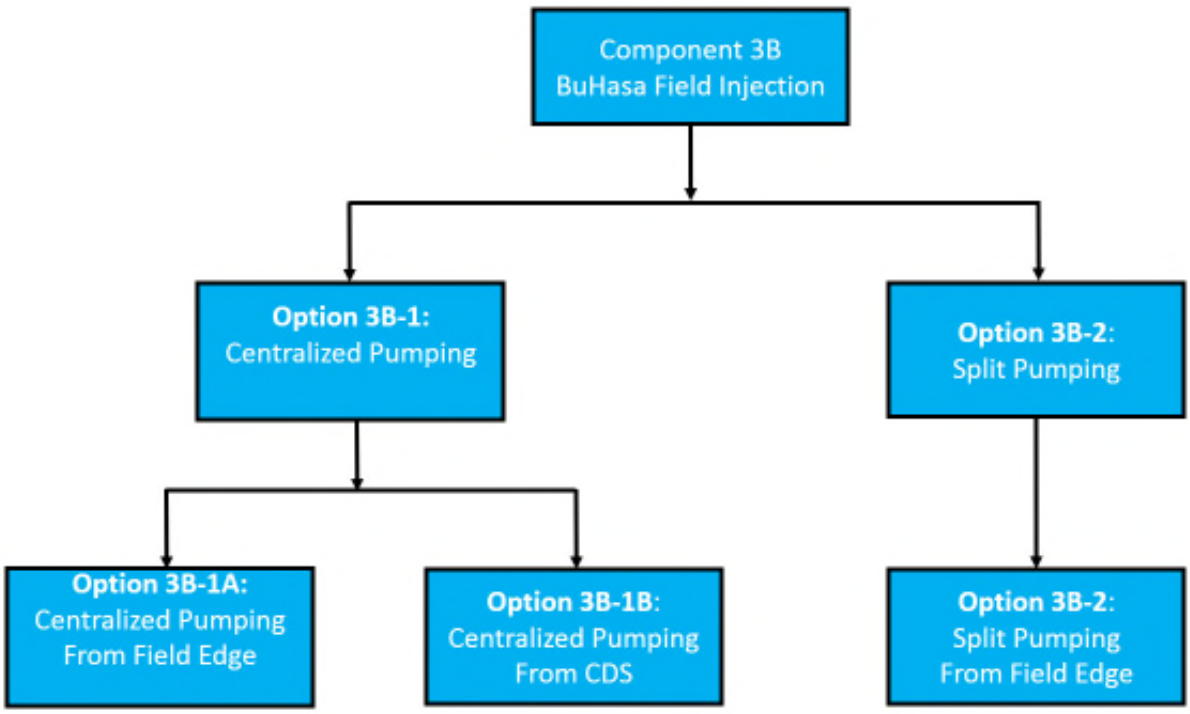
Option: Centralized Pumping 3B-1

The option of centralized pumping station was further divided into 2 options based on pumping station location and injection header orientation across the field:

1. Option 3B-1A:Centralized Pumping station at field Edge
2. Option 3B-1B:Centralized Pumping station at Buhasa CDS

Option: Split Pumping 3B-2

Figure 9.2-3: Option Tree for BuHasa Injection Network

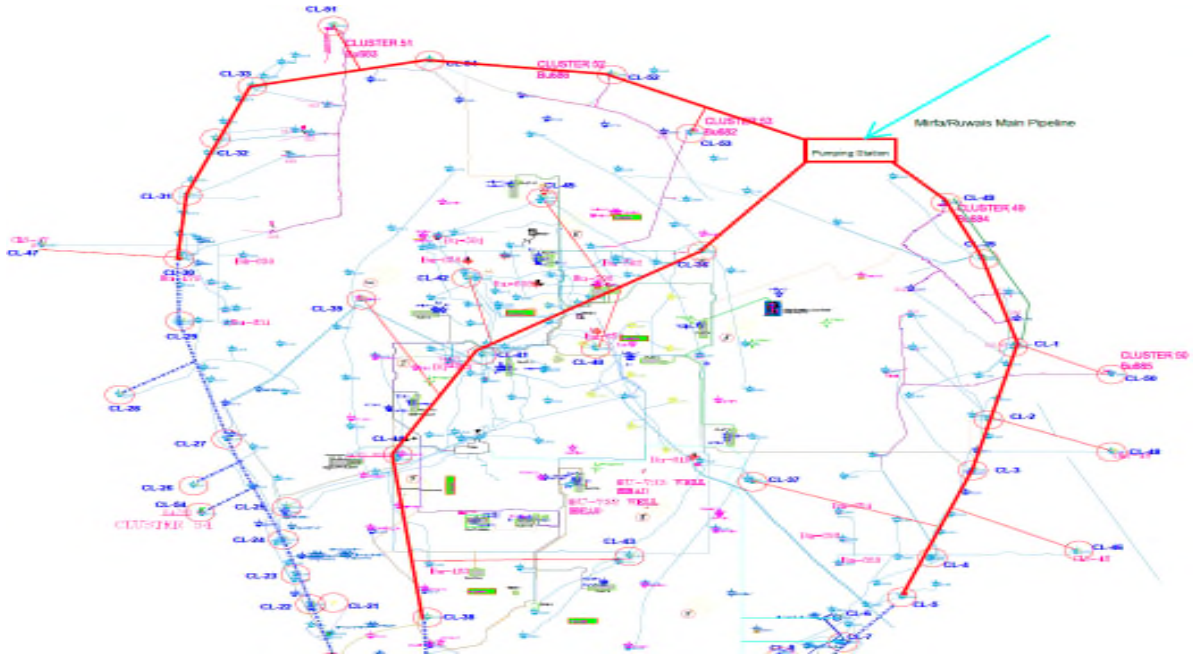


9.2.2.1 Option 3B-1 : Centralized Pumping

9.2.2.1.1 Option 3B-1A: Centralized Pumping From Field Edge

In this option, the location of the seawater injection pumping station is considered to be located at the seawater supply pipeline landing point near existing CLS-49. The seawater injection network will consist of three distinct main headers. The first main header in the north starts from existing cluster CLS-49 and terminates near CLS-29 covering the northern periphery of Bu Hasa field. The second main header covering the central region of Bu Hasa field starts from CLS-49 and terminates near CLS-25. The third main header in the south starts from existing cluster CLS-49 and terminates near CLS-5 & CLS-6 covering the southern periphery of Bu Hasa field. A simple schematic of this option is given below.

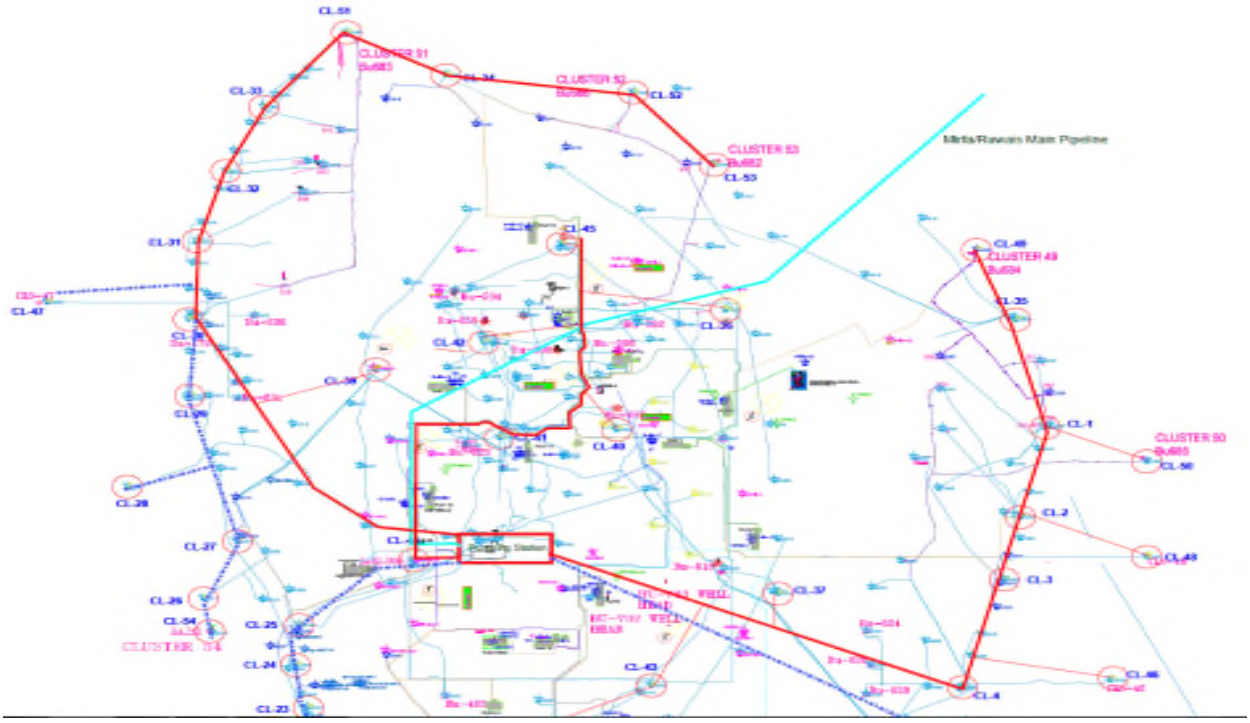
Figure 9.2-4: Field Layout for Option-3B-1A BuHasa Injection Network



9.2.2.1.2 Option Option 3B-1B: Centralized Pumping From CDS

In this option, the location of the seawater injection pumping station is considered to be located at the Bu Hasa CDS. The option will additionally include a portion of seawater supply pipeline from supply pipeline landing (CLS-49) to Bu Hasa CDS. The seawater injection network will consist of three distinct main headers. The first main header in the north starts from CDS and terminates near CLS-49 covering the northern periphery of Bu Hasa field. The second main header covering the central region of Bu Hasa field starts from CDS and terminates near CLS-45. The third main header in the south starts from CDS and terminates near CLS-35 covering the southern periphery of Bu Hasa field. A simple schematic of this option is given below in figure 9.2.5.

Figure 9.2-5: Field Layout for Option-3B-1B BuHasa Injection Network



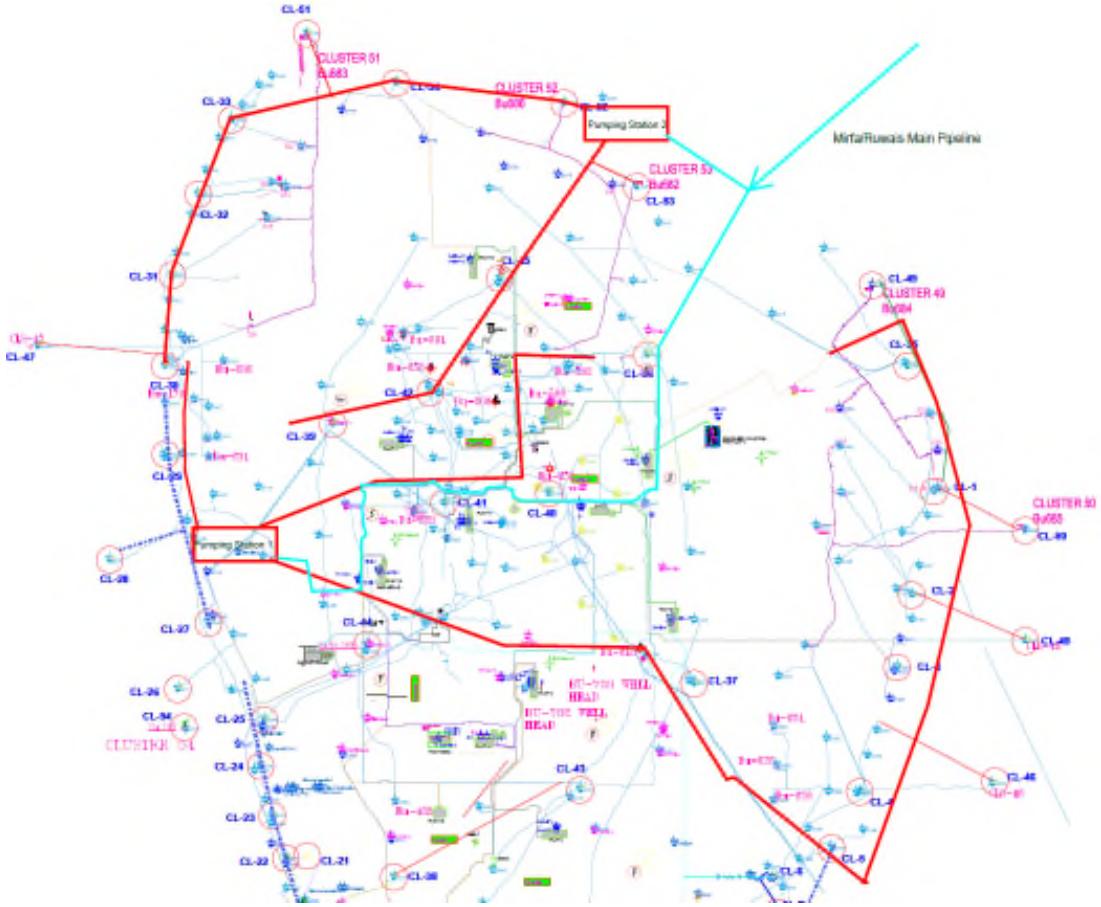
9.2.2.2 Option 3B-2: Split Pumping From Field Edge

This option, consists of having two seawater injection pumping stations. Pump station-2 is considered to be located near CLS-36 while pump station 1 is located diagonally opposite to PS-2 near CLS-28. The option will additionally include a portion of seawater supply pipeline (component-2) from PS-2 to PS-1. The seawater injection network connected with PS-1 will consist of three distinct main headers. The first main header in the north-west starts from PS-1 (CLS-28) and terminates near CLS-30 covering the north-west periphery of Bu Hasa field. The second main header from PS-1 covering the central region of Bu Hasa field starts from CLS-28 and terminates near PLAT-6. The third main header fed from PS-1 is in the center / south and starts from CLS-28 and terminates near CLS-35 covering the southern periphery of Bu Hasa field.

The seawater injection network connected with PS-2 will consist of two distinct main headers. The first main header starts from PS-2 (CLS-36) and terminates near CLS-32 covering the north periphery of Bu Hasa field. The second main header covering the central and portion of north-west region of Bu Hasa field starts from CLS-36 and terminates near CLS-30.

A simple schematic of this option is below in figure 9.2.6.

Figure 9.2-6: Field Layout for Option-3B-2 BuHasa Injection Network



9.2.3 Component-3B – BuHasa Injection Network: Option Selection

The capacity defining steady state case was simulated for the three options of injection networks using Schlumberger's PIPESIM® 2015.2 (version 2015.2.1031.0). This enabled to establish the sizes of main headers and sub headers. By the use of hydraulic study, the pumping requirement and number of pumps were determined.

In addition to this, pipeline lengths, plot space and electrical ancillaries required for each option was determined. A comparison table for all of the three options is presented below.

Table-9.2-2: Bu Hasa Option Comparison Table

	Option 3B-1A	Option 3B-1B	Option 3B-2
	Single Pumping Station at the Edge of Buhasa field	Single Pumping Station at Buhasa CDS	Dual Pumping Station 1st PS @ BuHasa field Edge 2nd PS @ Diagonally opposite to PS-1
Pipelines	Header-1: 28" 32.7 km Header-2: 28" 26.5 km Header-3: 24" 19.6 km	Header-1: 24" 37.3 km Header-2: 24" 21.4 km Header-3: 28" 32.4 km	Header-1: 14" 3.20 km Header-1: 20" 19.8 km Header-2: 20" 17.9 km Header-2: 20" 31.4 km Header-3: 28" 40.1 km
C-2 Pipeline	NR	48" 22.2 km	48" 7.8 km (From pipeline landing to PS-2) 40" 27.4 km (From PS-2 to PS-1)
Pumping Requirements	10W+2S 7.5 MW Disc. Pressure: 189.7 barg Capacity 154,000 BWPD	10W+2S 7.7 MW Disc. Pressure: 193.1 barg Capacity 154,000 BWPD	PS-1: 6W+1S PS-2: 4W+1S 7.5 MW Disc. Pressure: 186.2 barg Capacity 154,000 BWPD
Plot Space	168m x 18m	84m x 18m 84m x 18m	98m x 18m 70m x 18m
OHL	30km	40 km	70 km + 10 km
Substation	220 kV Compound 33 kV Substation (110mx45m)	220 kV Compound 33 kV Substation (110mx45m)	220 kV Compound 33 kV Substation (107mx25m) 33 kV Substation (78mx25m)

The electrical requirements for the three options are shown in table 9.2.3:

Table 9.2-3: Electrical scope for Bu Hasa C-3 options

	Option 3B-1A	Option 3B-1B	Option 3B-2
Power source from	New 220kV OHL D/C LINE from AWBU220S (TRANSCO) to New 220kV S/S)	New 220kV OHL D/C LINE from AWBU220S (TRANSCO) to New 220kV S/S	New 220kV OHL D/C LINE from AWBU220S (TRANSCO) to New 220kV S/S New 33kV OHL D/C D/C (AAAC 500 sq.mm. similar to BUH gas planet LINE)
Power demand	12 (10+2) Pump x 7700kW Near to CLS-49	12 (10+2) Pump x 7700kW at CDS Area	Bu-332: 7 (6+1) Pump x 7700kW Bu-751: 5 (4+1) Pump x 7700kW
OHL requirement	220kV OHL (Approx. 30km)	220kV OHL (Approx. 40km)	Bu-332: 220kV OHL (70 Km) Bu-751: 33KV OHL (10 Km)
Number of substation and size	S/S (110m x45m)	S/S (110mx45m)	Bu-332: S/S (107mx25m) Bu-751: S/S (78mx25m)
Equipment List	33KV HSWG through 2x120/150MVA 3.3kV HSWG through 10/12.5MVA 4 Nos. of 415V SWGR with 2.5MVA 12 Nos. VSD Systems	33KV HSWG through 2x120/150MVA 3.3kV HSWG through 10/12.5MVA 4 Nos. of 415V SWGR with 2.5MVA 12 Nos. VSD Systems	Bu-332: 33KV HSWG through 2x120/150MVA 3.3kV HSWG through 10/12.5MVA 4 Nos. of 415V SWGR with 2.5MVA 7 Nos. VSD Systems Bu-751: 33KV HSWG 3.3kV HSWG through 10/12.5MVA 4 Nos. of 415V SWGR with 2.5MVA 5 Nos. VSD Systems

The CAPEX comparison among Bu Hasa C-3 options are shown in table 9.6-4 below:

Table-9.2-3: BuHasa Options EPC cost summary

	Option-3B-1A	Option-3B-1B	Option-3B-2
	Single Pumping Station at the Edge of Buhasa field	Single Pumping Station at Buhasa CDS	Dual Pumping Station 1st PS @ BuHasa field Edge 2nd PS @ Diagonally opposite to PS-1
Pumping Station	330	327	337
Pipeline	119	131	145
Total	**449**	**458**	**482**
Add. C-2 Scope	-	47.5	66
Grand Total	**449**	**505.5**	**548**

It can be seen that the Single Pump Station at Periphery (Option-3B-1A) is the lowest CAPEX option.

Options selection workshop was conducted involving all key stakeholders. All the three options were rated on the basis of drivers defined in section 9.0. Table 9.2-4 shows the ratings of the three options.

Table-9.2-4: Option Ratings Table

Driver/Criteria	%	Option-3B-1A Field Periphary			Option-3B-1B CDS			Option-3B-2 Split Pumping		
			Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	10		5	10		5	10		5	10
(CAPEX)	20		5	20		4	16		3	12
(OPEX)	15		5	15		5	15		5	15
Maintenance	10		4	8		5	10		3	6
Risks	10		5	10		4	8		5	10
Area / Plot Availability	5		5	5		4	4		5	5
Constructibility	10		5	10		4	8		3	6
Operatibility	10		4	8		5	10		3	6
Decongestion	10		5	10		4	8		5	10
Ranking	**100**		**96**			**89**			**80**	

Bu Hasa Injection Network Conclusion:

Based on the evaluation, it can be seen that “Option 3B-1A – Centralised Pumping from Field Edge“ has higher technical and economical merits and is accordingly selected. Detailed network configuration, i.e. header, sub-headers and flowlines, is shown in Appendix-H.

9.2.4 Component-3B – BuHasa Injection Network: Demolition Scope

As part of the conversion of Bu Hasa field to sea water injection with the exception to existing PWRI scheme 1,2,3 & 4, table 9.2-5 below provides the number of water injection clusters, supply wells and disposal wells to be demolished:

Table 9.2-5: Quantification of demolition scope for Existing Bu Hasa water injection system

Cluster Count	Clusters Tags	Supply Wells	Disposal Wells	Remarks
29	001, 002, 003, 004, 005, 030, 031, 032, 033, 034, 035, 036, 037, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 051, 052, 053, 054	29	29	All clusters except PWRI clusters: refer to table 9.2.1.

9.3 Component-3C: Injection Network at Dy

9.3.1 Dabbiya Injection Network - Design Basis

Dabbiya field has a combination of onshore and offshore areas where a total of 4 offshore clusters (A,B,V & U) and 26 Onshore clusters having WAG injection wells fed by a centralized water injection system through dedicated water injection network. The total number of the existing injection wells (excluding P5 and infill development) is 100 wells. Refer to figure 9.3-1 for the overall field map of Dabbiya:

Figure 9.3-1 Dabbiya Islands

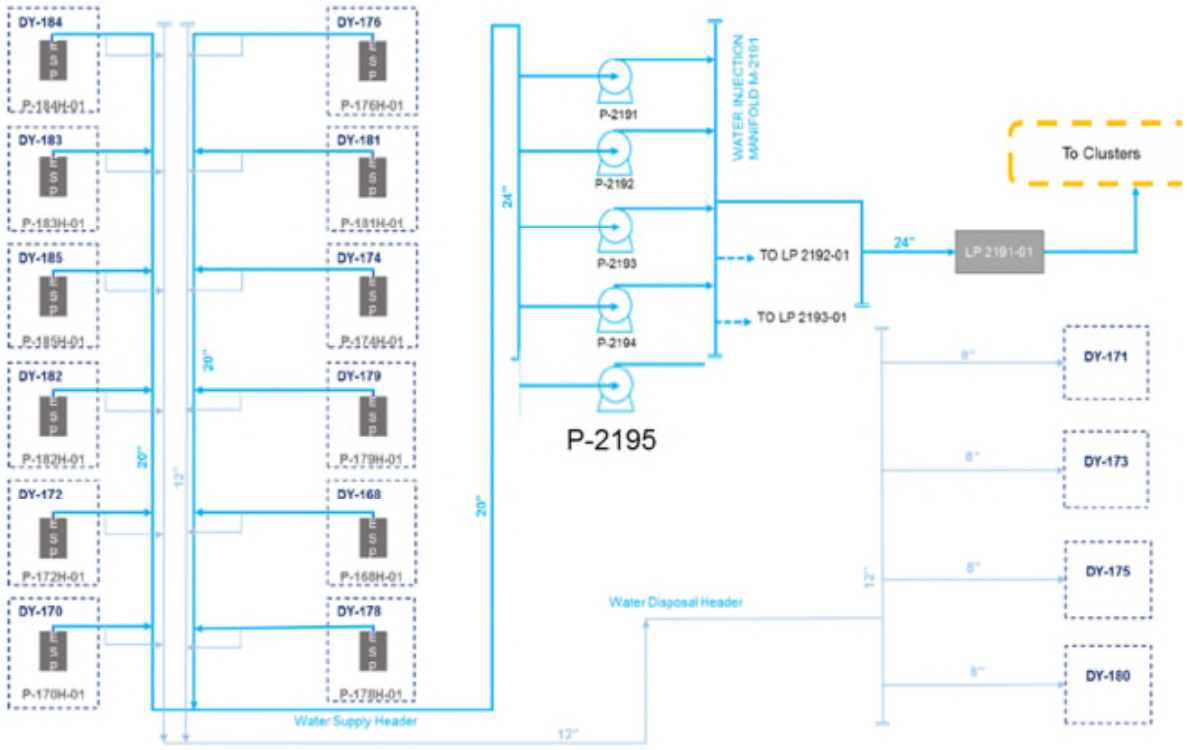


The following areas compromise the main Dabbiya islands:

1. Qusabi Island: CLS-AA,CLS-A,CLS-B,CLS-F & CLS-V
2. Rafayeq Island : CLS-Y,CLS-CC,CLS-M,CLS-N,CLS-L & CLS-K
3. Bu Labyad: CLS-Q,Z,S,T,U,DD,EE
4. North East Area:CLS-W,CLS-E & CLS-D
5. Bu Sharah Island: CLS-J,CLS-H,CLS-FF

The concept design of component-3 for Dabbiya field considers two main categories for the design of the water injection network. Existing water injection system in Dabbiya field is based on centralized injection where the following water injection system is installed in the CPP:

Figure 9.3-2: Existing Water Injection system in DY CPP Phase III



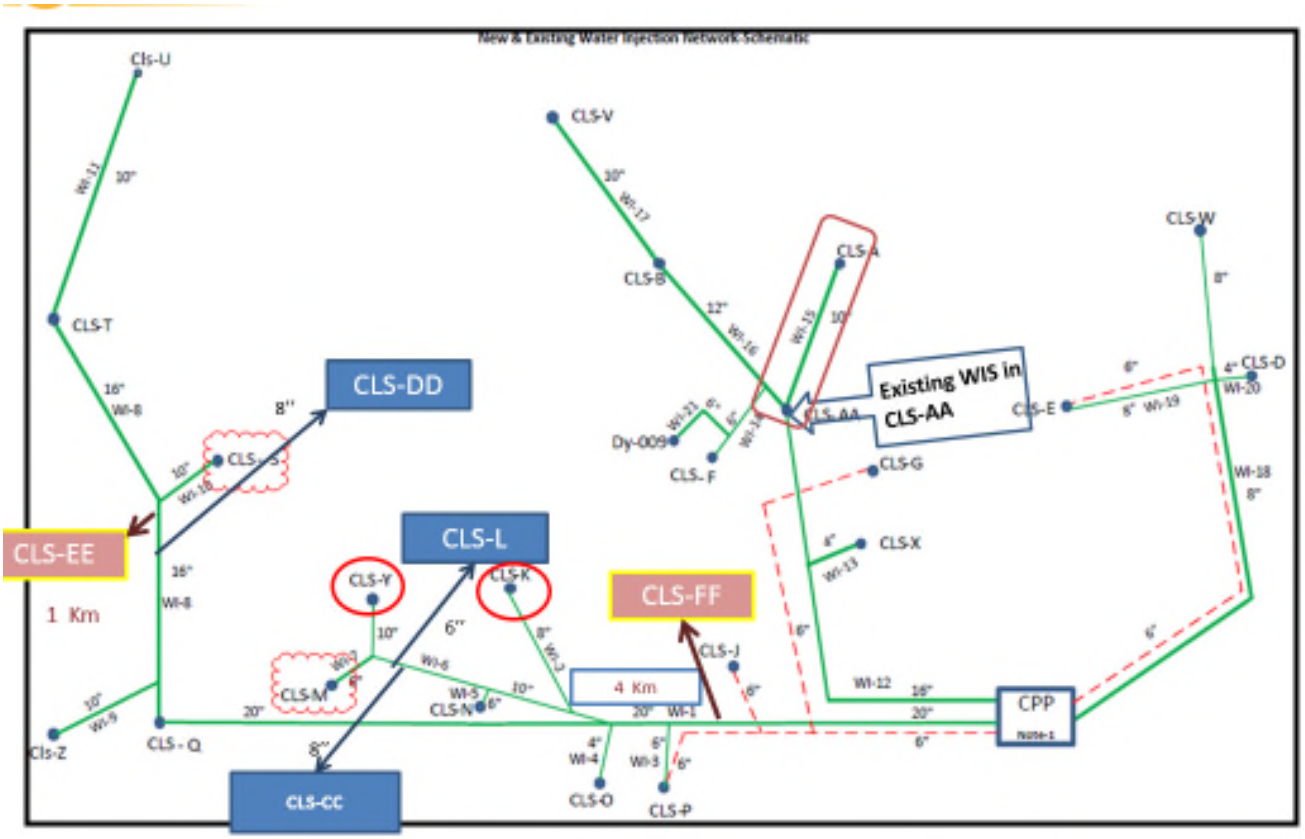
There are 5 x 25% existing water injection pumps designed for a rated capacity of 67 MBWPD and a rated differential head of 1143 meters (suction pressure of 27 barg and discharge pressure of 160 barg). Three out of the 4 pumps are under VSD control while P-2195 is a fixed speed pump. Refer to existing Phase III performance curve attached in Appendix-H.

Additionally, there are 3x50% pumps in CPP Phase I feeding Phase I clusters E,J,P & G, each pump having a rated capacity of 14 MBWPD and a rated differential head of 1352 meters.

Accordingly, the available water injection pumping requirement in CPP is 296 MBWPD. It is important to note that in order to utilize the existing pumps, the design of component-2 supply pipeline shall ensure meeting the minimum suction pressure requirement at CPP phase III pumps of 27 barg.

Refer to figure 9.3.3 below for the existing water injection network of Dabbiya field. Phase I and Phase III injection networks are interconnected at clusters E & P. Existing Cluster-R is not shown as part of the below network as it is an existing self-supplied water injection cluster having one water supply well distributing water injection to DY-22 & DY-24. This cluster will be supplied with seawater for injection as part of project's scope.

Figure 9.3-3: Existing Water Injection Pipeline Network



As part of ongoing EPC for Dabbiya transition zone B Phase I which has RDS in Q1-2021, a de-centralized water injection system is planned to be installed in CLS-AA to feed it along with CLS-A. A new VSD pump is installed as part of the aforementioned project's scope of a rated capacity of 44 MBWPD. As part of seawater injection scope, CLS-AA will be fed from the centralized existing water injection system and no de-centralized aquifer water injection system is applicable. Refer to Section 9.3.9 for the estimation of the demolition scope for the existing aquifer water injection in Dabbiya.

The design of the seawater injection network considers maximizing the utilization of the existing network. The seawater injection profile rates requirements are shown in figure 9.3-4 below (including all the following Dabbiya developments):

a- Dabbiya Phase I, II, III (existing)

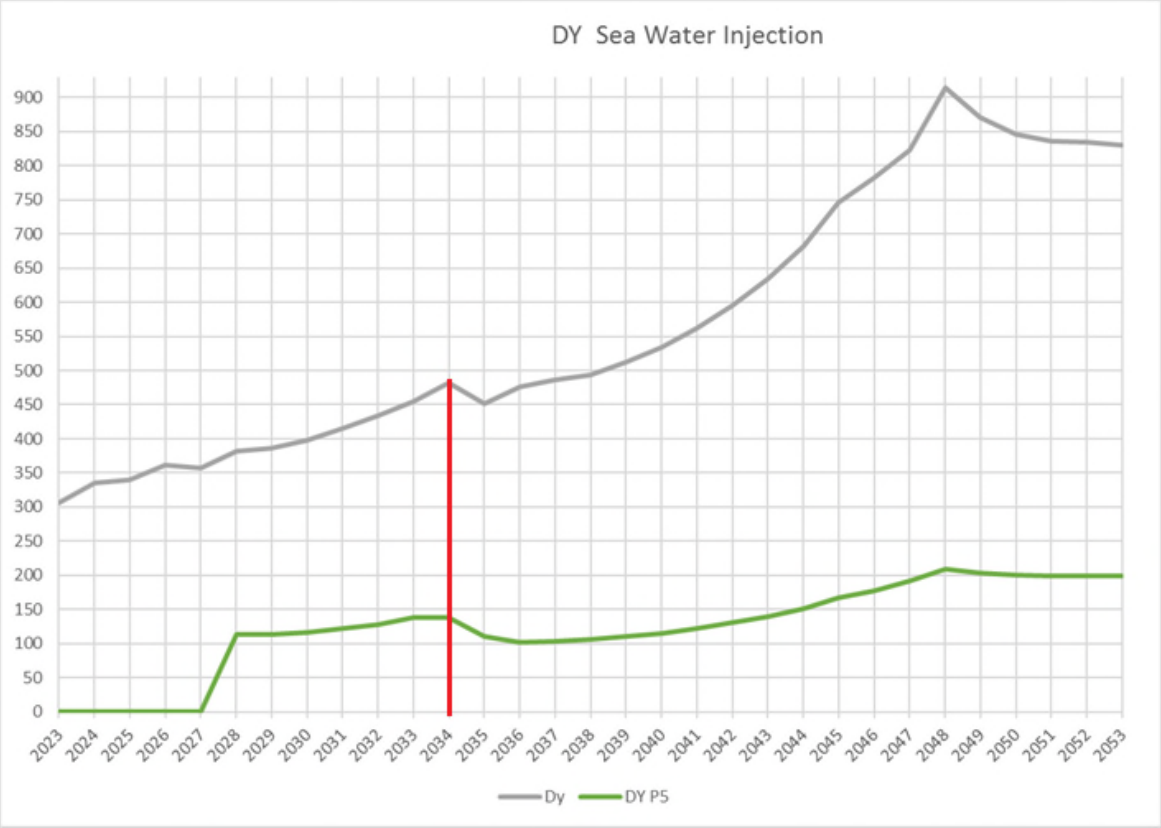
b- Dabbiya transition zone B PhaseI (RFC-2021)

c- Dabbiya transition zone B Phase II (RFC-2024)

d- Dabbiya infill development (RFC-2026)

e- Dabbiya P5 development (RFC-2028)

Figure 9.3-4: Dabbiya Seawater injection profile



The peak sea water injection demand is 914 MBWPD (inclusive of P5) in year 2048.The design and investment of component-3 sea water injection network for Dabbiya will be based on a phased scheme involving current project's EPC scope and deferred future scope.

9.3.2 Component-3C – Dy Injection Network: Options Identification

Various options were addressed for the design of Dabbiya component-3 injection network. Options are mainly sub-categorized into:

a- Centralized injection pumping at CPP following the existing injection scheme explained in section 9.3.1.

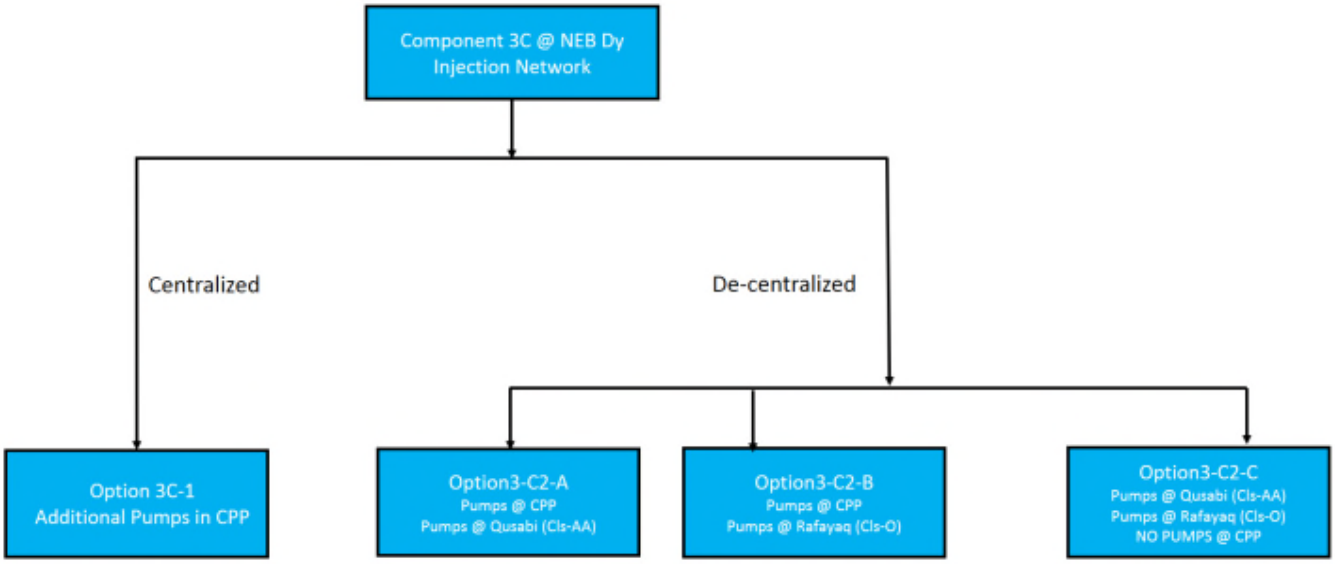
b- A combination of centralized injection pumping in CPP and de-centralized injection in specific Dabbiya islands.

c- Focusing on the remote de-centralized pumping with no additional water injection pumping revamps in CPP.

The various options considered for Component-3C (Injection network at NEB Dy) are as follows and reflected in figure 9.3-5 below:

1. Option 3C1 : Centralized Pumping
   a. Option 3C-1: Additional Pumps in CPP
2. Option 3B-2 : Split Pumping
   a. Option 3C-2A: Pumps at CPP Pumps at Qusabi (Cls-AA)
   b. Option 3C-2B: Pumps at CPP Pumps at Qusabi (Cls-AA) Pumps at Rafayaq (Cls-O)
   c. Option 3C-2C: Pumps at CPP Pumps at Rafayaq (Cls-O)

Figure 9.3-5: Options tree for Dabbiya C-3



Each option was evaluated in accordance with the drivers explained in section 9.

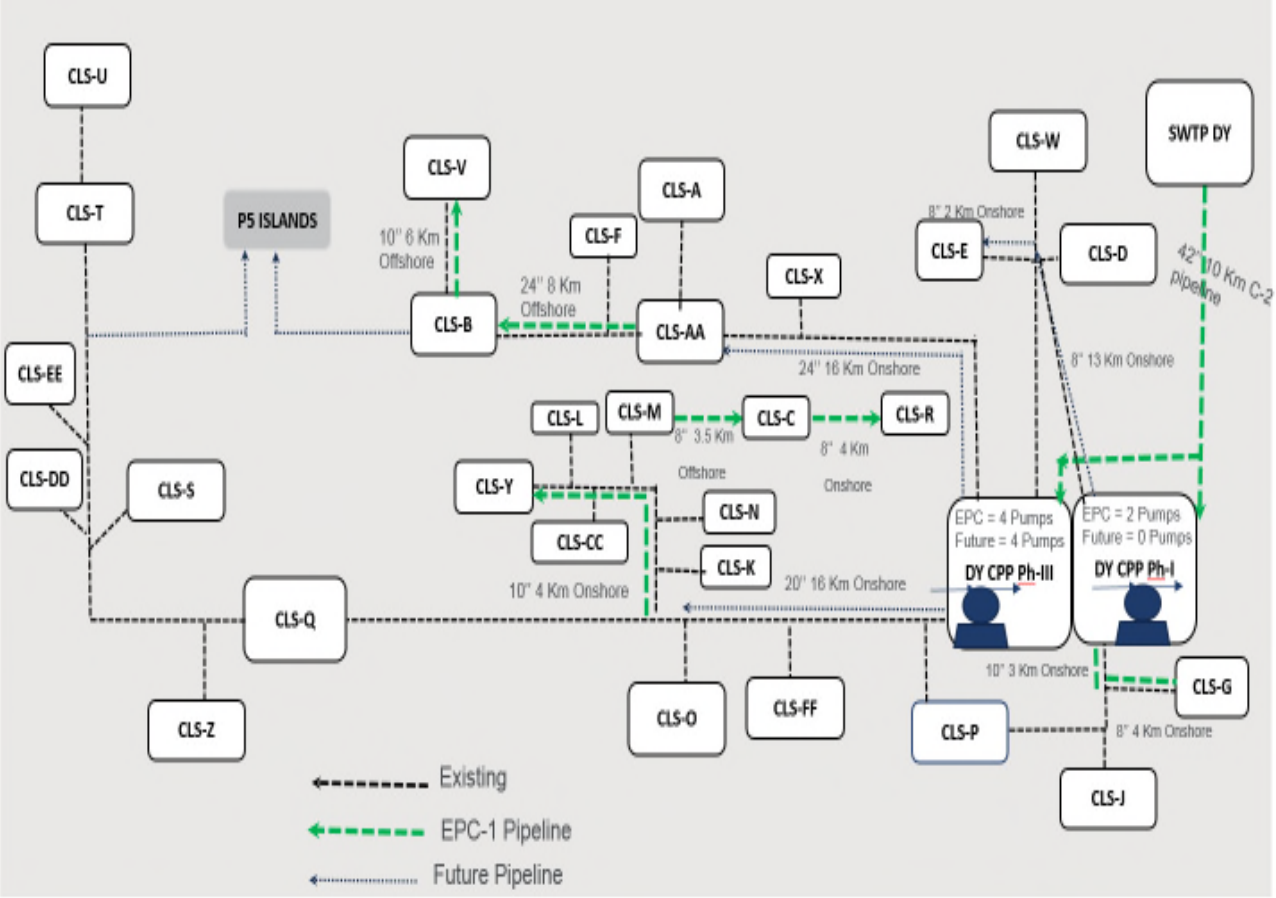
9.3.2.1 Dy Option 3C-1 : Centralized Pumping

In Option -3C-1, additional pumps considered in CPP and associated injection facilities are considered. However, de-bottlenecking of the existing water injection network is required in order to full fill the minimum wellhead injection pressure required at the injection wells, which is confirmed by development to be 2000 psig.

As can be seen from the water injection profile below, phasing of the investment of component-3 is required considering the peak water injection load occurs in year 2048 with a rate of 914 MBWPD. The first phase of investment to be executed in year 2023. The phased future investment is deferred to year 2034 which will cover the full profile injection requirements.

Refer to figure 9.3-7 for the details of the phasing of the injection pipeline and pumps:

Figure 9.3-7: Option 3C-1 Centralized pumping Facilities requirements



Required Modifications for the existing W.I header approach to DY CPP shall be studied during next engineering phase due to C2 component approach for the sea water line coming from SWTP to DY CPP and the line from DY CPP to Ra CPP. Refer to Appendix-I for DY CPP plot plan and proposed modification to existing W.I line.

Table 9.3-1 below summarizes the full C-3 pipeline requirement for option 3C-1:

Table 9.3-1: Option 3C-1 Dabbiya pipeline scope details

	From	To	SIZE (in)	Length (km)			Notes
				Onshore	Offshore	Total	
Phase-I Requirements							
1	DY CPP (P-I P/L)	CLS-07 (G)	8”	7.4	1.6	9	
2	CLS-27 (AA)	CLS-02 (B)	24’’	2.7	6.3	9	
3	CLS- 2(B)	CLS-22 (V)	10”	0	7	7	
4	Branch from existing Main Header from CPP to CLS-15 (Q)	CLS-25 (Y)	10”	4.5	0	4.5	
5	Branch from the main header going to CLS-12 (M)	CLS-03 (C)	8”	2.5	1.5	4	
6	CLS-3 (C)	CLS-R	8”	0.5	4.5	5	Note-1
7	Pumps: 3+1 pumps each 120 MBWPD with a discharge pressure of 165 barg to be connected with the existing 5x25% phase III pumps.						Note-2
8	Pumps: 1+1 pump of 30 MBWPD with a discharge pressure of 162 barg to be connected with the existing 3x50% phase I pumps.						
Future Requirement							
9	CPP Phase III	CLS-27(AA)	24’’	5	6	13	
10	CPP Phase III	CLS-19(O)	20’’	4	12	16	
11	Branch from main header	CLS- E	8’’	1.668	-	1.668	
12	Pumps: 3 x 120 MBWPD pumps with a discharge pressure of 165 barg						Note-2

Note 1: The space availability in CLS-03 (C) for wenching or pulling area, and constructability of the shallow water injection line shall be studied during next engineering phase.

Note-2: The estimated number of pumps consider the derating of the existing Phase III pumps from 67 MBWPD to 60 MBWPD due to the increase in differential head from 1143 m to 1200 m as a result of the increase in the required discharge pressure from 160 barg to 165 barg. Suction pressure shall be maintained at 27 barg.

Refer to Dabbiya field layout in Appendix-J.

9.3.2.2 Option 3C-2A: Pumps at CPP Pumps at Qusabi (Cls-AA)

In Option -3C-2A, additional pumps in CPP and Qusabi (Cls-AA) and associated injection facilities are considered. This enables de-coupling existing Qusabi area from the existing centralized water injection system by adding dedicated centralized pumping at CLS-AA to feed the following clusters: CLS-A,CLS-AA,CLS-B,CLS-V & future P5 clusters.

This option differs from the centralized option 3C-1 with respect to the following:

a- Additional component-2 sea water supply pipeline required to tie-in with CLS-AA pumping system (30'' 24 Km).

b- Future parallel pipeline from CPP Phase III to CLS-AA is not required.

Refer to figure 9.3-8 below for the schematic showcasing the phased requirements for option 3C-2A:

Figure 9.3-8: Option 3C-2A Split pumping Facilities requirements (Qusabi/CPP)

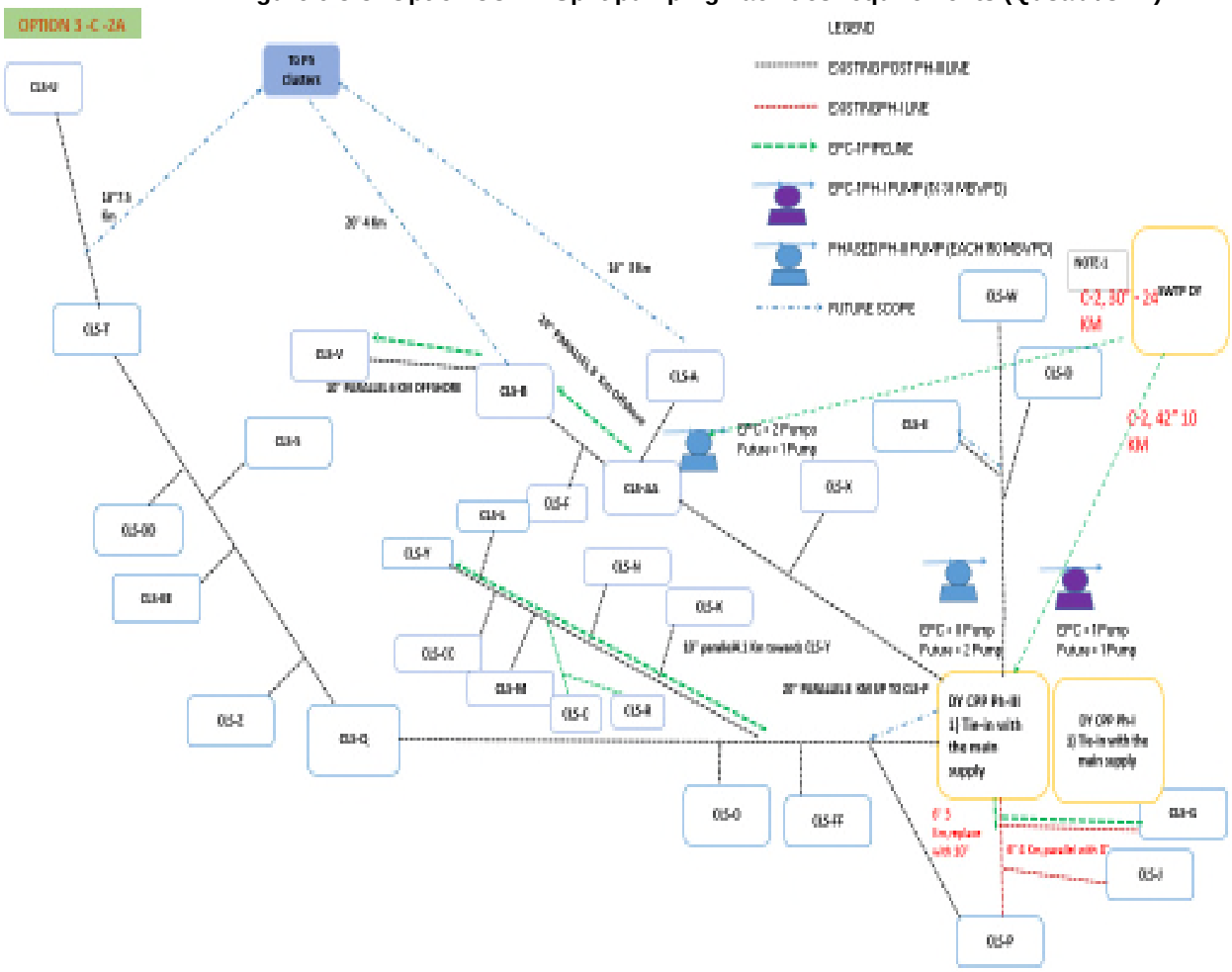


Table 9.3-2 below summarizes the full C-3 pipeline requirement for option 3C-2A:

Table 9.3-2: Option 3C-2A pipeline requirements

	From	To	SIZE (in)	Length (km)			Notes
				Onshore	Offshore	Total	
Phase-I Requirements							
1	DY CPP	CLS-07 (G)	8”	7.4	1.6	9	
2	CLS-27 (AA)	CLS-02 (B)	24’’	2.7	6.3	9	
3	CLS- 2(B)	CLS-22 (V)	10”	0	7	7	
4	Branch from existing Main Header from CPP to CLS-15 (Q)	CLS-25 (Y)	10”	4.5	0	4.5	
5	Branch from the main header going to CLS-12 (M)	CLS-03 (C)	8”	2.5	1.5	4	
6	CLS-3 (C)	CLS-R	8”	0.5	4.5	5	Note- 1
7	Pumps: 2+1 pumps each 150 MBWPD with a discharge pressure of 163 barg to be installed in CLS-AA						
8	Pumps: 1+1 pumps of 30 MBWPD with a discharge pressure of 162 barg to be connected with the existing 3x50% phase I pumps						
Future Pipeline Requirement							
9	CPP Phase III	CLS-19(O)	20’’	4	12	16	
10	Branch from main header	CLS- E	8’’	1.668	-	1.668	
11	Pumps: Additional 1 x 150 MBWPD pump in CLS-AA with a discharge pressure of 163 barg						

Note-1: The space availability in CLS-03 (C) for wenching or pulling area, and constructability of the shallow water injection line shall be studied during next engineering phase.

9.3.2.3 Option 3C-2B: Pumps at CPP & Pumps at Rafayaq (Cls-O)

In Option -3C-2B, additional pumps considered in CPP along with Rafayeq Island, which involves existing clusters: CC, N, L, M, O, K & Y.

This enables de-coupling existing Rafayeq area from the existing centralized water injection system by adding dedicated centralized pumping at CLS-O to feed the following clusters: CLS-M, CLS-CC, CLS-L, CLS-N, CLS-K, CLS-C, CLS-R & CLS-Y.

This option differs from the centralized option 3C-1 with respect to the following:

1) Additional component-2 sea water supply pipeline required to tie-in with CLS-O pumping system (30'' 27 Km).
2) Future parallel pipeline from CPP Phase III to CLS-O is not required.

Figure 9.3-9: Option 3C-2B Split pumping Facilities requirements

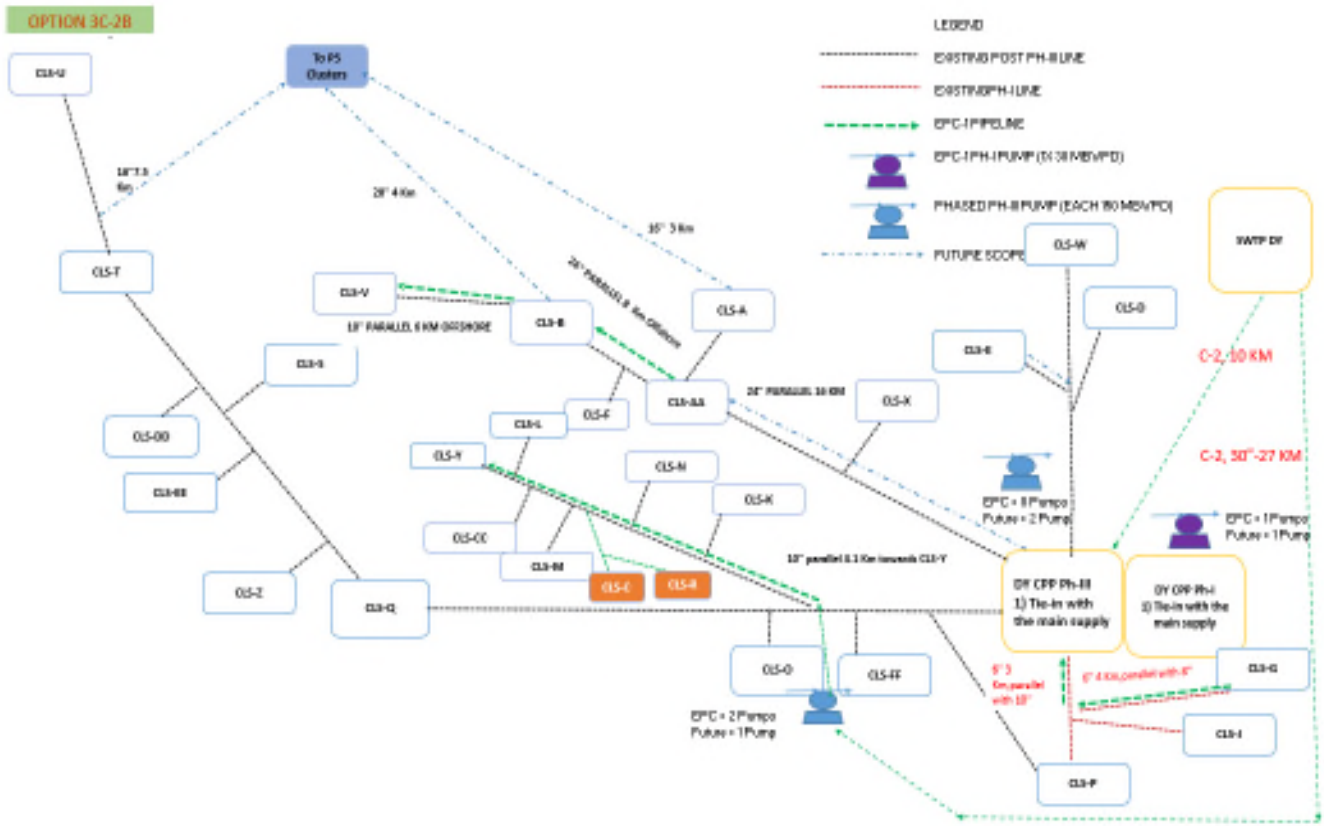


Table 9.3-4 below summarizes the full C-3 pipeline requirement for option 3C-2B:

Table 9.3-4: Option 3C-2B pipeline requirements

	From	To	SIZE (in)	Length (km)			Notes
				Onshore	Offshore	Total	
Phase-I Requirements							
1	DY CPP	CLS-07 (G)	8”	7.4	1.6	9	
2	CLS-27 (AA)	CLS-02 (B)	24’’	2.7	6.3	9	
3	CLS- 2(B)	CLS-22 (V)	10”	0	7	7	
4	Branch from existing Main Header from CPP to CLS-15 (Q)	CLS-25 (Y)	10”	4.5	0	4.5	
5	Branch from the main header going to CLS-12 (M)	CLS-03 (C)	8”	2.5	1.5	4	
6	CLS-3 (C)	CLS-R	8”	0.5	4.5	5	Note-1
7	Pumps: 2+1 pumps each 150 MBWPD with a discharge pressure of 163 barg to be installed in CLS-O						
8	Pumps: 1+1 pumps of 30 MBWPD with a discharge pressure of 162 barg to be connected with the existing 3x50% phase I pumps						
Future Requirements							
9	CPP Phase III	CLS-27(AA)	24’’	5	6	13	
9	Branch from main header	CLS- E	8’’	1.668	-	1.668	
10	Pumps: 1 additional pump in CLS-O with a capacity of 150 MBWPD and with a discharge pressure of 163 barg						
11	Pumps: 2+ 1 MBWPD pumps at CPP Phase III each 120 MBWPD with a discharge pressure of 165 barg						

Note-1: The space availability in CLS-03 (C) for wenching or pulling area, and constructability of the shallow water injection line shall be studied during next engineering phase.

9.3.2.4 Option 3C-2C: Pumps at Rafayaq (Cls-O) & Qusabi (CLS-AA)

In Option -3C-2C , no pumps are added in CPP Phase III while the de-bottlenecking of the pumping capacity is focused on Qusabi and Rafayeq areas.

This option differs from the centralized option 3C-1 with respect to the following:

a- Additional component-2 sea water supply pipeline required to tie-in with CLS-O pumping system (30'' 27 Km).

b- Additional component-2 sea water supply pipeline required to tie-in with CLS-AA pumping system (30'' 24 Km).

c- Future parallel pipeline from CPP Phase III to CLS-O is not required.

d- Future parallel pipeline from CPP Phase III to CLS-AA is not required.

Refer to figure 9.3-10 below for the schematic showcasing the phased requirements for option 3C-2C:

Figure 9.3-10: Option 3C-2C Phased Requirements

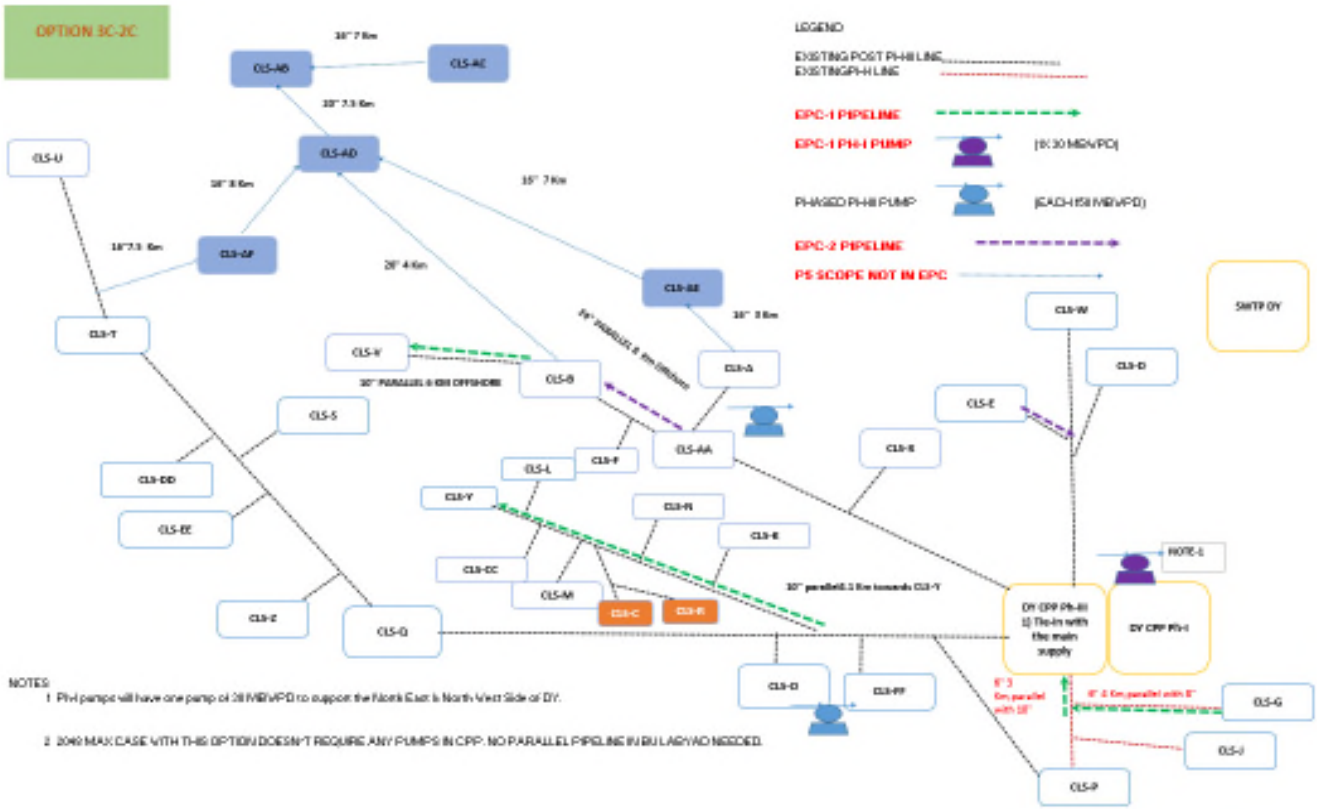


Table 9.3-5 below summarizes the full C-3 pipeline requirement for option 3C-2C:

Table 9.3-5: Option 3C-2C pipeline requirement

	From	To	SIZE (in)	Length (km)			Notes
				Onshore	Offshore	Total	
Phase-I Requirements							
1	DY CPP	CLS-07 (G)	8”	7.4	1.6	9	
2	CLS- 2(B)	CLS-22 (V)	10”	0	7	7	
3	Branch from existing Main Header from CPP to CLS-15 (Q)	CLS-25 (Y)	10”	4.5	0	4.5	
4	Branch from the main header going to CLS-12 (M)	CLS-03 (C)	8”	2.5	1.5	4	
5	CLS-3 (C)	CLS-R	8”	0.5	4.5	5	Note- 1
6	2+1 standby pump each 150 MBWPD with a discharge pressure of 163 barg to be installed in CLS-O						
7	2+1 standby pump each 150 MBWPD with a discharge pressure of 163 barg to be installed in CLS-AA						
8	1+1 standby pump of 30 MBWPD with a discharge pressure of 162 barg to be connected with the existing 3x50% phase I pumps						
Future Requirements							
9	CLS-27 (AA)	CLS-02 (B)	24”	2.7	6.3	9	
10	Branch from main header	CLS- E	8’’	1.668	-	1.668	
11	Pumps: 1 additional pump in CLS-O with a capacity of 150 MBWPD and with a discharge pressure of 163 barg.						
12	Pumps: 1 additional pump in CLS-AA with a capacity of 150 MBWPD and with a discharge pressure of 163 barg						

Note-1: The space availability in CLS-03 (C) for wenching or pulling area, and constructability of the shallow water injection line shall be studied during next engineering phase.

9.3.3 Component-3C – Dy Injection Network: Option selection

Based on the concept study outcomes reflected in above sections for each of the Dabbiya centralized and de-centralized options, table 9.3.6 below provides an overall comparison between the two options with respect to various design aspects, the table highlight the ultimate project's requirements including future scope:

Table 9.3-6: Options Comparison Summary for DY Component-3

	Option 1	Option 2A	Option 2B	Option 2C
Description	Fully Centralized at CPP	Split Pumping at CPP + Qusabi (CLS-AA)	Split Pumping at CPP + Rafayeq (CLS-O)	Remote Pumping at Qusabi (CLS-AA) + Rafayeq (CLS-O)
Pipelines	36 Km Onshore 14 Km Offshore	12 Km Onshore 14 Km Offshore	20 Km Onshore 14 Km Offshore	4 Km Onshore 14 Km Offshore
Add. C2 Pipeline	-	24 Km	27 Km	51 Km
Total Pipeline	36 Km Onshore 14 Km Offshore	36 Km Onshore 14 Km Offshore	47 Km Onshore 14 Km Offshore	55 Km Onshore 14 Km Offshore
No. of Pumps	7 pumps at CPP + 2 S (29MW)	3 pumps at CLS-AA+1 S 3 pumps at CPP +2 S (29 MW)	3 pumps at CLS-O+1 S 3 pumps at CPP +2 S (29 MW)	3 pumps at CLS-O+1 S 3 pumps at CLS-AA +1S 1 Pump at CPP + 1 S (38 MW)

For the details of the phasing of the investment of the required pumps and pipeline, refer to table 9.3-7 below:

Table 9.3-7: Comparison among the various options for DY C-3

PHASES OF INVESTMENT				
EPC-1 (2023 UP TO 2033)				
OPTION IDENTIFIED	OPTION A FULLY CENTRALIZED @ CPP	OPTION B CENTRALIZED @ CPP +QUSABI	OPTION C CENTRALIZED @ CPP+ RAFAEQ/BU LABYAD	OPTION D CENTRALIZED @ Qusabi+ RAFAEQ/BU LABYAD NO CPP Pumps
Total Number of Pipeline Paralleling Required	Qusabi : 14 Km Offshore Rafayeq: 10" 4 Km Onshore	Rafayeq: 10" 4 Km Onshore	Qusabi : 14 Km Offshore Rafayeq: 10" 4 Km Onshore	Rafayeq: 10" 4 Km Onshore Qusabi : 6 Km from B to V
Number of Tie-ins	1 @ CPP	2 @ CPP & CLS-AA	2 @ CPP & CLS-O	2 @ CLS-O and CLS-AA
Number of Pumps with Capacity MBWPD/Discharge Pressure barg	(2+1 spare) X120 MBWPD @ CPP Discharge pressure= 165 barg	2 x 150 MBWPD @ CLS-AA Discharge Pressure=163 barg Ph-III pumps in operation (NOTE)	2 x 150 MBWPD @ CLS-O Discharge Pressure=163 barg Ph-III pumps in operation (NOTE)	2 x 150 MBWPD @ CLS-O 2 x 150 MBWPD @ CLS-AA Discharge Pressure=164 barg Ph-III pumps in operation (NOTE)
EPC-2 POST 2033				
Total Number of Pipeline Paralleling Required	Qusabi : **16 Km onshore** **Bu Labyad : 20" 16 km Onshore**	Qusabi : 14 Km Offshore **Bu Labyad : 20" 8 km Onshore**	Qusabi : **16 Km onshore**	Qusabi : 8 Km from AA to B Offshore
Number of Pumps with Capacity MBWPD/Discharge Pressure barg	additional 3 x120 MBWPD@ CPP Discharge pressure= 162 barg	1 additional pump @ CLS-AA 150 MBWPD additional 2+ 1 spare pump @ CPP 120 MBWPD	additional 1x150 pump @ CLS-O additional 2 pump @ CPP 120 MBWPD	additional 1x150 pump @ CLS-O additional 1x150 pump @ CLS-AA
Total number of pumps by 2048	*6 pumps @ CPP+ 1 spare (Additional*	*3 pumps @ CLS-AA + 1 spare 2 pumps @ CPP + 1 spare*	*3 pumps @ CLS-O + 1 spare 2 pumps @ CPP + 1 spare*	*3 pumps @ CLS-O + 1 spare 3 pumps @ CLS-AA + 1 spare*
COMMON C-3 PUMPING REQUIREMENTS	*1 + 1 Spare X 30 MBWPD in CPP Ph-I connecting in parallel with the existing Ph-I pumps*			
COMMON C-3 Pipeline Required in all Options (EPC-1)	*Parallel 4 Km 8" to CLS-G Parallel 3 Km WI-2 from CPP Phase I towards CLS-G New WI Pipeline from near CLS-M to CLS-C (8"-3.5 Km) New WI pipeline from CLS-C to CLS-R (8"-4 Km)*			
COMMON C-3 Pipeline Required in all Options (EPC-2)	*Parallel 2 Km to CLS-E 8" WI-19*			

The electrical requirements for all C-3 Dabbiya options are shown in table 9.3.8 below:

Table 9.3-8: Comparison among the various options for DY C-3

	Option 3C-1	Option 3C-2A	Option 3C-2B	Option 3C-2C
Power source from	Existing S/S-5 at DY CPP (ADNOC ONSHORE S/S)	• CL(AA) –New 33KV • Existing S/S-5 (ADNOC ONSHORE S/S)	• CL-AA: -New 33KV OHL • CL-O: -33KV OHL • Existing S/S-5 (ADNOC ONSHORE S/S)	• CL-O: -New 33KV OHL • Existing S/S-5 (ADNOC ONSHORE S/S)
Power demand	• 6 Pumps + 1 Spare x 4.7MW each • 1 Pump + 1 Spare x 1.25MW	• 3 Pumps in CLS-AA x 5.5MW + 1 Spare • 1 Pump in CLS-AA + 1 Spare x 1.25MW each • 2 Pumps in CPP x 5.5MW + 1 Spare	• 3 Pumps in CLS-AA x 5.5MW + 1 Spare • 3 Pumps in CLS-O x 5.5MW + 1 Spare • 1 Pump in CPP x 1.25MW + 1 Spare	3 Pumps in CLS-O x 5.5MW + 1 Spare 1 Pump in CLS-O x 1.25MW + 1 Spare
OHL requirement	not required	• 33KV OHL (10 Km)	• CL-AA: 33KV OHL (10 Km) • CL-O: 33KV OHL (7 Km)	• CL-O: 33KV OHL (7 Km)
Number of substation and size	1 S/S (77m x 11m)	• New S/S (40mX25m) • extension of the existing 11KV HSWG (02-01—HSWG-4317) in SS-5	• CL-AA: New S/S (40mX25m) • CL-O: New S/S (40mX25m) • extension of the existing 11KV HSWG (02-01—HSWG-4317) in SS-5	• CL-O: New S/S (40mX25m) • extension of the existing 11KV HSWG (02-01—HSWG-4317) in SS-5
Equipment List	• 33/11.5KVA TR (31.5 MVA) • 11KV HSWG	• 33/11.5KVA TR (31.5 MVA) • 11KV HSWG • Modification for existing 11KV HSWG	• 4 X 33/11.5KVA TR (31.5 MVA) • 4 X 11KV HSWG • Modification for existing 11KV HSWG	• 2 X 33/11.5KVA TR (31.5 MVA) • 2 X 11KV HSWG • Modification for existing 11KV HSWG

All developed Dabbiya options were analysed thoroughly with respect to the below design aspects which are in line with the options drivers explained in section 9:

a- Total Length and required sizes for component-3 pipeline system which directly contributes in CAPEX

b- Additional pipeline required for sea water supply which contributes in CAPEX

c- Field congestion with respect to the associated requirement of more supply pipeline, distribution injection headers and OHL.

d- Plot availability with respect to accommodating the required number of pumps in CPP, CLS-AA or CLS-O.

e- Availability of injection system, which is a function of the number of pumping locations.

f- Maintenance requirements, which is associated with the required operational load to maintain numerous pumping stations.

g- Risk associated with operational handling of multiple pumping locations in various areas across the field.

The CAPEX comparison of all options is shown in table 9.3-9 below:

Table 9.3-9: CAPEX comparison among the various DY options

	Option 1 CPP	Option 2A CPP + Cls-AA	Option 2B CPP + Cls-O	Option-2C Cls-O + Cls-AA
Component-3	207	194	198	210.5
Add. C2 Scope	-	33	37	69
Total	207	227	235	279.5

An option selection workshop was conducted involving the key stakeholders (Engineering, subsurface, Project's team), each option's driver was jointly assigned a weightage factor and was evaluated subjectively as explained above. Refer to table 9.3-10 below for the Options selection comparison matrix:

Table 9.3-10: Dabbiya Options selection matrix chart

Driver/Criteria	%	Option-3C-1 CPP			Option-3C-2A CPP+AA			Option-3C-2B CPP+O			Option-3C-2C Cls-AA+O		
			Rating	Wtage		Rating	Wtage		Rating	Wtage		Rating	Wtage
Availability	10	🟡	5	10	🟢	4	8	🟡	4	8	🟢	4	8
(CAPEX)	20	🟢	5	20	🟡	4	16	🟢	4	16	🟡	4	16
(OPEX)	15	🔴	5	15	🔴	3	9	🔴	3	9	🔴	3	9
Maintenance	10	🟡	5	10	🔴	3	6	🟡	3	6	🔴	2	4
Risks	10	🟢	3	6	🟢	3	6	🟢	4	8	🟢	4	8
Area / Plot Availability	10	🟢	3	6	🟡	3	6	🟢	3	6	🟡	4	8
Constructibility/Brownfield modificatio	10	🟢	2	4	🟢	2	4	🟢	2	4	🟢	4	8
Operatibility	10		5	10		4	8		4	8		3	6
Decongestion	5		5	5		4	4		4	4		4	4
Ranking	100	🟢	71		🟢	55		🟢	57		🟢	61	

Dabbiya Injection Network Conclusion

Based on the above table, it can be seen that Option 3C-1: centralized pumping at CPP has the highest score among all options and accordingly it is selected for conceptual design.

The following will be considered during Conceptual Design and same shall be studied by In house Engineering Team:

- Cost of modifications in Clusters due to the tie-in with the parallel pipeline
- Pipeline relocations, as required
- Plot space availability in CPP
- Substation requirement in CPP

9.3.4 Pipeline & Piping Design Aspects

The following design features are considered for the pipeline design as well as the allocation of the new water injection pumps in CPP:

- All Sea Water Injection Pipelines shall be buried/ and Sabkha construction with externally coated with 3-layer polypropylene and CP protected.
- For those existing lines and those others to be installed with CP protection being crossed by the project pipelines, joint protection solution shall be resolved between the parties involved for the portion permanently buried.
- Various Rig / Road crossing dimension (length) will be identified during next engineering stage, which shall be based on the site conditions / findings of topographic survey report / road width etc.
- All treated sea water injection pipelines are designed to be piggable
- The space availability for crane access and pig traps installation has been checked and confirmed in DY CPP. Space availability in other Clusters shall be confirmed during next engineering phase.

9.3.5 Dabbiya C-3 demolition scope

As part of the conversion of the existing Dabbiya field to sea water injection, the existing aquifer water wells installed near CPP Phase I and III are to be demolished as listed below:

- 2 water supply wells near CPP Phase I for Ph-I injection system.
- 12 water supply wells near CPP Phase III for Ph-III injection system.
- The 2 water supply wells to be installed near CLS-AA as part of Dabbiya transition zone B Phase I.
- One disposal well installed near CLS-AA as part of Dabbiya transition zone B Phase I.
- One existing supply in CLS-R.

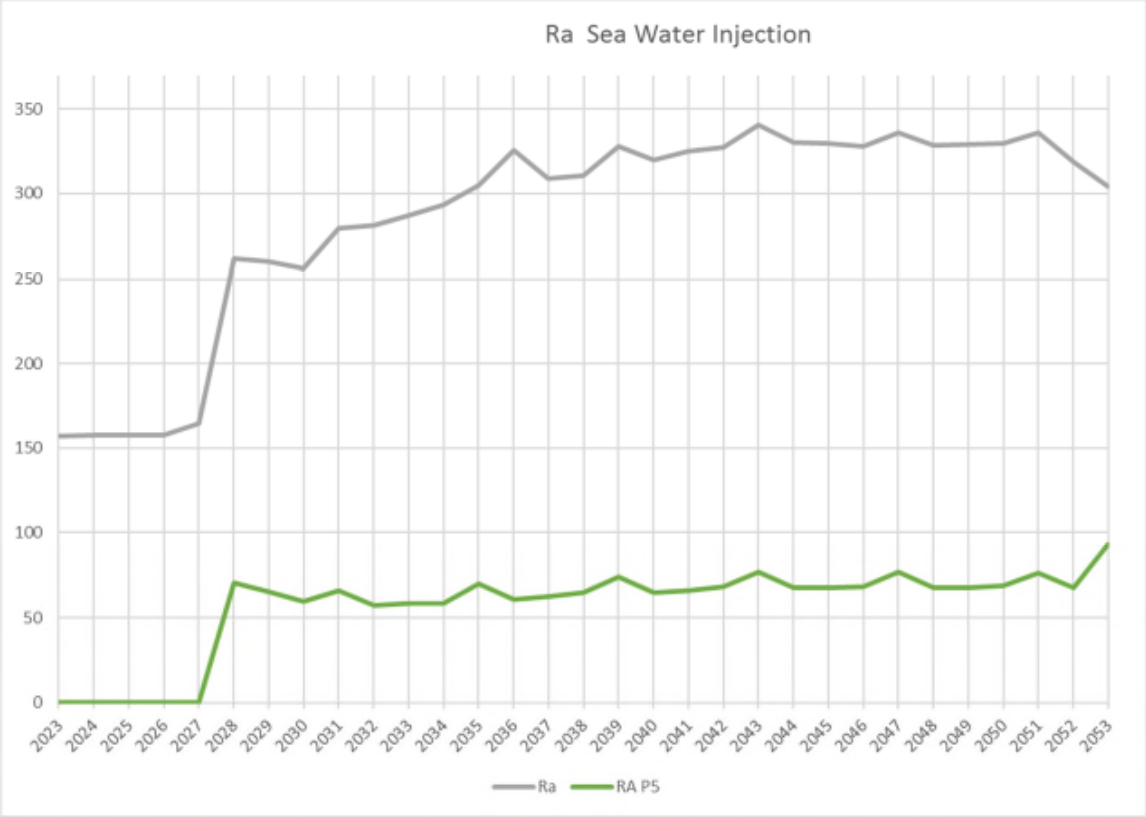
9.4 Component-3D: Injection Network at Ra

9.4.1 Rumaitha Injection Netowrk - Design Basis

Existing Rumaitha water injection system is based on centralized pumping where 3 x 50% pumps are installed in CPP Phase III with a capacity of 42 MBWPD each and 3x33% pumps are installed In CPP Phase I with a capacity of 24 MBWPD. Refer to Appendix-J for the performance curve of these pumps. Both pumping systems are interconnected as part of P44021- Rumaitha zone B expansion project and accordingly the total rated injection capacity available is 156 MBWPD.

The total injection profile for Rumaitha is shown in figure 9.4-1 below where the requirements peaks to a maximum of around 341 MBWPD.

Figure 9.4-1: Rumaitha Seawater Injection Profile

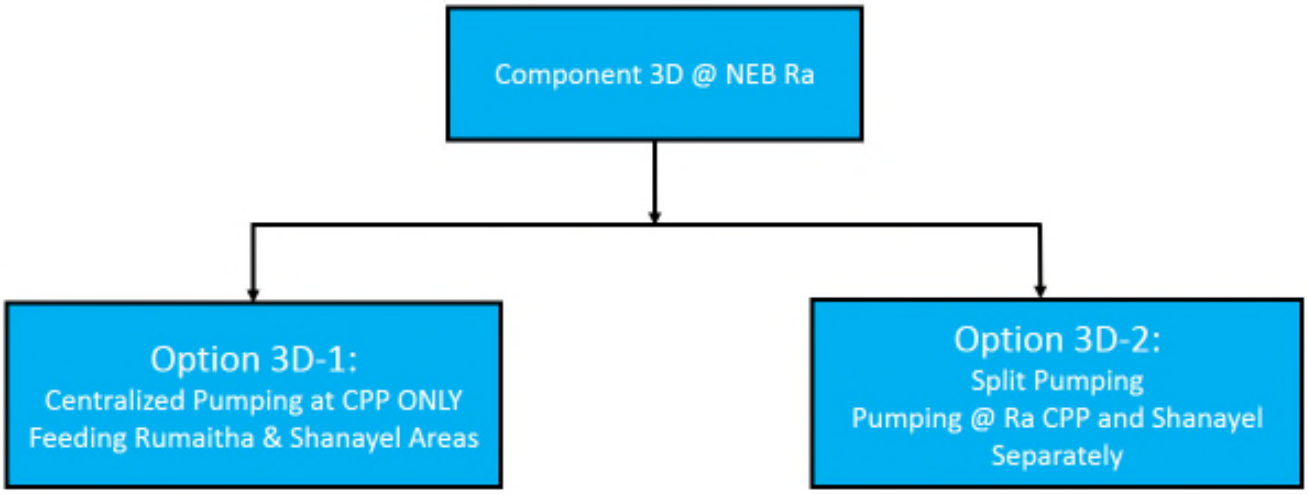


9.4.2 Component-3D – Ra Injection Network: Options Identification

There are mainly two options considered Component-3D (Injection network at NEB Ra):

1. Option 3D-1 : Centralized Pumping at CPP ONLY Feeding Rumaitha & Shanayel Areas
2. Option 3D-2 : Split Pumping at Ra CPP and Shanayel Separately

Figure 9.4-2: Option 3D1 and Option 3D2



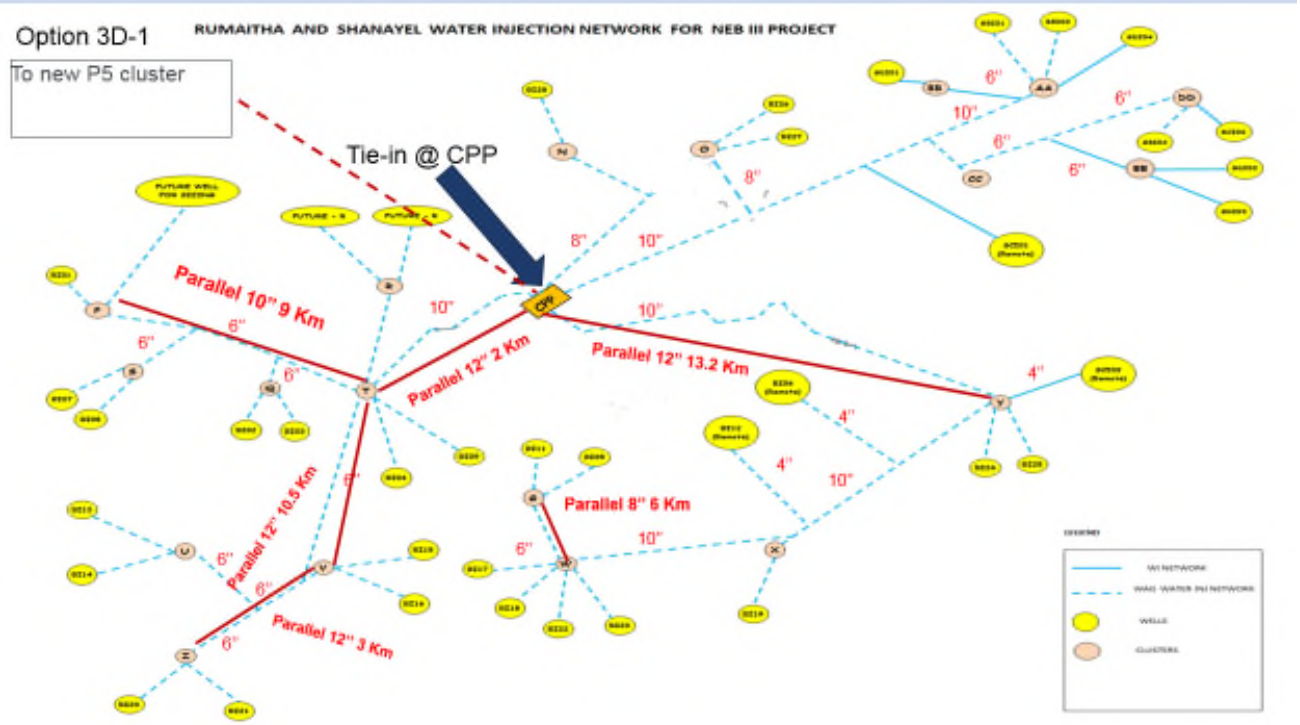
9.4.2.1 Option 3D1 : Centralized Pumping at CPP ONLY Feeding Rumaitha & Shanayel Areas

This option considers maximizing the utilization of the existing water injection system in CPP Phase I & III. Existing Phase III pumps are designed for a suction pressure of 32 barg. The revised suction pressure as part of C-2 supply pipeline is 20 barg which de-rates the existing Phase III pumps from 42 MBWPD to 28.6 MBWPD. Existing phase I pumps will operate at their original rated capacity as they were designed for a suction pressure of 8.5 barg and a discharge pressure of 191 barg. The required discharge pressure post accommodating peak seawater demand is 198 barg for a suction pressure of 20 barg. Refer to Appendix-K for the existing Rumaitha Pumps performance curves.

Accordingly, 3 x 70 MBWPD pumps are required to be added in parallel with the existing pumps to cover for the seawater injection demand. No phasing is required as part of Rumaitha C-3 investment.

The de-bottlenecking of existing Rumaitha injection network is mandated by the restricted hydraulics in existing network, Refer to figure 9.4-3 for the required pipeline paralleling:

Figure 9.4-3: Rumaitha water injection pumps de-bottlenecking-Option 3D-1



Refer to Appendix-L for field layout drawing.

Required modifications to the existing W.I header approach to Ra CPP shall be studied during next engineering phase due to C2 component approach for the seawater line coming from DY CPP. Refer to Appendix-L for Ra CPP plot plan to find the location of the required facilities. Refer to table 9.4-1 for the required pipeline as part of scope:

Table-9.4-1: Pipeline routing summary in Rumaita Field

	From	To	SIZE (in)	Length (km)
1	Ra CPP	CLS-25 (Y)	12”	13.2 km
2	Ra CPP	CLS -26 (Z)	12”	10.5 km
3	Branch from Ra-CPP to CLS-26 (Z)	CLS-16 (P)	10”	9 km
4	Branch from Ra-CPP to CLS-26 (Z)	CLS-20 (T)	12”	2 km
5	Branch from Ra-CPP to CLS-26 (Z)	CLS-22 (V)	12”	3 km
6	CLS-07 (G)	CLS- 23 (W)	8”	6 km

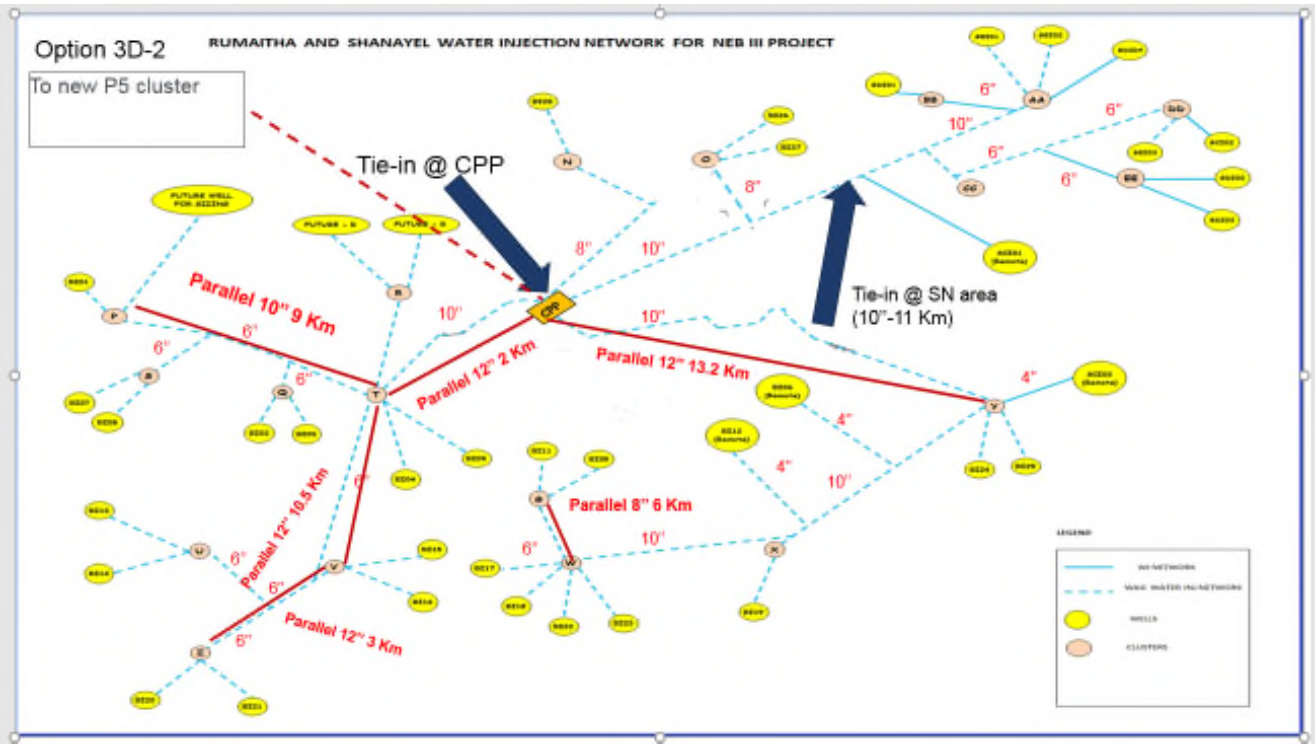
9.4.2.2 Option 3D-2 : Split Pumping Pumping at Ra CPP and Shanayel Separately

This option considers de-coupling Shanayel area from the existing centralized injection system in Rumaitha CPP. Shanayel area has a maximum injection demand of 30 MBWPD out of the 341 MBWPD overall injection requirement.

Additionally, 11-Km seawater supply pipeline is required to supply seawater to existing Shanayel area near CLS- CC.

The required de-bottlenecking of the existing pipeline network is the same as option 3D-1 as shown in figure 9.4-4 below:

Figure 9.4-4: Rumaitha water injection pumps de-bottlenecking-Option 3D-2



Refer to Appendix-K for field layout drawing.

Required modifications to the existing W.I header approach to Ra CPP shall be studied during next engineering phase due to C2 component approach for the sea water line coming from DY CPP. Refer to Appendix-K for Ra CPP plot plan to find the location of the required facilities. Refer to table 9.4-2 for the required pipeline as part of scope:

Table-9.4-2: Pipeline routing summary in Rumaitha Field

	From	To	SIZE (in)	Length (km)
1	Ra CPP	CLS-25 (Y)	12”	13.2 km
2	Ra CPP	CLS -26 (Z)	12”	10.5 km
3	Branch from Ra-CPP to CLS-26 (Z)	CLS-16 (P)	10”	9 km
4	Branch from Ra-CPP to CLS-26 (Z)	CLS-20 (T)	12”	2 km
5	Branch from Ra-CPP to CLS-26 (Z)	CLS-22 (V)	12”	3 km
6	CLS-07 (G)	CLS- 23 (W)	8”	6 km
7	Additional Length on top of Sea water supply C-2 pipeline	Shanayel Remote pumping station	10’’	11 Km

9.4.3 Component-3D – Ra Injection Network: Options Selection

Based on the concept study outcomes reflected in above sections for each of the Rumaitha centralized and de-centralized options, table 9.4-3 below provides an overall comparison between the two options with respect to various design aspects:

Table-9.4-3: Options Comparison for Rumaitha C-3

	Option 3D-1	Option 3D-2
Description	Fully Centralized at CPP	Split Pumping at CPP & Remote Shanayel
Pipelines	38 Km Onshore	38 Km Onshore
Add. C2 Pipeline	-	11 Km
Total Pipeline	38 Km	49 Km
No. of Pumps	3 pumps at CPP + 1 S 11 MW	3 pumps at CPP + 1 S 1 pump at Shanayel +1 S 12 MW

All developed Rumaitha options were analysed thoroughly with respect to the below design aspects which are in line with the options drivers explained in section 9:

a- Total Length and required sizes for component-3 pipeline system which directly contributes in CAPEX

b- Additional pipeline required for sea water supply which contributes in CAPEX

c- Field congestion with respect to the associated requirement of more supply pipeline, distribution injection headers and OHL.

d- Plot availability with respect to accommodating the required number of pumps in CPP/shanayel area.

e- Availability of injection system which is a function of the number of pumping locations.

f- Maintenance requirements which is associated with the required operational load to maintain numerous pumping stations.

g- Risk associated with operational handling of multiple pumping locations in various areas across the field.

The electrical requirements for both options are shown in table 9.4-4:

Table-9.4-4: Electrical Requirements for Rumaitha C-3 Options

	Option 3D-1	Option 3D-2
Power source from	Existing S/S-5 (ADNOC ONSHORE S/S)	• Existing S/S-4 at CPP RU (ADNOC ONSHORE S/S) • New 33KV OHL (3Km) at Shanayel
Power demand	3 nos. Pumps + 1 Spare 3.5MWatt 11kV	• 3 nos. Pumps + 1 Spare 3.5MWatt 11KV • 1 nos. Pumps + 1 Spare 1.7MWatt 11kV
OHL requirement	not required	New 33KV OHL
Number of substation and size	extension of the existing 11KV HSWG (44-01—HSWG-4314) in SS-4	• extension of the existing 11KV HSWG (44-01—HSWG-4314) in SS-4 at CPP • New Power Supply Skid (18mx5m) at Shanayel
Equipment List	Modification for existing 11KV HSWG	• Modification for existing 11KV HSWG at CPP • 11kV switchgear through 5MVA step down transformer • 415V switchgear through step down transformer

The CAPEX comparison of both options is shown in table 9.4-5 below:

Table 9.4-5: CAPEX comparison among the various Rumaitha options

	Option 1 CPP Centralized	Option 2 CPP +Remote Shanayel
Component-3	67	81
Add. C2 Scope	-	5
Total	67	86

An option selection workshop was conducted involving the key stakeholders (Engineering, subsurface, Project's team a), each option's driver was jointly assigned a weightage factor and was evaluated subjectively as explained above. Refer to table 9.4-6 below for the Options selection comparison matrix:

Table 9.4-6: Options Selection Matrix Chart

Driver/Criteria	%	Option-3C-1			Option-3C-2		
			Rating	Wtage		Rating	Wtage
Availability	15	🟡	5	15	🟢	4	12
(CAPEX)	20	🟢	5	20	🟡	3	12
(OPEX)	15	🔴	5	15	🔴	4	12
Maintenance	10	🟡	5	10	🔴	3	6
Risks	10	🟢	5	10	🟢	4	8
Area / Plot Availability	10	🟢	4	8	🟡	4	8
Constructibility	5	🟢	4	4	🟢	4	4
Operatibility	10		5	10		4	8
Decongestion	5		4	4		3	3
Ranking	100	🟢	82		🟢	62	

Rumaitha Injection Network Conclusion

Based on the above table, it can be seen that Option 3C-1: centralized pumping option at CPP has the highest score among all options and accordingly it is selected for conceptual design.

The following will be considered during Conceptual Design and same shall be studied by In house Engineering Team:

- Cost of modifications in Clusters due to the tie-in with the parallel pipeline
- Pipeline relocations, as required
- Plot space availability in CPP
- Substation requirement in CPP

9.4.4 Pipeline & Piping Design Aspects

The following design features are considered for the pipeline design as well as the allocation of the new water injection pumps in CPP:

- All Seawater Injection Pipelines shall be buried/ and Sabkha construction with externally coated with 3-layer polypropylene and CP protected.
- For those existing lines and those others to be installed with CP protection being crossed by the project pipelines, joint protection solution shall be resolved between the parties involved for the portion permanently buried.
- Various Rig / Road crossing dimension (length) will be identified during next engineering stage, which shall be based on the site conditions / findings of topographic survey report / road width etc.
- All treated sea water injection pipelines are designed to be piggable
- The space availability for crane access and pig traps installation has been checked and confirmed in Ra CPP. Space availability in other Clusters shall be confirmed during next engineering phase.

9.4.5 Rumaitha C-3 demolition scope

As part of the conversion of the existing Rumaitha field to seawater injection, the existing aquifer water wells installed near CPP Phase I and III are to be demolished as listed below:

- 3 water supply wells near CPP Phase I for Ph-I injection system.
- 6 water supply wells near CPP Phase III for Ph-III injection system.

10.0 Health, Safety and Environment

HSE inputs were provided for the different proposed options taking into consideration mainly environmental impact aspects. Additionally the following points shall be taken into consideration:

- SRU plants shall be considered nearby the sea-shore in order to allow easy disposal of the brine and rejected water.
- Design of reject water disposal line to the sea shall be developed in detail during FEED.
- Base Line Survey, Brine Dispersion Study and Environmental Impact Assessment shall be the key study in order to finalize the design of the selected options from HSE point of view.
- Fire Protection and F&G Detection (Fire Detection in buildings and alarm systems) shall be finalized during FEED Stage. At this point, general fire protection system were considered in line with UAE Fire Protection Regulations (fire water network, pumps, tanks, hydrants, deluge skids for transformers, etc.). Fire Protection for Sea water treatment plants in Mirfa and Dabbiya, is mandatory requirement for any industrial area. Fire extinguishers, fire protection manual means, safety equipment as windsocks, PPEs and others shall be considered

11.0 Energy Management

Total Energy and cost required throughout the operating life cycle was estimated for the various options studied. Following are the recommendations based on the study from energy optimisation point of view:

- For Component-1 Bab / Bu Hasa requirement, locating the Seawater treatment plant at Mirfa consumes less overall energy when compared to locating at Ruwais.
- For Component-2 following are the preliminary line size recommended based on total life cycle cost for Carbon steel material, which will be again confirmed during the concept study:
    - 64” line size from Mirfa to Bab;
    - 48” line size from Bab to Bu Hasa;
    - 42” line size from Dabbiya sea water treatment plant to Dabbiya water injection pump;
    - 30” line size from Dabbiya to Rumaitha.
- Regarding VSD requirement to optimize the cost, following is recommended:
    - VSD is required for C3 pump package at all locations which provides huge energy and cost savings;
    - C1 package VSD is not required for Water supply booster and main supply pump;
    - Regarding VSD requirement for Seawater lift pump and Seawater treatment plant feed pump in C1 package further study will be carried out during the concept stage once the data’s are made available;

Additional study was carried out to determine the effect of booster pumping station at Bab for Bu Hasa requirement and following are the observation based on the study:

- If VSD is considered in C3 package, having common pumping facility at Mirfa consumes less overall energy when compared to providing booster station at Bab for Bu Hasa.
- In case if VSD is not considered, having booster station at Bab for Bu Hasa consumes less overall energy when compared to common pumping facility at Mirfa.

- Based on the preliminary selected line size for the options selected among components 2 & 3, and considering VSD in C3 package, power required for additional facilities at various locations were estimated and given below:

Table 11.1: Power requirements summary

Location	Maximum Power, MW	30 years Average Power , MW	30 years Average Energy KPI, kw/bbl
Mirfa Supply Pumps	95	80	0.761
Bab Injection Pumps	91	80	1.257
Bu hasa Injection Pumps	62	43	1.040
Dabbiya Supply Pumps	33	23	0.631
Dabbiya Injection Pumps	33	20	0.848
Rumaitha Injection Pump	16	13	1.091
Total	330	259	-

- Estimated energy KPI due to Project Wave for various assets was compared with actual energy KPI consumed currently and given below:

Table 11.2: Energy KPI summary

Location	30 years average Flow, MBPD	30 years Average Energy KPI, kw/bo	Current WI Energy KPI. kW/bo	Savings in Energy, kW/bo	Savings in cost, Million USD /Year
Bab	1527	2.02	1.90	-0.12	-3.82
Bu Hasa	998	1.80	1.70	-0.10	-2.08
Dabbiya	567	1.48	1.70*	0.22	2.61
Rumaitha	286	1.72	2.35*	0.63	3.76

*Dabbiya and Rumiatha actual energy KPI are based on Ph-I WI facilities. Ph-III WI facilities are more energy efficient due to availability of VSD and actual savings will be less than projected.

Based on the above table it is observed that there is increase in energy cost by around 5% for Bab and Bu Hasa and more than 10% reduction in energy cost for Dabbiya and Rumaitha.

30 years average energy cost estimated are based on the available preliminary vendor inputs currently. Once confirmed vendor inputs are made available the above working will be reworked and the revised values will be provided.

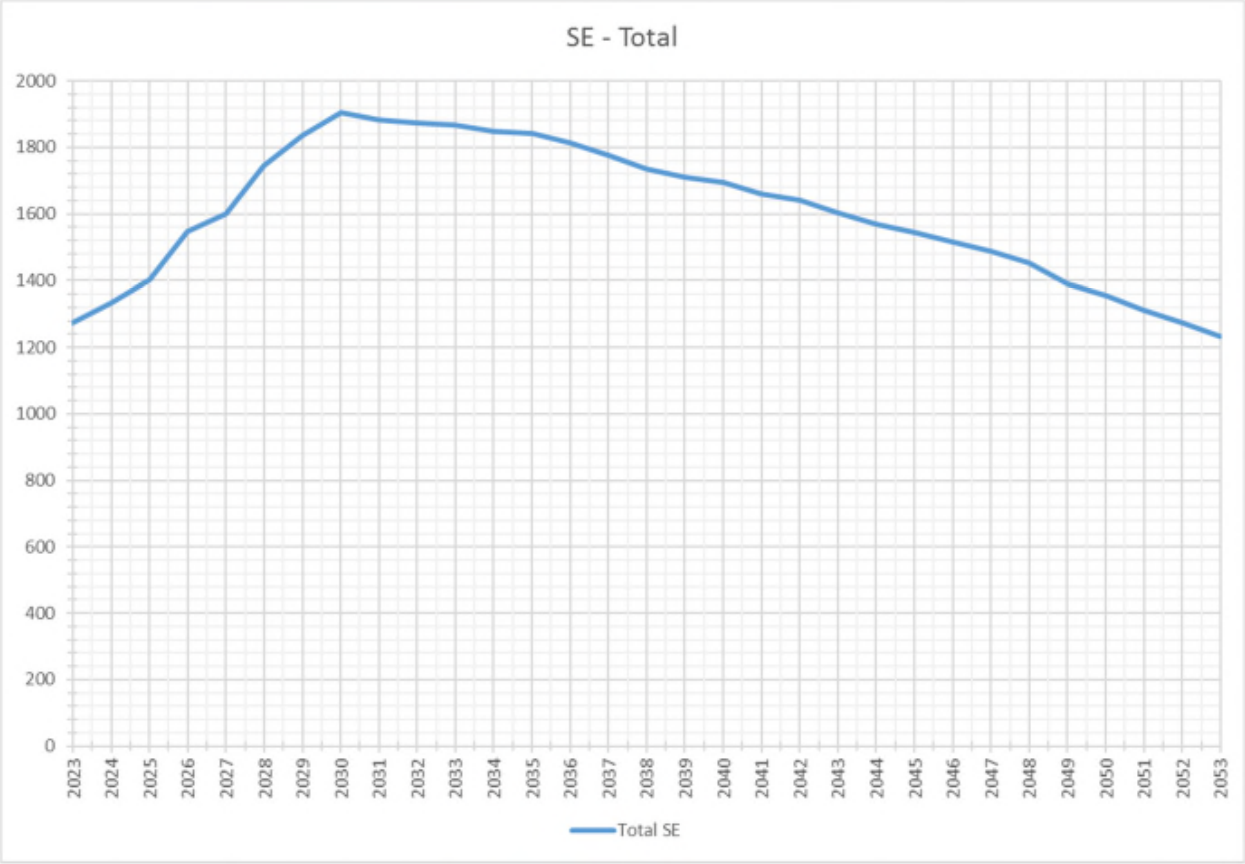
12.0 South East (SE) Fields Requirements

12.1 General

South East fields, which includes, Asab, Sahil, Shah, Qusahwaira and Mender were included lately for study purposes.This section will briefly describe the basis, location selection, analysis and costs for SE fields.

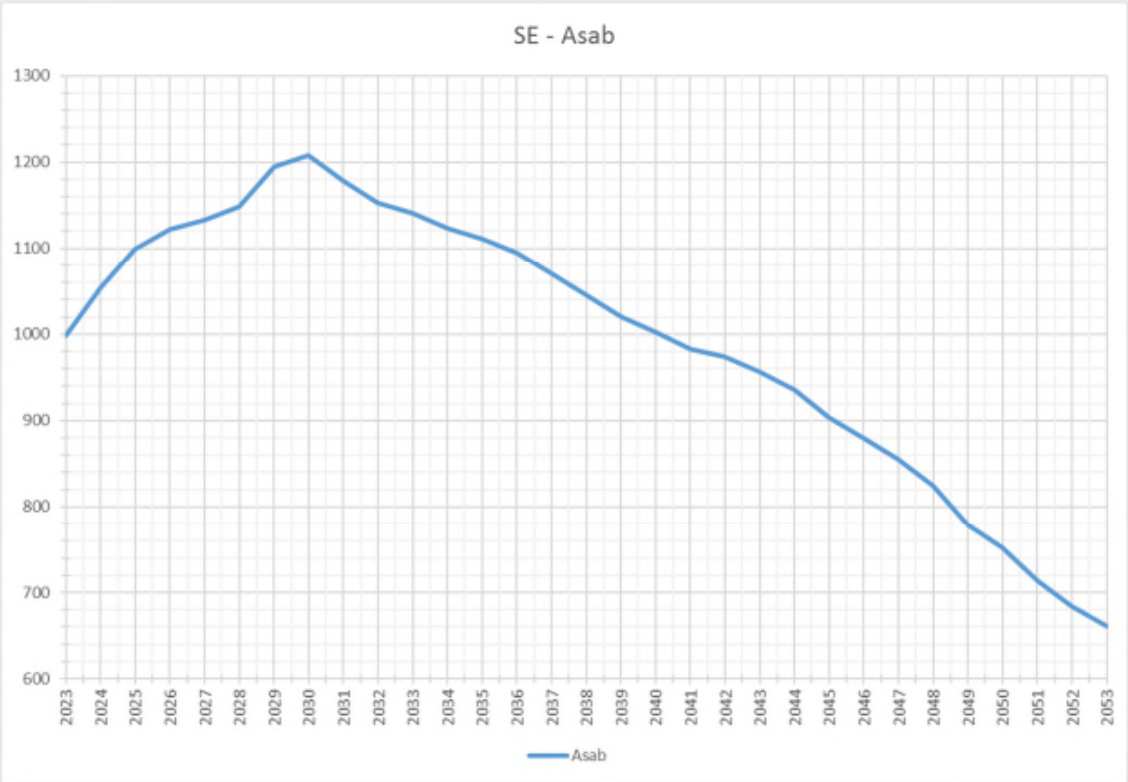
The injection profiles for the SE fields are provided in below figure 12.1 below:

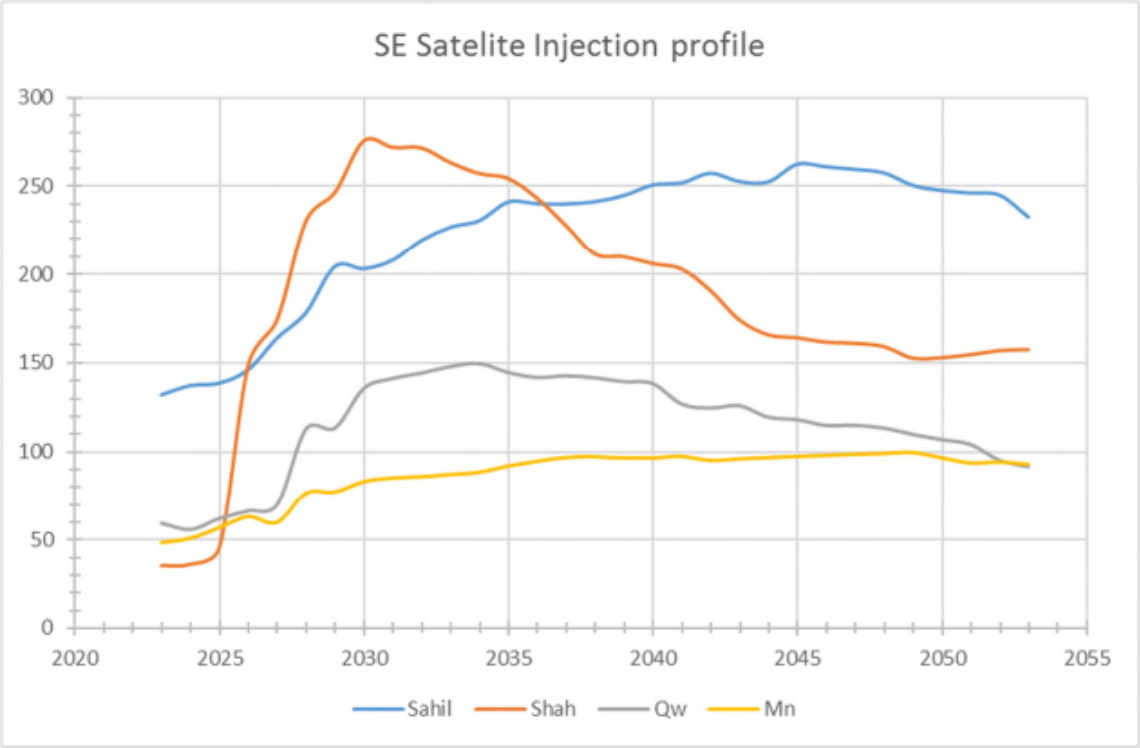
Figure 12.1-1 : SE total Seawater injection profile



It should be noted that at the time of study, SE Development didn't perform analysis with the seawater injection, therefore aquifer water injection profile is taken and treated as seawater injection profile.

Figure 12.1-2 : ASAB & Satteline fields Sea Water injection profile





12.2 SOUTH EAST (SE) SUPPLY

A study was conducted to select the plant to supply the seawater for SE. The options are;

- Mirfa to supply Bab, BuHasa and SE
- Dy to supply Dy, Ra and SE

The summary of pipeline lengths is given below;

Table 12.2-1: Supply pipeline length to SE

	Supply from Dabbiya	Supply from Mirfa
Total Pipeline Length	309 km	357 km

Since more length require more CAPEX and OPEX, therefore, Dabbiya has been selected as a supply source for SE fields. Based on this updated seawater quantities required from Dabbiya Plant are shown below:

Table 12.2-2: Seawater Treatment Plant Capacity

Location	Capacity BWPD		
	Maximum	Minimum	Turndown
Dabbiya (Note-1)	1,242,000	464,000	50%
Dabbiya (Note-2)	2,696,000	1,348,000	50%

Note-1: Considering NEB sea water injection demand
Note-2: *Considering NEB+ SE seawater injection demand.*

Refer to section 12.3. The supply pipelines are envisaged to have a design pressure of 120 barg.

Preliminary sizes for the pipelines and Pumps are given below:-Sizes & Lengths

Table 12.2-3: Supply pipeline length to SE

S.No.	Description	Length	Size
1	Dy to Sahil	79 km	64”
2	Sahil to Asab	54 km	64”
3	Asab to Shah	52 km	30”
4	Asab to Qw	80 km	20”
5	Qw to Mn	44 km	20”
6	Pumps	8 W +2 S (1575 m³/h x 6 MW ea.)	

The EPC cost for the SE Supply Pumps and Pipelines is provided below;

Table 12.2-4: Supply pipeline length to SE-CAPEX

	Supply Network – CAPEX
	Supply from Dy SWTP
Pumping Station	186
Pipeline	565
Total	**751**

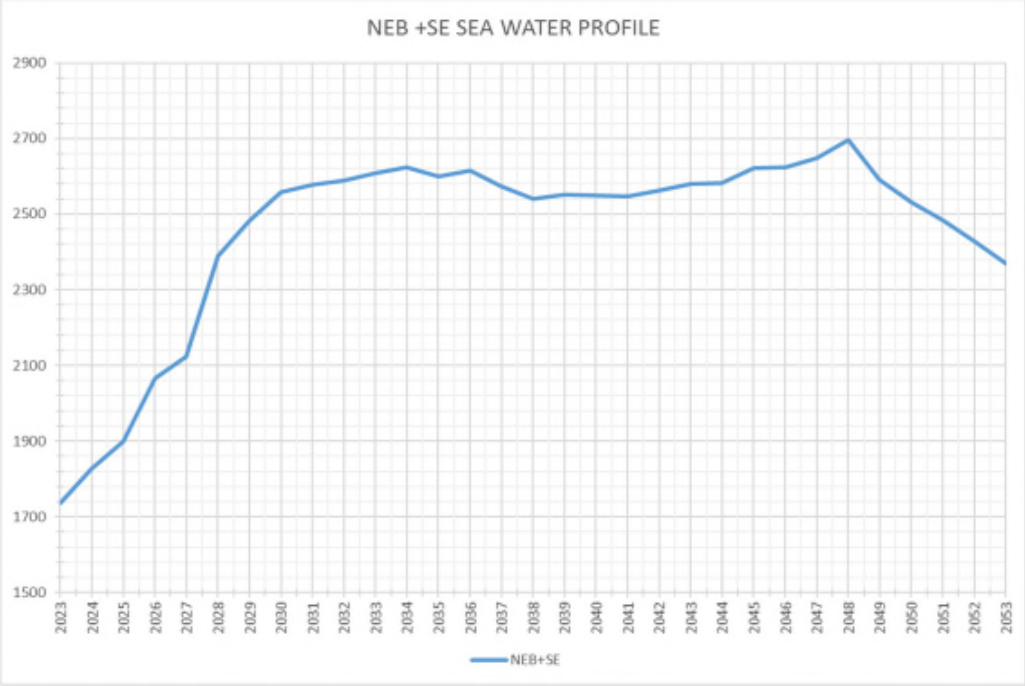
The estimated cost for the SE component-2 is found to be 751 MMUSD.

The supply line from Dabbiya plant covering all injection requirements will be routed from Dabbiya to SE. The interconnecting field pipeline will supply intake water to pump stations in each field. Following are the pipeline distances between each field. Pipeline will be CS, laid underground.

12.3 Sea Water Treatment Plant –Dabbiya

Due to the accomodation of south east within the Dabbiya sea water treatment plant, the capacity of the plant will have to be increased from 1242 MBWPD as explained in section 7 to 2700 MBWPD at the outlet of the package's battery limit. Refer to figure 12.3 below:

Figure 12.3-1 : Combined NEB + SE Sea Water Profile

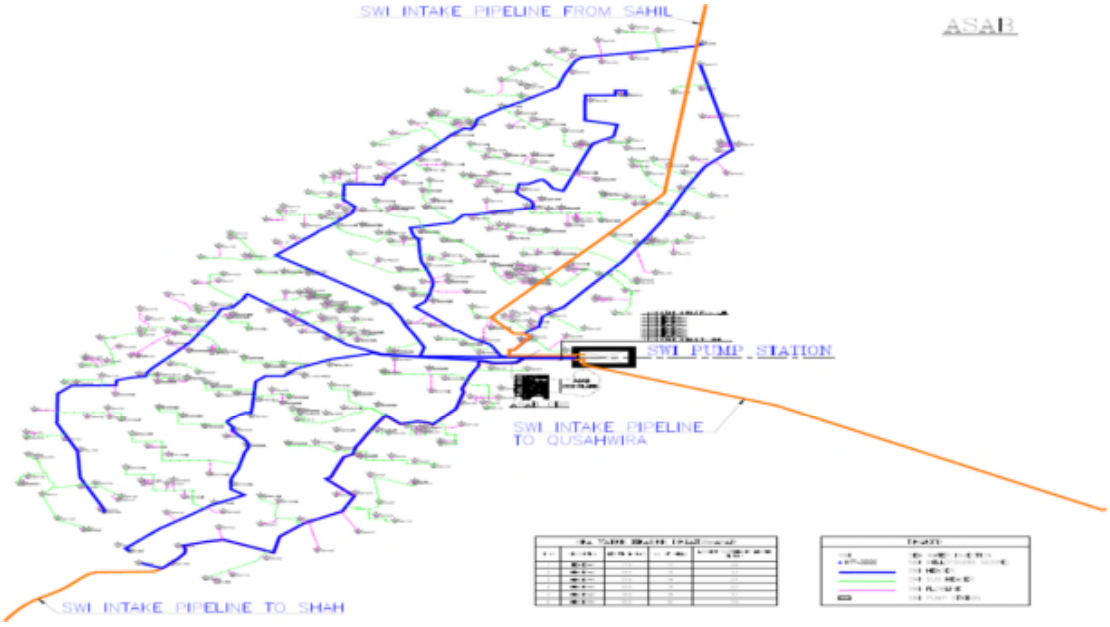


Accordingly, the intake capacity to Dabbiya treatment plant explained in section 7.2 shall be 3500 MBWD considering 30% margin to account for the reject outfall.

12.4 SE – ASAB

Asab profile is shown above in figure 14.4. Peak injection volume is ~1.2MMBPD. This injection volume is inclusive of the Project 5.0 requirements. The injection pressure is considered as 155 barg (2200 psig). Note that it is assumed that additional 500 psi pressure is required above aqufier water injection. All clusters are considered to be replaced with seawater injection except the injectors where PWRI is being injected. It may be noted that Asab PWRI scheme has centralised pumping station at the CDS. For this preliminary study peak injection rate with pumping station at edge is studied and is presented in this section.

Figure 12.4-1: Asab field layout with new headers



Preliminary study is conducted to ascertain the confguration of Asab injection requirements. Major items summary for the Asab field is given below;

Table 12.4-1: Major items summary

	Asab Major Items
	Single Pumping Station at the Edge
Pipelines	Headers: 16” – 90 km Headers: 14” – 40 km
No. of Pumps	1010 m3/h @ 185 Bar, Motor : 7.5 MW (8W + 2S)
OHL	30 km
Substation	Modification in existing Substation

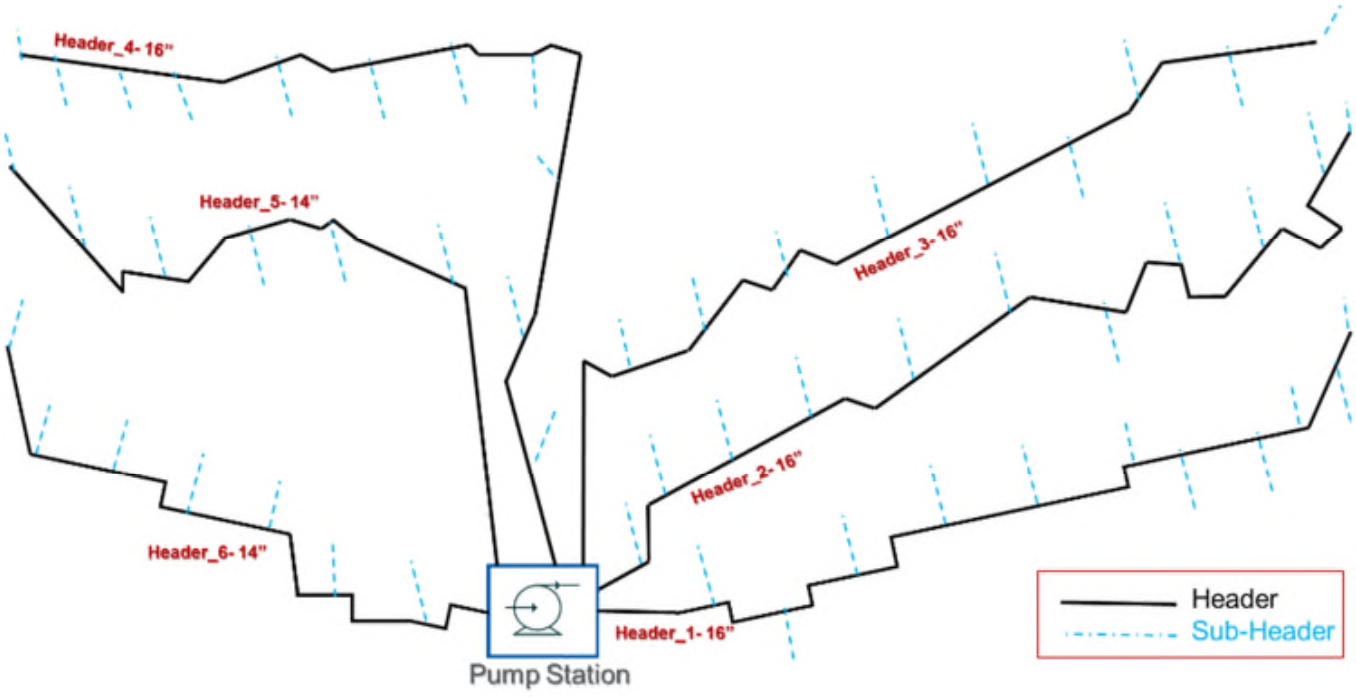
The EPC cost for the Asab injection pumping station and pipelines is found out to be 451 MMUSD and is given in below table.

Table 12.4-2 : ASAB C-3 Pipeline CAPEX

	Asab - CAPEX
	Central Pumping Station at the Edge
Pumping Station	190
Pipeline	261
Total	**451**

The schematic of the injection headers is given in below figure;

Figure 12.4-2 : ASAB C-3 Network



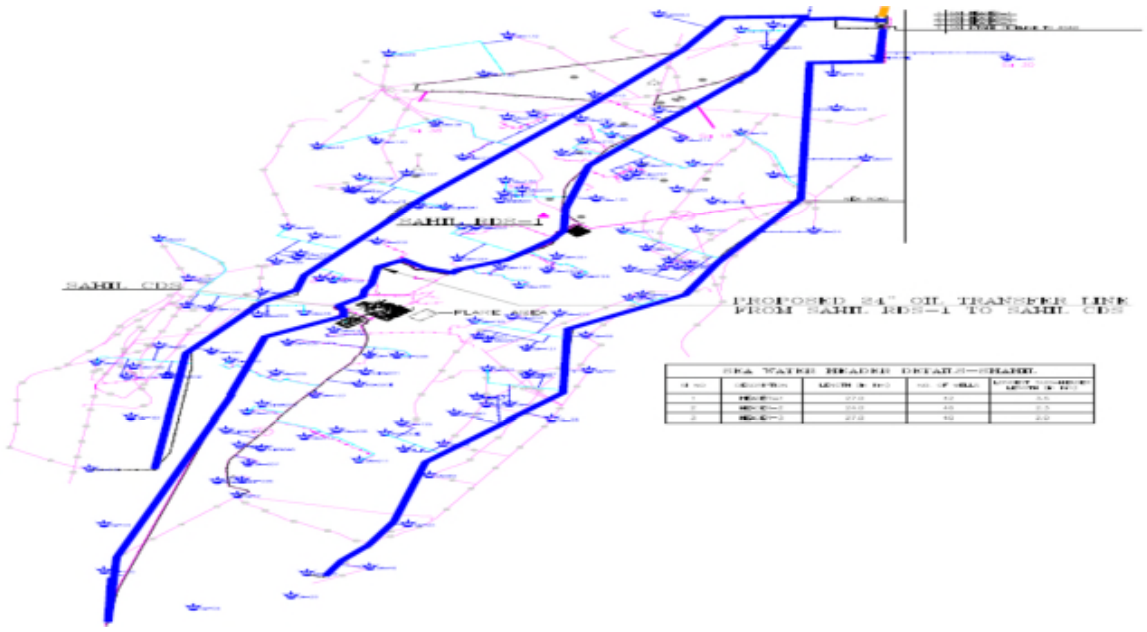
Injection pipelines follows fish bone network. Pump station is proposed in center of the field near CDS. The supply pipeline to asab pump station is from Sahil. Injection wells are spread all over the field, accordingly three pipeline headers are routed to the north, and three headers to the south of field.

Off plot headers size is 16/14", sub header is 6" and injection flowline upto well is 4". Total length of pipeline is 1,610 km. All pipelines will be CS. Headers will be underground and sub headers/flowline will be aboveground to provide flexibility for future tie-in connections.

12.5 SE – SAHIL

Sahil peak injection demand is ~260 MBPD, which is inclusive of Project 5.0. Injection pressure is considered to be 172 barg (2500 psig – 500psi more than aquifer case). Sahil field layout with main injection headers is provided in below figure:

Figure 12.5-1: Sahil layout with new headers



The major requirements for the Sahil injection network are listed in below table:

Table 12.5-1: Major items summary table

	Sahil Major Items
	Single Pumping Station at the Edge
Pipelines	Header: 12” – 78 km
No. of Pumps	680 m3/h @ 170 Bar, Motor : 4.6 MW 2W + 1S
OHL	32 km
Substation	Modification in existing Substation

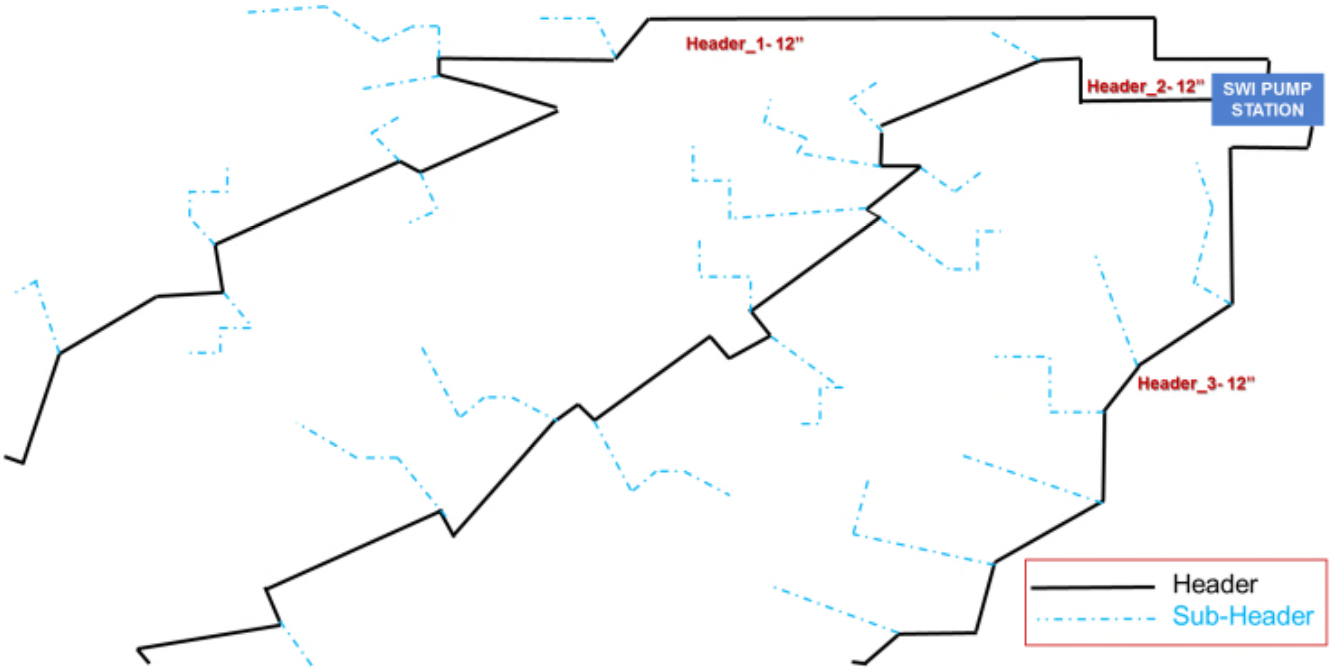
EPC cost for Sahil injection pumps and network is found out to be 156 MMUSD. Its summary table is provided below:

Table 12.5-2: EPC Cost summary table

	Sahil - CAPEX
	Central Pumping Station at the Edge
Pumping Station	58
Pipeline	98
Total	156

The schematic of the injection headers is given in below figure;

Figure 12.5-2: Injection pumps and network schematic



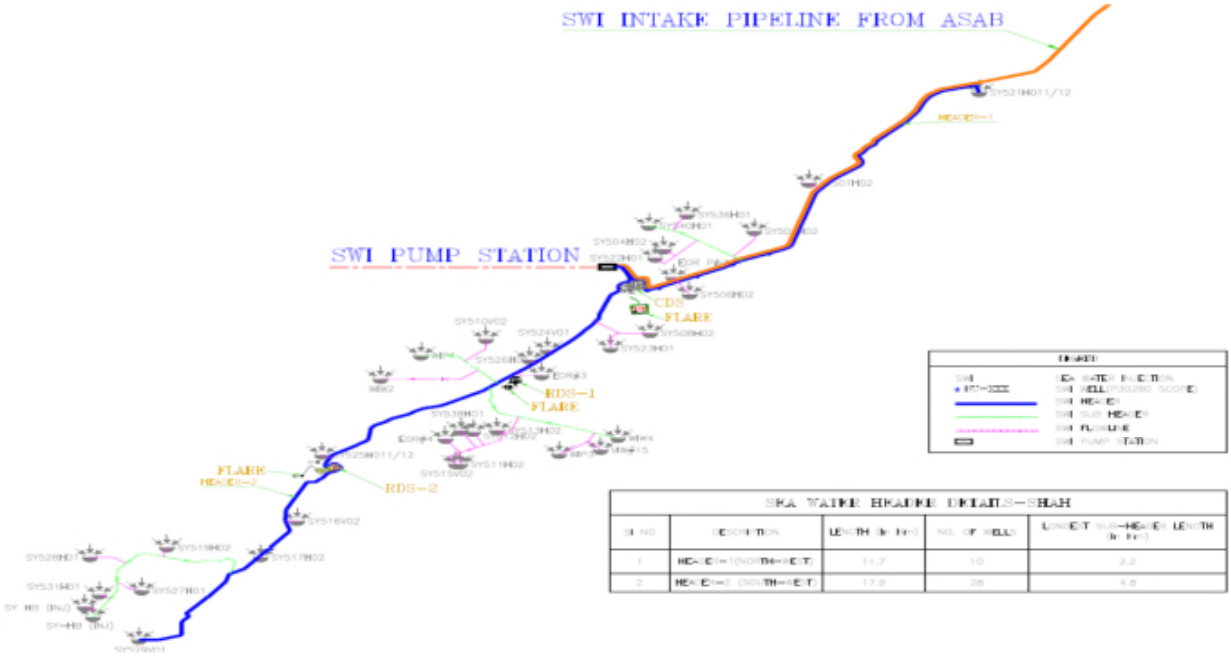
Injection pipelines follows fish bone network. Pump station is proposed at north of the field, where supply pipeline is from Dabbiya. Based on the geographcial location of wells, three pipeline headers are routed from north to south covering whole field.

Off plot headers size is 12”, sub header is 6” and injection flowline upto well is 4”. Total length of pipeline is 570 km. All pipelines will be CS. Headers will be underground and sub headers/flowline will be aboveground to provide flexibility for future tie-in connections.

12.6 SE – SHAH

Shah peak injection demand is ~265 MBPD, which is inclusive of Project 5.0. Injection pressure is considered to be 138 barg (2000 psig – 500psi more than aquifer case). Shah field layout with main injection headers is provided in below figure:

Figure 12.6-1: Shah field layout



The major requirements for the Shah injection network are listed in below table;

Table 12.6-1: Major items summary table

	Shah – Major Items
	Single Pumping Station at the Edge
Pipelines	Header: 12'' – 11.7 km Header: 14'' – 17.9 km
No. of Pumps	912 m3/h @ 170 Bar, Motor : 6.2 MW 2W + 1S
OHL	18 km
Substation	New Substation

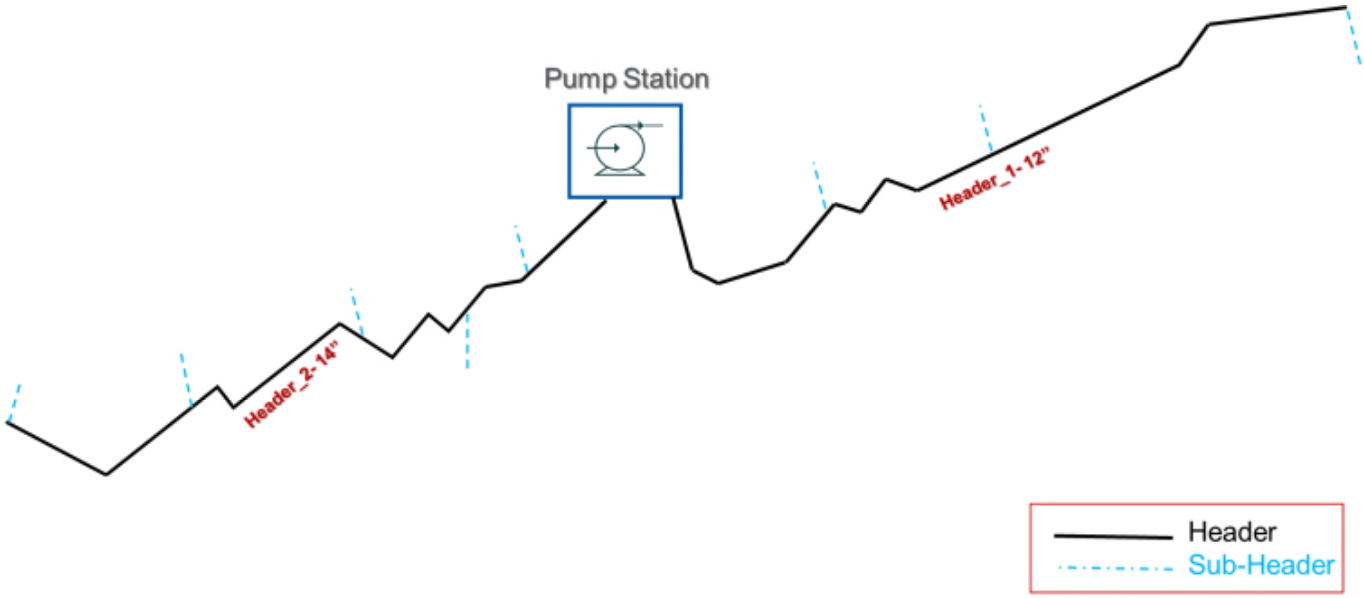
EPC cost for Shah injection pumps and network is found out to be 100 MMUSD. Its summary table is provided below;

Table 12.6-2: EPC Cost summary table

	Shah - CAPEX
	Central Pumping Station at the Edge
Pumping Station	50
Pipeline	50
Total	**100**

The schematic of the injection headers is given in below figure;

Figure 12.6-2: Injection pumps and network schematic



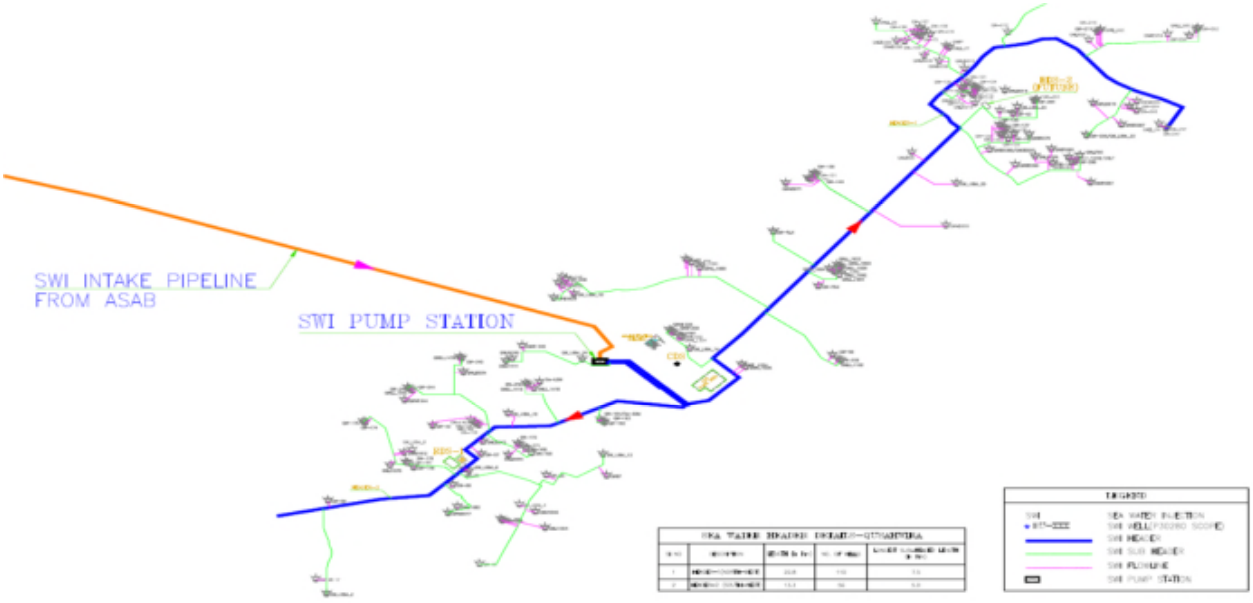
Injection pipelines follows fish bone network. Pump station is proposed in center of the field near CDS. The supply pipeline to Shah pump station is from Asab . Injection wells are spread along north and south trip of field. Two pipeline headers are proposed, one to north and other header to the south.

Off plot headers size is 12/14", sub header is 6" and injection flowline upto well is 4". Total length of pipeline is 330 km. All pipelines will be CS. Headers will be underground and sub headers/flowline will be aboveground to provide flexibility for future tie-in connections.

12.7 SE – QUSAHWAIRA

Qusahwaira peak injection demand is ~150 MBPD, which is inclusive of Project 5.0. Injection pressure is considered to be 138 barg (2000 psig – 500psi more than aquifer case). Qusahwaira field layout with main injection headers is provided in below figure:

Figure 12.7-1: Qsauhwaira field layout



The major requirements for the Qusahwaira injection network are listed in below table:

Table 12.7-1: Major items summary table

	Qusahwira Major Items
	Single Pumping Station at the Edge
Pipelines	Header: 12" – 36 km
No. of Pumps	900 m3/h @ 165 Bar, Motor : 5.9 MW 1W + 1S
OHL	6 km
Substation	New Substation

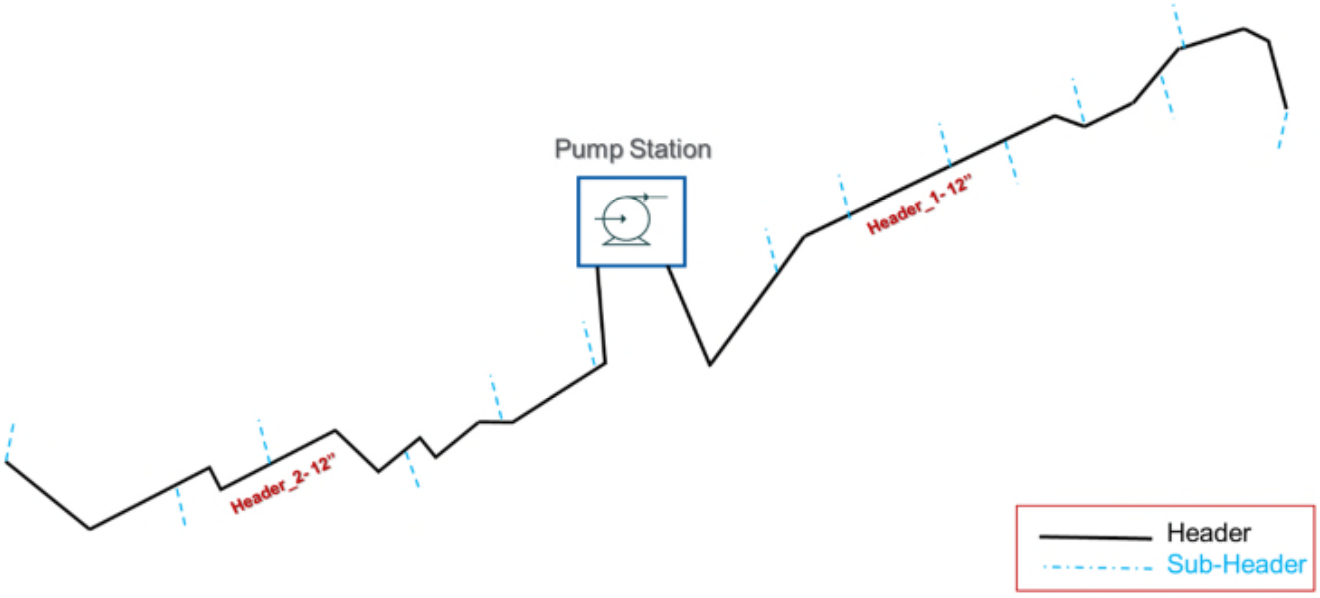
EPC cost for Qusahwaira injection pumps and network is found out to be 119 MMUSD. Its summary table is provided below;

Table 12.7-2: EPC Cost summary table

	Qusahwaira - CAPEX
	Central Pumping Station at the Edge
Pumping Station	31
Pipeline	88
Total	**119**

The schematic of the injection headers is given in below figure;

Figure 12.7-2: Injection pumps and network schematic



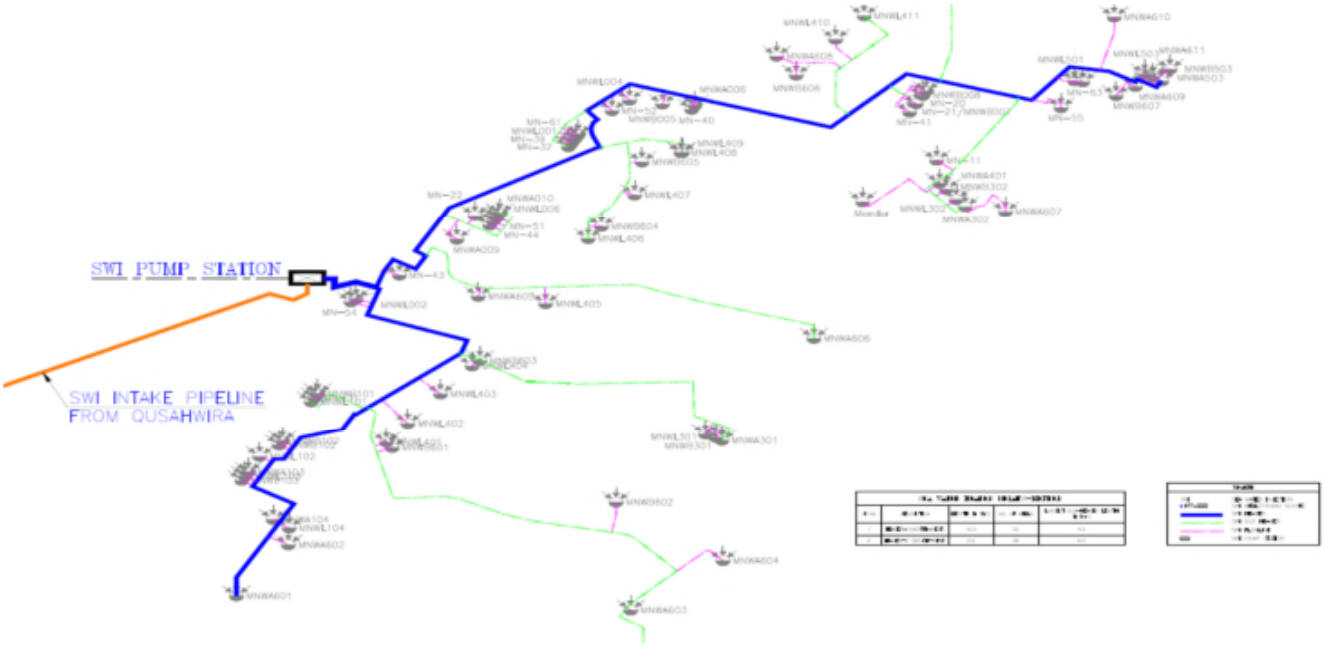
Injection pipelines follows fish bone network. Pump station is proposed in center of the field near CDS. The supply pipeline to Qusahwira pump station is from Asab. Injection wells are spread all over the field. Two pipeline headers are proposed, one to north and other header to the south.

Off plot headers size is 12”, sub header is 6” and injection flowline upto well is 4”. Total length of pipeline is 650 km. All pipelines will be CS. Headers will be underground and sub headers/flowline will be aboveground to provide flexibility for future tie-in connections.

12.8 SE – MENDER

Mender peak injection demand is ~100 MBPD, which is inclusive of Project 5.0. Injection pressure is considered to be 155 barg (2200 psig – 500psi more than aquifer case). Mender field layout with main injection headers is provided in below figure,

Figure 12.8-1: Mender field layout



The major requirements for the Mender injection network are listed in below table;

Table 12.8-1: Major items summary table

	Mender Major Items
	Single Pumping Station at the Edge
Pipelines	Header: 10'' – 10.3 km Header: 8'' – 6.5 km
No. of Pumps	570 m3/h @ 165 Bar, Motor : 3.7 MW 1W+1S
OHL	1 km
Substation	New Substation

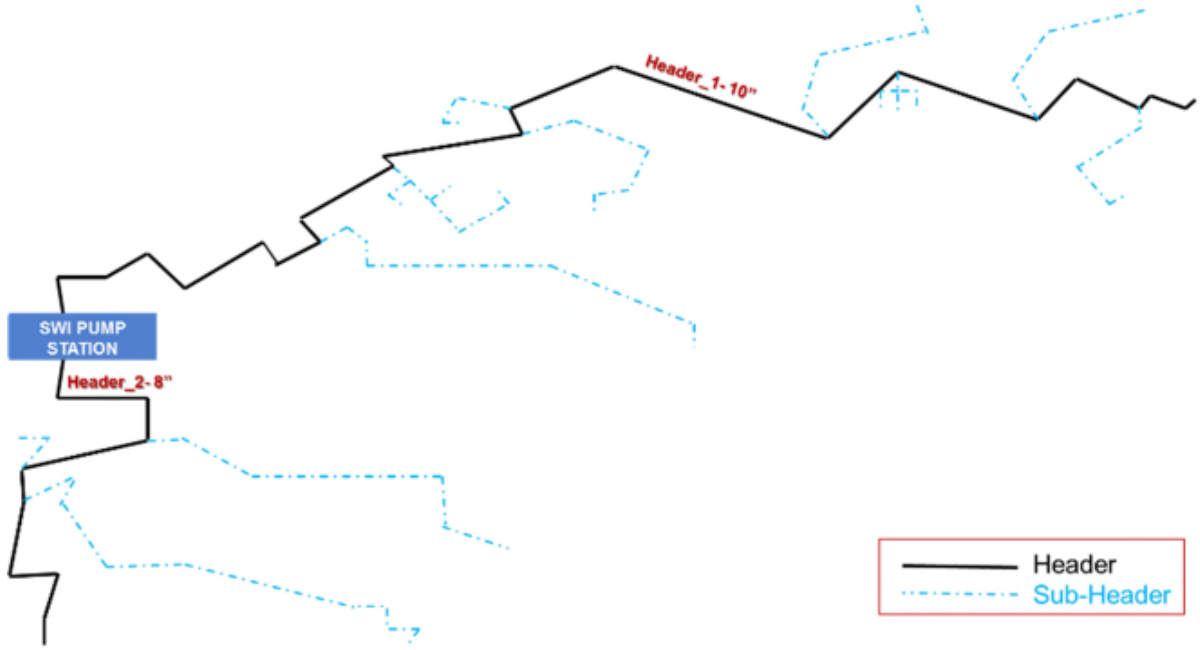
EPC cost for Mender injection pumps and network is found out to be 63 MMUSD. Its summary table is provided below;

Table 12.8-2: EPC Cost summary table

	Mender - CAPEX
	Central Pumping Station at the Edge
Pumping Station	23
Pipeline	40
Total	**63**

The schematic of the injection headers is given in below figure;

Figure 12.8-2: Injection pumps and network schematic



Injection pipelines follows fish bone network. Pump station is proposed in east side of the field where the supply pipeline is from Qusahwira. Injection wells are spread all over the field. Two pipeline headers are proposed, one to north and other header to the south.

Off plot headers size is 10”/8”, sub header is 6” and injection flowline upto well is 4”. Total length of pipeline is 310 km. All pipelines will be CS. Headers will be underground and sub headers/flowline will be aboveground to provide flexibility for future tie-in connections.

12.9 SE – Cost Summary

The cost summary for SE requirements is found out to be 2,093 MMUSD inclusive of Component-1 and Component 2 cost.

Table 12.9-1: SE EPC Cost Summary table

Items	SE
Component 1	454
Component 2	751
Component 3	
Asab	451
Sahil	155
Shah	100
Qusahwaira	119
Mender	63
Total	**2,093**

This cost estimate is +/- 50% and excludes the following;

- Hot tapping / stoppling works are excluded
- Well tie-in cost and flowline costs are excluded from the estimate
- It is assumed that new control room required for all options
- Any modification works at existing Clusters are excluded
- Demolition works are excluded

13.0 Cost Estimate

CAPEX is one of the major criteria in selecting the identified options for all components. Hence, comparative Cost estimates (EPC Cost) with an accuracy level of +/-50% were carried out separately for each components' Option Selection as indicated in previous sections based on the identified options.

Below Cost Estimate includes Project Cost Estimate based on updated offers from SWTP Specialized Vendors to an accuracy of ±40% with the relevant exclusions:

Table 13.1 – Estimated CAPEX (MMUSD)

Mirfa Plant (BAB & Bu Hasa)	CAPEX (MMUSD)
Component 1 (Intake & Plant)	1,102
Component 2 (Supply Pipeline)	350
Component 3 (In-Field Distribution)	1,727
EPC Cost	**3,179**
ADNOC Onshore Engineering & Management Cost:	230
Project Overall Contingency	156
Total Installed Cost	**3,565**

Dabbiya Plant (NEB)	CAPEX (MMUSD)
Component 1 (Intake & Plant)	774
Component 2 (Supply Pipeline)	125
Component 3 (In-Field Distribution)	292
EPC Cost	**1,191**
ADNOC Onshore Engineering & Management Cost:	85
Project Overall Contingency	58
Total Installed Cost	**1,334**

Dabbiya Plant (NEB+SE)	CAPEX (MMUSD)
Component 1 (Intake & Plant)	1,183
Component 2 (Supply Pipeline)	956
Component 3 (In-Field Distribution)	1,278
EPC Cost	**3,417**
ADNOC Onshore Engineering & Management Cost:	246
Project Overall Contingency	166
Total Installed Cost	**3,829**

Cost Estimate Exclusions:

- Demolition cost associated with existing WICs
- Any modification works at existing Clusters
- Cost Estimate excludes Drilling Cost

13.1 Project Phasing

Project investment phasing is looked upon and the results are discussed below.

Mirfa Seawater Treatment Plant along with its Supply Pumps can be phased as below;

Mirfa Plant Treatment Plant Phase-I = 2700 MBPD (Y2023 to Y2027)

Mirfa Plant Treatment Plant Phase-II = 3004 MBPD (Y2032 peak rate)

Bab Injection Pumps can also be phased and is provided below;

Phase-I 1557 MBPD (Y2023 to Y2027)

Phase-II 1701 MBPD (Y2029 Peak rate)

BuHasa Injection Pumps can also be phased and is provided below;

Phase-I 1172 MBPD (Y2023 to Y2027)

Phase-II 1354 MBPD (Y2033 Peak rate)

Dhabb'iya Plant along with its Supply Pumps can be phased as below;

Dhabb'iya Sea Water Treatment Plant Phase-I = 736 MBWPD (Y2023 to Y2033)

Dhabb'iya Sea Water Treatment Plant Phase-II = 982 MBWPD (Y2033 to Y2043)

Dhabb'iya Sea Water Treatment Plant Phase-III = 1262 MBWPD (Peak rate Y2048)

Dy Injection Pumps can also be phased and is provided below;

Phase-I 361 MBPD (Y2023 to Y2027)

Phase-II 914 MBPD (Y2048 Peak rate)

Ra Injection Pumps can also be phased and is provided below;

Phase-I 165 MBPD (Y2023 to Y2027)

Phase-II 341 MBPD (Y2043 Peak rate)

This is preliminary phasing and will be further reviewed during Concept Design.

It must be noted that SE fields will also be supplied by Dy Seawater Treatment Plant. Phasing will be addressed inclusive of SE during Concept Design. Refer to section 12.

13.2 Potential Optimization Opportunities

Value / assurance engineering workshops are planned in Concept Design Phase. Following review sessions are planned;

- Plot Plan Review
- HAZID
- Design Review & Value Engineering Review
- Energy Review
- Project Risk Management Review
- HAZOP Review
- SIL Review
- Constructability & SIMOPS
- PHSER – Stage II

A few of the value improvement / optimization items, which will be reviewed during Concept Design / FEED stage, are listed below;

- Re-utilize existing equipment based on integrity adequacy check
- Re-utilize existing headers / subheaders / flowlines subject to decrease in injection pressures (see item below) and current pipelines integrity
- Decreasing Wellhead Injection Pressure will reduce CAPEX and OPEX
- Study to increase in PWRI and decrease Seawater Injection Requirements
- Feasibility and technical merits for utilization reject water from Mirfa or other source(s) based on reject water availability and quantity in consultation with vendors recommendations.
- Optimization of plant plot spaces and pipelines routings.
- Studying different metallurgies (including non-metallic) for the supply and injection networks.

14.0 Appendices

- **Appendix A: Field Wise Injection Profile**
- **Appendix B: Mirfa, Dabbiya & Ruwais Treatment Plants Plot Plan**
- **Appendix C: Comparison Analysis for Seawater Treatement from Vendors**
- **Appendix D: GRE size versus pressure Limits (multiple vendors)**
- **Appednix E: Vendor Inputs on HDPE Pipe Limitations**
- **Appendix F: Pipeline Schematics for Selected BAB Option**
- **Appednix G: Detailed Breakdown of Demoliton Scope in BAB**
- **Appednix H: Pipeline Schematics for Selected Bu Hasa Option**
- **Appednix I: Dabbiya Existing Pumps Performance Curves**
- **Appendix J: Dabbiya Field Layout & CPP Plot Plan**
- **Appendix K: Rumaitha Existing Pump Performance Curves**
- **Appendix L: Rumaitha Field Layout & CPP Plot Pla**

APPENDIX-A:

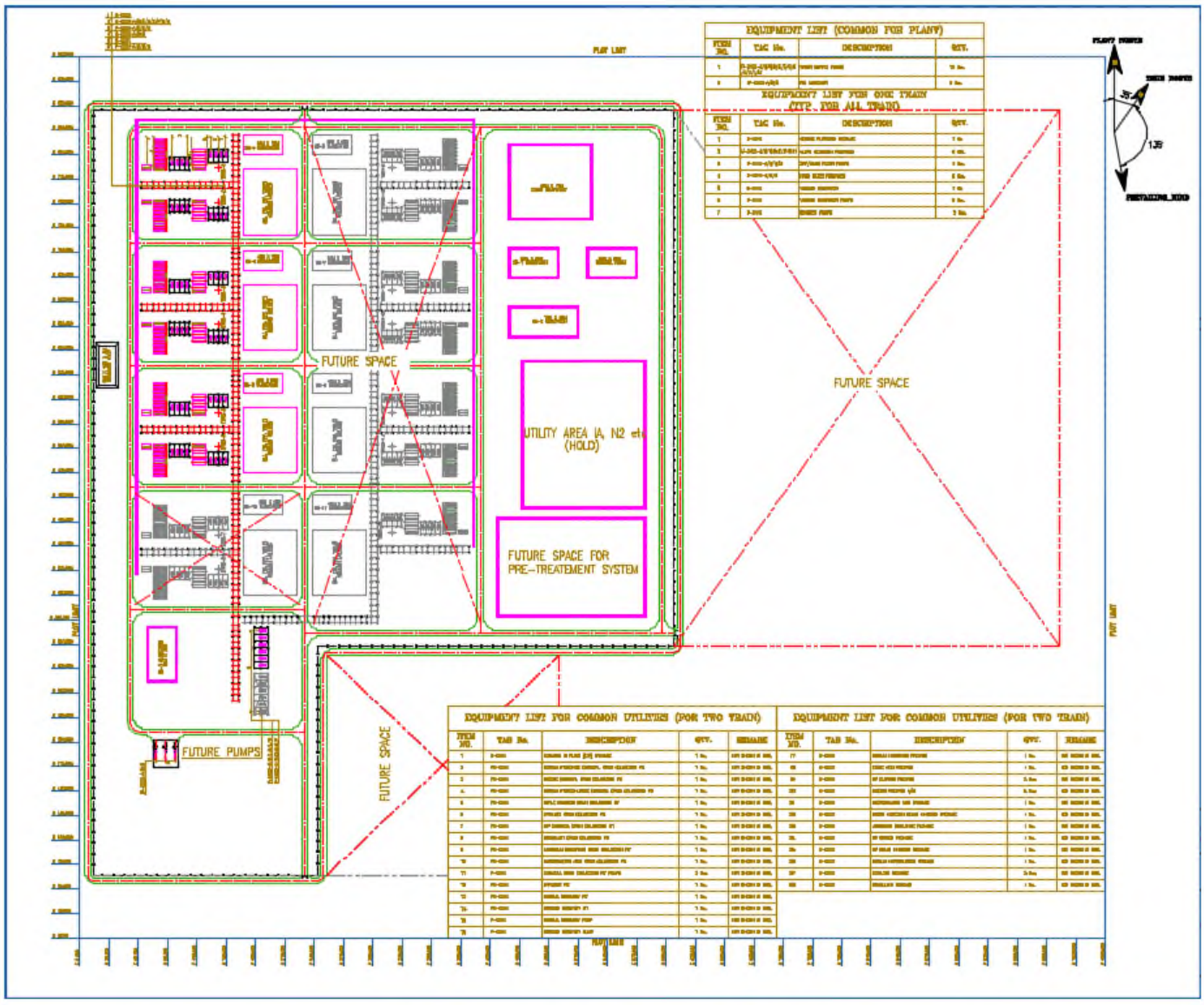
FIELD WISE INJECTION PROFILES

Year	BuHasa	Dy	Ra	BAB	Asab	Sahil	Shah	Qw	Mn
	MBWPD								
2023	1080.1	306.2	213.2	513.0	998.5	132.1	35.2	59.7	48.3
2024	1199.7	335.1	224.3	546.0	1053.6	137.3	36.0	56.1	50.8
2025	1171.9	339.1	227.4	586.0	1098.7	138.6	45.3	62.3	56.8
2026	1156.5	360.9	231.4	699.0	1122.4	146.2	148.4	66.6	63.1
2027	1172.0	357.7	245.3	705.0	1133.2	164.0	174.1	70.2	59.8
2028	1295.0	381.8	264.9	1026.4	1148.2	178.3	230.2	112.8	76.4
2029	1299.9	385.8	270.5	1313.7	1194.6	204.5	246.4	113.4	77.1
2030	1295.3	398.2	273.6	1324.4	1207.5	203.2	275.5	135.5	83.0
2031	1297.7	415.0	275.7	1317.6	1177.9	208.0	271.8	141.1	85.1
2032	1343.8	434.2	277.6	1350.3	1153.1	219.4	271.4	144.2	85.7
2033	1354.4	454.8	280.7	1471.3	1141.3	226.9	263.2	147.8	87.0
2034	1326.5	482.6	284.7	1510.8	1123.4	230.6	257.0	149.5	88.3
2035	1247.8	452.0	289.8	1563.5	1111.2	241.2	254.2	144.5	91.9
2036	1190.9	476.3	296.8	1539.9	1094.4	240.2	243.1	141.7	94.5
2037	1143.8	485.6	305.0	1572.4	1071.0	240.0	227.5	142.7	96.6
2038	1067.0	493.9	310.2	1568.6	1045.4	241.4	211.3	141.5	97.0
2039	997.6	512.7	324.2	1528.6	1019.5	244.9	209.7	139.3	96.3
2040	925.0	534.4	328.2	1513.5	1002.9	250.8	205.8	138.3	96.4
2041	894.0	562.0	329.4	1449.0	982.4	252.0	202.7	126.8	97.2
2042	868.9	594.6	331.6	1403.1	973.9	257.4	190.5	124.6	94.9
2043	834.8	634.4	347.7	1403.8	955.9	252.7	174.0	125.9	95.9
2044	836.1	682.6	351.9	1341.7	935.7	252.6	165.7	119.4	96.6
2045	809.2	746.1	351.1	1328.6	903.4	262.5	164.0	118.1	97.2
2046	740.0	781.6	352.5	1302.3	879.3	261.1	161.6	114.8	97.8
2047	725.8	823.5	354.9	1282.7	855.3	259.6	160.8	114.9	98.4
2048	713.0	913.6	348.4	1270.4	824.7	257.7	159.1	113.4	98.8
2049	680.1	871.0	343.0	1274.2	778.9	250.6	152.5	109.8	99.3
2050	660.0	846.8	337.6	1291.6	751.7	247.7	152.8	106.9	96.4
2051	615.1	835.9	334.4	1397.0	713.2	246.2	154.5	104.2	93.5
2052	528.2	834.4	326.0	1397.3	683.8	245.0	156.8	95.4	94.0
2053	454.5	830.8	323.7	323.7	660.5	232.6	157.4	91.8	92.8

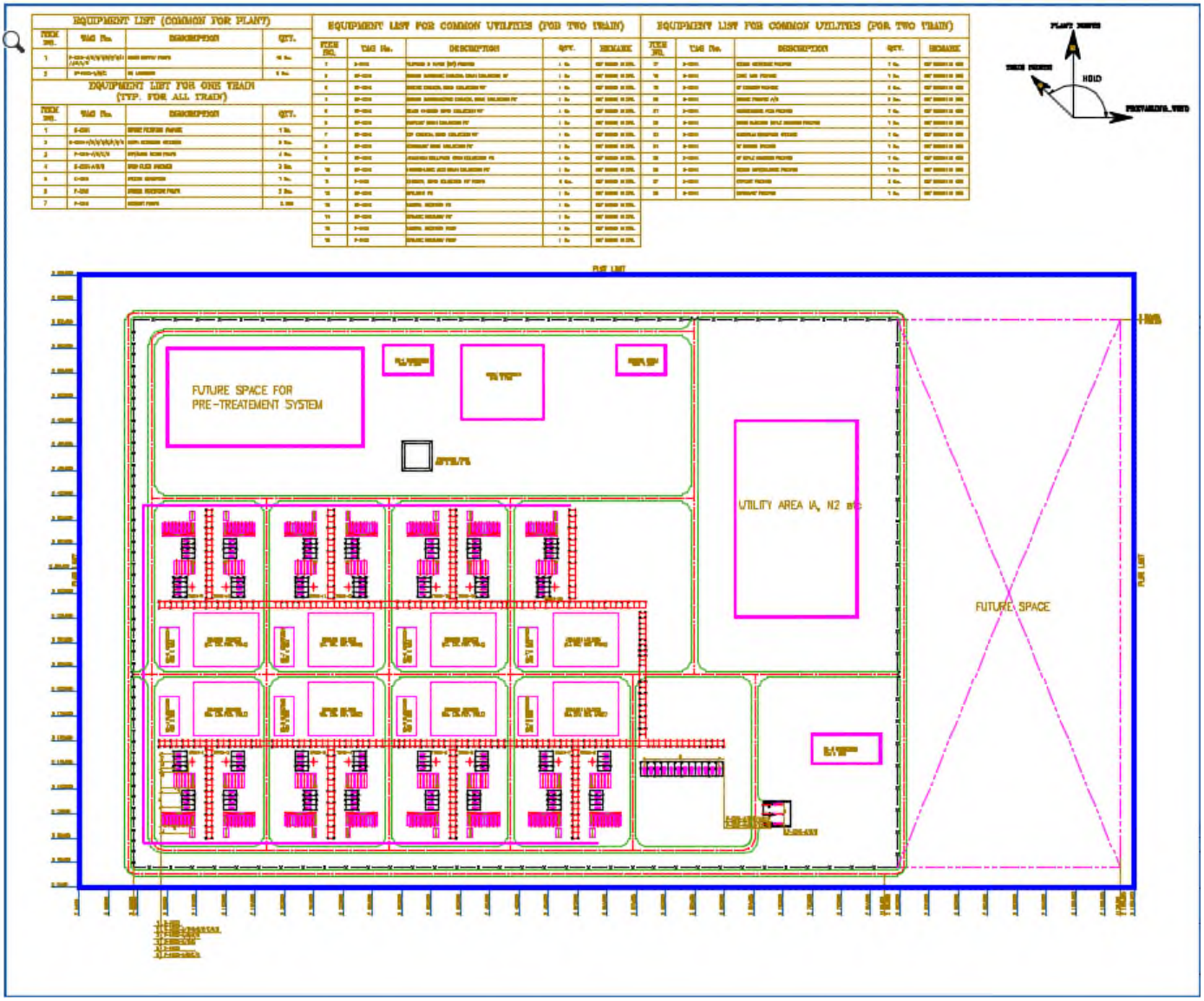
INCREMENTAL P5 PROFILES FOR WATER INJECTION

Year	BuHasa	Dy	Ra	BAB	Asab	Sahil	Shah	Qw	Mn
	MBWPD								
2023	134	0	0	0	0	0	0	0	0
2024	229	0	0	0	0	0	0	0	0
2025	200	0	0	258	0	0	0	0	0
2026	191	0	0	257	0	0	0	0	0
2027	185	0	0	248	0	0	0	0	0
2028	291	113	71	244	59	4	71	26	18
2029	274	113	66	636	91	17	86	25	15
2030	254	116	60	632	56	16	82	27	19
2031	262	122	66	631	49	16	76	28	19
2032	321	128	57	631	48	16	73	30	18
2033	412	138	59	630	65	17	64	35	20
2034	392	138	58	638	69	17	57	36	21
2035	313	110	70	638	65	14	57	38	24
2036	252	102	61	635	63	16	54	39	27
2037	205	103	62	632	72	17	45	42	29
2038	145	106	65	631	89	17	41	39	30
2039	19	110	74	629	97	18	45	40	29
2040	0	115	65	629	105	18	53	40	29
2041	0	122	66	628	114	20	49	39	30
2042	0	130	68	629	125	24	50	39	27
2043	0	140	77	629	132	25	36	38	28
2044	0	151	67	630	136	20	37	37	29
2045	0	166	68	629	139	23	37	35	30
2046	0	177	68	629	143	19	44	32	30
2047	0	192	77	629	146	23	47	31	31
2048	0	210	67	630	150	30	49	29	32
2049	0	204	68	630	153	18	45	28	32
2050	0	201	69	630	150	17	49	28	29
2051	0	200	76	629	146	16	50	26	26
2052	0	199	68	630	143	18	54	24	27
2053	0	198	93	629	139	8	58	23	26

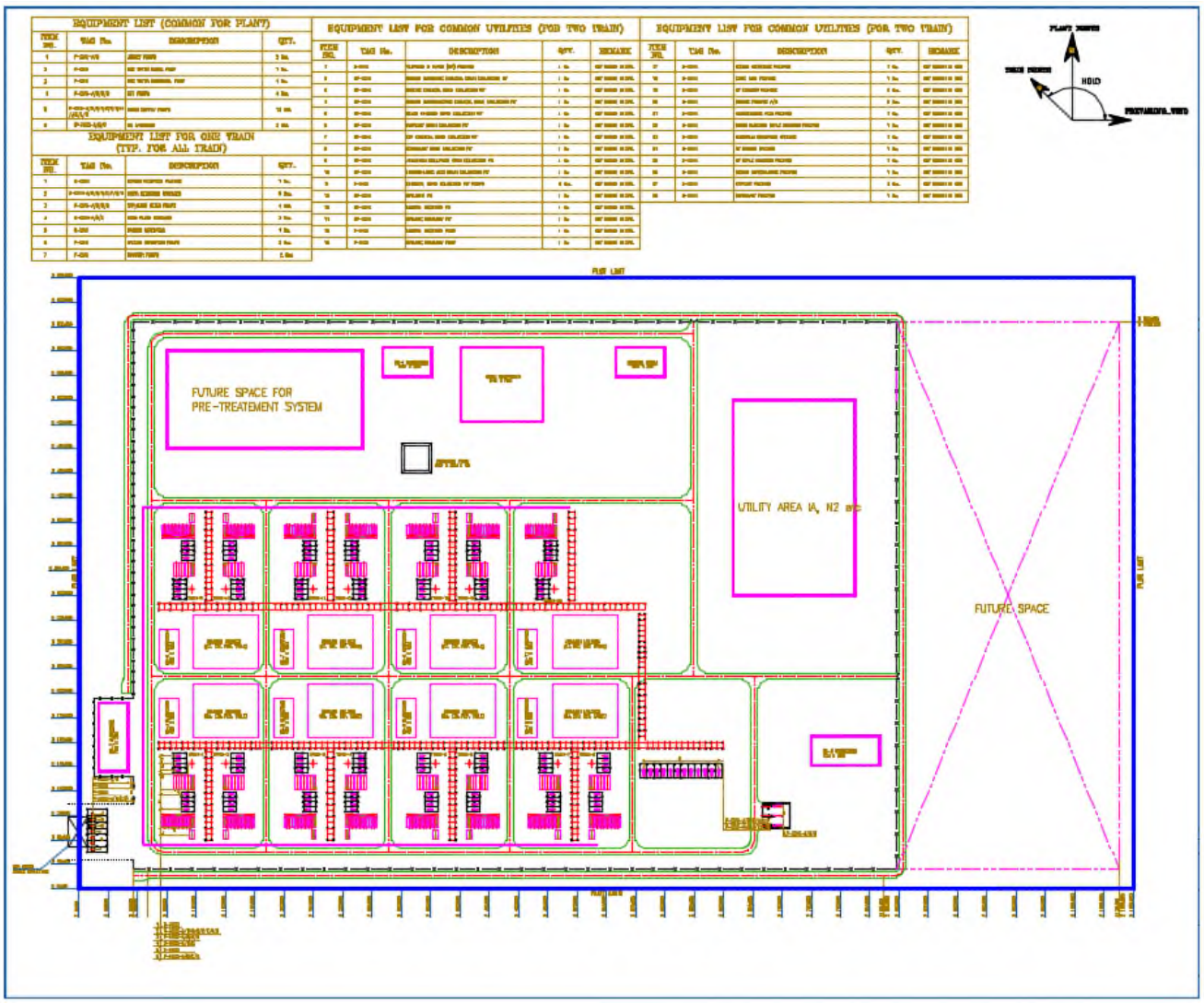
APPENDIX-B: MIRFA, DABBIYA AND RUWAIS TREATMENT PLANTS PLOT PLAN



Plot Plan for Dabbiya Sea Water Treatment Plant
Synopsis from drawing no. P30280-02-XX-SK-0651-1



Plot Plan for Mirfa Sea Water Treatment Plant
Synopsis from drawing no. P30280-74-XX-SK-0651-1



Plot Plan for Ruwais Sea Water Treatment Plant
Synopsis from drawing no. P30280-33-XX-SK-0651-1-

APPENDIX-C: COMPARISON ANALYSIS FOR SEA WATER TREATMENT TECHNICAL INPUTS OF SRU TREATMENT PLANT

ADNOC Class

Sea Water Treatment Package - ADNOC Onshore - Concept stage - P30280				
Summary of Package Equipment, Details and Requirement		**Veolia (mail dt:31.07.2019)**	**Suez (mail dt: 02.08.2019)**	**Petreco International (Middle East) Ltd. (SLB) (mail dt: 04.08.2019)**
Capacity Requirements for Sea Water Treatment Plant (at package outlet)	**Mirfa & Ruwais:**	**Noted to all.**		
	Max: 3,004,000 BWPD		Confirmed - 477.6 MLD	**Max: 3,004,000 BWPD**
	Min: 1,895,000 BWPD		Confirmed - 301.3 MLD	**Min: 1,895,000 BWPD**
	Turndown capacity: 50% of minimum requirement		Confirmed	**Turndown capacity: 50% of minimum requirement**
	Dy:			
	Max: 2,696,000 BWPD		Confirmed - 197.5 MLD	Max: 2,696,000 BWPD
	Min: 1,737,000 BWPD		Confirmed - 73.7 MLD	Min: 1,737,000 BWPD
	Turndown capacity: 50% of minimum requirement		Confirmed	Turndown capacity: 50% of minimum requirement
Vendor Experience	Reference list with similar capacity within Middle east	**See attached.**	**SWRO Plant** Mirfa UAE 136 MLD: 10 SWRO trains + 3 BWRO trains Al Dur BAHRAIN 218 MLD: 25 SWRO trains + 12 BWRO trains Barka 4 OMAN 280 MLD: 12 SWRO trains + 3 BWRO trains Barka 2 OMAN 136 MLD: 14 SWRO trains + 7 BWRO trains Fujairah UAE 170.5 MLD: 18 SWRO trains + 8 BWRO trains **WWTP RO Reuse** Sulaibiya KUWAIT 600 MLD: 68 UF trains + 42 RO trains	240,000 BWPD ADNOC Offshore West Island
	Max. installed capacity and location			2 x 350,000 BWPD SWI offshore Angola
No. of Trains	Vendor specific, specify details	Basis for data below: 315kBWPD Trains		4 clusters/trains per site. Refer PFD 610054-01Z-PE-390-0001/3/5 for each site for cluster details. (Attachment 1)
Sea water Inake	Sea water intake channels (by others) Sea water supply lift pumps (by Others) Electro chlorination package skids: 1) Size, Capacity, arrangement 2) No.of units / racks 3) Material 4) Size / dimensions	**1 x 100% ECU (~20 kg/hr hypochlorite output)**	The onshore structure should include a coarse screening system of 20-25 mm followed by two (2) 100% capacity Travelling Band Screen of 500-1000 micron in order to protect downstream SW pumping station (not included in our scope). A shock chlorination of the intake pipes is required, on a regular basis, to limit the growth of biological life (mussels…) on the internal surface of intake pipes. Max dosing rate 15 mg/l. Seawater will be made available with max 1.5 ppm residual chlorine at SWNF plant inlet. Bisulfite injection upstream pretreatment is foreseen to avoid any residual chlorine on the SWNF plant that may damage the RO membranes. NaClO liquid storage tank is preferred vs electro chlorination unit	Sea water intake channels (by others) Sea water supply lift pumps (by Others) 4 x electro chlorination (ECU) package skids per site: 1) Size, Capacity, arrangement: 15 kg/h Cl_2 capacity. 2) No.of units / racks: / 5 x 25% cells per skid 3) Material: GRP/cPVC piping + Ti Hypo pumps + proprietary catalytic coated electrodes + GRP tank 4) Size / dimensions: 6 x 5 x 5 m (lxwxh) per skid
	Sea water coarse strainer / filter package skids: 1) Size, Capacity, arrangement 2) No.of units / racks 3) Material 4) Size / dimensions	**1 x 100% 100um autobackwashable coarse strainer per train. ~900mm ID x 1800mm T/T**	Inlet flow rate - Mirfa 33,000 m3/h - Dhabb'iya 12,600 m3/h A battery of disc filters is provided for filtration of larvae or any suspended particles greater than 70 µm present in SW. This size is necessary to remove spawning shellfish or aquatic organisms like plankton that are typically 80-120 µm in size. Most of the particles could be less than 70 µm and pass through the system and be removed by the UF system downstream. Disc filters are grouped in: - 25 trains for Mirfa - 12 trains for Dhabb'iya Each train consist of six (6) Modules and each module has three (3) disc filter pods installed. Disc filters will be installed downstream SeaDAF if any.	4 x Sea water coarse strainer / filter package skids per site: 1) Size, Capacity, arrangement: 2 x 100% normally operating 2 x50% 2) No.of units / racks: 2 vessels per skid 3) Material: Either CS/lined or SDSS vessel with SDSS internals 4) Size / dimensions: 7 x 5 x 7 m (lxwxh) per skid
	Sea water pre-treatment / conditioning for future scenarios (Provision only)		Provision for SeaDAF as per Suez existing SWRO Mirfa Plant with coagulation and flocculation. 16 SeaDAF for SWNF plant in Mirfa and 8 SeaDAF for Dhabb'iya of 90 m2 each	Provision for future coagulant injection upstream coarse strainers
Filtration system (UF)	Ultra Filtration racks / units / packages: 1) UF Type, Size, Capacity, Arrangement 2) No.of units / racks 3) Material 4) Size / dimensions 5) Limitation (if any) - Temperature, pressure, moisture etc., 6) Any additional equipment (vendor specific)	**Out-to-in, PVDF, Dow UF hollow fibre. Nine off Multi-element vessels (N+2) per train. Each vessel holds circa 5000m2 filtration area. Vessels/pipe in GRP.**	SUEZ WTS offers the most advanced ultrafiltration technologies in the market: the ZW 700 B type. This product contains SWTS seven-bore fiber technology with inside/out flow orientation. The seven-bore fiber is regarded as leading PES (polyether sulfone) product available in the market. We have evaluated both horizontal and vertical models and are confident that both products are suitable for the proposed solution. The final decision will be taken considering smaller footprint, reduced capital and installed costs. The proposed layout presents the vertical model, - 8 banks with 10 trains for Mirfa - 6 banks with 7 trains for Dhabb'iya Footprint could be 20-30% less with the horizontal model	4 x Ultra Filtration clusters per site: 1) UF cluster capacity: 10 x 11% (Mirfa & Ruwais); 9 x 12.5% (Dy) 2) No.of units / racks: 6 vessels in parallel per skid 3) Material: Ti or GRP vessels + Polymem PS or PVDF membranes 4) Size / dimensions: 11 x 7 x 9 m (lxwxh) per skid 5) Limitation (if any) - Temperature max 50 deg C. 6) Any additional equipment: Air receiver replaces UF air blowers
SRP Feed pumps	SRP Feed pumps: 1) Pump Type, Size, Capacity, Arrangement 2) No.of units / racks 3) Material 4) Size / dimensions	**2 x 50% units, each ~1400 m3/hr @ 33 bar, 2MW electric motors. Super duplex**	1 pump/rack. N+2 configuration. Casing, Impeller, Shaft: SS PREN>40, CF>37.5. Unitary flow rate Mirfa 2200 m3/h, Dhabb'iya 1600 m3/h. Pressure 25-30 barg	4 x SRP Feed pump clusters per site: 1) Pump Type, Size, Capacity, Arrangement: API610 BB2, refer PFD 2) No.of units/cluster: 5 duty + 1 standby 3) Material: 25% Cr SDSS 4) Size / dimensions: 6.5x2.5x 3.3 m (lxwxh) per pumpset
SRP Packages	SRP racks / units / packages: 1) SRP Type, Size, Capacity, Arrangement 2) No.of units / racks 3) Material 4) Size / dimensions 5) Limitation (if any) - Temperature, pressure, moisture etc., 6) Any additional equipment (vendor specific)	**2 x 50% units. Each 116 / 58 vessel array with 6 x Dow SR90 elements.**	The SUEZ SWSR-Series membranes is our latest nanofiltration (NF) innovation. With nearly 30-year experience in NF membrane manufacturing, SUEZ has advanced the DK NF membrane. A membrane recognized for its low fouling properties. This is a result of an extremely smooth surface enabled by our unique 3-layer membrane design. The SWSR-Series incorporates a true Nanofiltration membrane that features: high rejection of sulfate and hardness meeting reservoir injection requirements, high transmission of sodium chloride into the permeate minimizing the operating pressure, physical barrier for any suspended particles, bacteria, pyrogens and colloids. The SWSR-Series membranes can be stored for a period of 12 months in its original packaging at ambient temperature up to 100°F (38°C). Mirfa is designed with 14 + 2 trains, Dhabb'iya 8+2 trains, flux ave 25 lhm, 2 stages, recovery 75% @ 25°C	4 x SRP clusters per site: 1) SRP cluster capacity: 5 x 20% trains in parallel 2) No.of units / racks: 2 stages of vessels with 6 membranes each 3) Material: GRP/SDSS vessels; polyamide TFC membranes 4) Size / dimensions: 12 x 6 x 9 m (lxwxh) per skid 5) Limitation (if any) - Temperature max 45 deg C. 6) Any additional equipment : Commonn CIP package with UF

ADNOC Class

Sea Water Treatment Package - ADNOC Onshore - Concept stage - P30280				
Summary of Package Equipment, Details and Requirement		**Veolia (mail dt:31.07.2019)**	**Suez (mail dt: 02.08.2019)**	**Petreco International (Middle East) Ltd. (SLB) (mail dt: 04.08.2019)**
Deaerator System	**(a) Deareator / units / packages**: 1) Deareator type (vacuum / gas / catalyst) 2) Deareator Size, Capacity, Arrangement 3) No.of units 4) Material 5) Internals type 6) Limitation (if any) 7) Any additional equipment (vendor specific) **(b) Vacuum Ejector System**: 1) Ejector type 2) Ejector size, capacity, arrangement 3) No.of units 4) Material 5) Limitations (if any) **(c) Vacuum Pump System**: 1) Pump type 2) Ejector size, capacity, arrangement 3) No.of units 4) Material 5) Limitations (if any) **(d) Separators** 1) Separator type 2) Vessel Size, Capacity, Arrangement 3) No.of units 4) Material 5) Internals type 6) Limitation (if any)	**1 x 100% tower, 5400mm id x 22000mm t/t. Two stage vacuum. Ejector on 2nd stage. Each stage ~4000 mm bed depth using 2" Pall rings or similar.** **2 x 100% liquid ring vacuum pumps each with dedicated separator vessel and ejector. Circa 150 kW motor**	The Deaeration Columns are foreseen to reduce the water oxygen content down to 50 ppb by mechanical means and down to below 20 ppb (vol) by chemical injection (SBS injection). The treatment will consist of 30 trains of a design continuous net production of 700 m3/h of deoxygenated water for Mirfa and 12 trains of the same capacity for Dhabb'iya. The Vacuum Deaerator Package is fed by water coming from NFSW treatment by means of 2x100% Feeding Pumps. A Surge tank shall be foreseen to guarantee a surge capacity of 5 minutes. Deoxygenated treated water will be sent to Water Injection Storage Tank by means Transfer Pump (out of Suez's scope). The unit Vacuum Deaerator Package shall be configured for a total treated water net production of 700 m3/h and will include: N° 1 x 100% CS Vacuum Column with ebonite internal lining N° 1 x 100% CS Surge Drum with ebonite internal lining N° 2 x 100% Vacuum Pumps N° 1 Set of instruments including O2 analyzer N° 1 Oxygen scavenger Pakage: N° 2x100% dosing pumps N° 1 Static mixer. Each Vacuum Tower will be realized in two stages complete with filling, and will be placed under vacuum conditions at pressures respectively equal to 56 mmHg and 18 mmHg. The vacuum is obtained by means of a liquid ring pump and two injectors. The gas extracted from the two sections is mainly composed of oxygen, nitrogen and water vapor. The filling consists of Pall Rings from 1 ½" polypropylene.	**(a) Deareator / units / packages**: 4 clusters per site 1) Deareator type (vacuum / gas / catalyst): vacuum 2) Deareator Size, Capacity, Arrangement: approx 5 m dia x 15 m t-t 3) No.of units: 2 x 50% per cluster 4) Material: CS GFVE internal lined 5) Internals type: 2 stage random packed bed 6) Limitation (if any): vessel turndown typically to 25% flow 7) Any additional equipment (vendor specific): none **(b) Vacuum Ejector System**: 4 clusters per site 1) Ejector type: [roprietary atmospheric air motive fluid 2) Ejector size, capacity, arrangement: confirmed with firm bid 3) No.of units: 3 x 50% 4) Material: SDSS 5) Limitations (if any): npne **(c) Vacuum Pump System**: 4 clusters per site 1) Pump type: liquid ring 2) Pump size, capacity, arrangement: to be confirmed with firm bid 3) No.of units: 3x50% per cluster 4) Material: 25% SDSS 5) Limitations (if any): turndown typically limited to 25% **(d) Separators: 4 clusters per site** 1) Separator type: atmospheric vapour/condensate separator 2) Vessel Size, Capacity, Arrangement: to be confirmed with firm bid 3) No.of units: 2 x 50% per cluster 4) Material: GRP/PP lined 5) Internals type: none 6) Limitation (if any): design temperature
Treaded Sea water supply (by others)	Treated Sea water supply system (by others) - Booster pumps - Supply pumps	**Presently 1 x 100% Booster pump is allowed for, circa 10 barg discharge pressure. 1MW motor.**		Treated Sea water supply system (by others) - Booster pumps - Supply pumps
Sea water outfall / reject	Sea water outfall / reject (by others) - Specify the effluent type, qty - Recommend the treatment type & provide details (provisional only) - Effluent pit - Effluent pump	**Circa 81 kBWPD discharge (per train). Effluent is 95% SR reject containing high level of salts particularly divalent ions. Presence of chemicals such as DBNPA biocide can be neutralised with ammonium bisulphite.**		Please refer to section 4.10 of our techncial proposal. Sea water outfall / reject (by others) - Specify the effluent type, qty: SRP waste (continuous to sea outfall) + UF chlorinated backwash (intermittent via effluent pit) + CIP wastes (via effluent pit) Recommend the treatment type & provide details (provisional only): pH adjustment and chlorine removal with chlorine scavenger - Effluent pit (by others): preliminary sizing attached - Effluent pump (by others)
Chemical Injection system	Chemical Injection Packages: capacity & material - Coagulant package: - Sodium hypochlorite - Ammonium biosulphate - scale inhibitor - Biocide -Oxygen scavenger - Citric acid -specify other chemical required (if any)	**Two further chemicals are foreseen: Antifoam and sodium hydroxide.**	A variety of chemicals are required for dosing within the seawater treatment including NaHSO3, Antiscalant, Biocide, NaOH, H2SO4, ETDA, Citric Acid and NaClO. Coagulant will be used if needed upstream UF or in coagulation if SeaDAF. Storage tank will be foreseen for 15d capacity.	Chemical Injection Packages: can be 1 per cluster or common for site. Typical specifications: - 2 x 15 day chemical storage tanks - 2 x 100% API chemical injection pumps - chemical injection fittings, calibration pots, pulsation dampers etc For proposed chemicals refer attached POWER, CHEMICAL, UTILITY CONSUMPTION & OPEX (under OPEX below).
Clean-in-Place System (CIP)	Vendor specific, specify details			1 per cluster includes common CIP system for UF + SRP membranes: with CIP tank (GRP) + heater/cooler + CIP filter (316 ss) + CIP pumps (316ss)
Utilities	Utility list (consumptions and conditions) covering: - IA - N2 - Electric power - Procured water - chemical - specify others (specific to vendor)		Electricity is a the big cost in these Plants. The installed power for Mirfa can be estimated equal to 50 MW for an average consumption of 1000 MWh/d, for Dhabb'iya the estimated values are about 25 MW and 450 MWh/d. For chemical we can estimate a budgetary cost of 1,750,000 USD/year for Mirfa and 700,000 USD/year for Dhabb'iya. This preliminary estimation will be confirmed in later stage.	For proposed utilities refer attached POWER, CHEMICAL, UTILITY CONSUMPTION & OPEX (under OPEX below).

ADNOC Class

Sea Water Treatment Package - ADNOC Onshore - Concept stage - P30280				
Summary of Package Equipment, Details and Requirement		**Veolia (mail dt:31.07.2019)**	**Suez (mail dt: 02.08.2019)**	**Petreco International (Middle East) Ltd. (SLB) (mail dt: 04.08.2019)**
Process description	As per process specification 30-99-37-0601	Supplied in technical bid document ref 11097		As per process specification 30-99-37-0601 and attached Vendor PFD
Inlet Composition	Inlet Composition (as per 30-99-37-0601)	Noted		Inlet Composition (as per 30-99-37-0601)
	1) Mirfa/Dy		Confirmed	1) Mirfa/Dy
	2) Ruwais seawater		To be checked	2) Ruwais seawater
	Reject water from existing desalination plant is available, It is proposed to utilize this reject water and biosulphate it and inject to reservoirs			Reject water from existing desalination plant - treatment to be confirmed once brine samples available for treatment verificatin tests.
For Ruwais reject water	Reject Spec.	This is currently being investigated to assess the highest Ruwais reject blend that can be achieved. We assume that the intent is to maximise the reuse of reject water over seawater. As the reject water contains high levels of sulphates it is unsuitable for direct injection to water injection reservoirs.	The inlet flowrate is 33,000 m3/h for Mirfa and 12,600 m3/h for Dhabb'iya. Reject will contain chemical and much higher concentration of Ca, Mg, SO4 than SW. Effect of scaling on NF membranes is to be evaluated with pilot test.	Noted, please refer PFD for Ruwais for proposed mass balance - to be confirmed once brine samples available for treatment verification tests.
	Min reject available = 5,300 m3/h			
	Max reject = 6,200 m3/h			
	Balance water to meet the required sea water injection			
Treated Sea Water Specifications	Sulphates: Mirfa: 800 mg/l Ruwais: 800 mg/l Dy: 600 mg/l	Noted to all.	Expected sulphates concentration could be better (<60 mg/l) , oxygen target could be < 10 ppb, confirmed for other parameters	Sulphates: Mirfa: 800 mg/l Ruwais: 800 mg/l Dy: 600 mg/l
	TSS: 0.1 mg/L (particle size: 95% separation > 2 microns)			TSS: 0.1 mg/L (particle size: 95% separation > 2 microns)
	Oxygen: 20 ppb for all			Oxygen: 20 ppb for all
Design Life	30 years	Noted	Design Life confirmed	30 years
Service Water System	Vendor specific, specify details	Freshwater is required for membrane Clean-in-Place (CIP) operations. This can be made in-situ optionally via a dedicated SWRO plant if necessary. Per train, CIP freshwater requirement is circa 70 m3 batch volume per week.		Assume this will be site washdown/flushing purposes so not specified.
Potable Water System	Vendor specific, specify details	None required.		Refer attached POWER, CHEMICAL, UTILITY CONSUMPTION & OPEX (under OPEX below).
Plant / Equipment Availability	The plant / equipment shall ensure 95% availability.	Noted		The plant / equipment shall ensure 95% availability.
Disposal Requirements	As per process specification 30-99-37-0601	Yet to be evaluated.	Confirmed. N+1 or N+2 installed spare philosophy is applied	As per process specification 30-99-37-0601
Codes and Standards	Latest issue of Shell Design DEP 39.01.40.30-Gen Engineering Practices (DEP) except where ADNOC Onshore Standards, Philosophies, Specifications, Local Statutory codes and regulations and applicable International Codes and Standards herein are indicated otherwise.	Noted.	Confirmed	Confirmed although no specifications have been provided for Vendor review/comments .
Vendor Data Requirement	Process description	Yes (see technical quotation for details)	See presentation in attachment	Please refer to Section 4 of our technical proposal.
	Design and operating conditions	Yes	See presentation in attachment	Please refer to Section 3 of our technical proposal.
	Mass Balance	Yes	See presentation in attachment	Mass Balance - to follow with firm bid
	Material of construction	Yes	Compatible with seawater. Suez has realized and is operating SWRO plant in Mirfa	Material of construction - listed above
	PFDs	Yes	Later	Please refer to PFDs attcahed as Attachment 1.
	Technology selection	Yes	UF and NFSW membranes are Suez WTS products, fabricated in his factories (Europe and US). Suez is not only an EPC company but is the supplier of the key components of this plant	Please refer to Section 6 of our technical proposal.
	Merits and demerits of utilization of reject water at Ruwais	To be completed	Reject have higher concentration of sulphates and hardness, chemicals antiscaling must be tested at these conditions. Pilot test is suggested to verify the process before the construction of this kind of large plant	Please refer to Section 4.6 of our technical proposal.
	Utilities consumption (including fresh water / service water)	Yes	All fresh/service water will be produced inside the new plant with dedicated SWRO line	Utilities consumption (including fresh water / service water)
	Sparing Philosophy	Yes	N+2 for sensitive equipment	Sparing Philosophy - to follow with firm bid
	Power requirement (kW / treated sea water bbl.)	Yes	Approx 0.3-0,35 kW/bbl	Please refer to Attachment 2 .
	Downtime requirements for cleaning	Yes	Cleaning interval for NFSW is estimated in 4 months, the procedure is completed in 8-12h normally. For UF maintenance cleaning procedure can take 1-2h/week; recovery cleaning procedure is applied 3-4 time per year for 8-12h duration.	Please refer to our technical proposal
	General arrangement sketches	Yes	For UF vertical or horizontal models, NF will be installed in skids similar than SWRO. See presentation for general arrangement	General arrangement sketches - to follow with firm bid
	Plot Plan (specify the plot space with typical plot plan)	Yes	Mirfa: 300x315m - Dhabb'iya: 220x290 m, with UF vertical	Plot Plan (specify the plot space with typical plot plan) - see attachment
	Effluent Pit sizing basis	To be completed		Effluent Pit sizing basis - preliminary sizing attached under intake/outfall
	Reject Water quantity and required treatment for disposal	Yes	No treatment is required for reject. Sludge will be treated and dewatered internally	Reject Water quantity and required treatment for disposal
	Pump ratings	Yes		Pump ratings - refer attached POWER, CHEMICAL, UTILITY CONSUMPTION & OPEX
	Equipment list	No		Please refer to Attachment 3
	Vendor service for installation, pre-commissioning, commissioning, SAT - Supervision rate - No.of. Days	Available	Included in the cost estimation. Suez WTS is open to fully operate with own operators as did for the existing Mirfa SWRO plant	Details to follow with firm bid but estimate each site startup/handover/SAT will take about 16 to 20 weeks.
	OPEX summary:	Provisional Information Only Based on Industry Norms. Refer to Email dated 28 June 2019 for further information	Later	Please refer to Attachment 2 on inidcative figures for POWER, CHEMICAL, UTILITY CONSUMPTION & OPEX
	- Energy consumption and unit cost	5 MW per 315kBWPD Train	Consumption is indicated above	USD 0.09/m3 (Power 1.8 kWh/m3 @ $0.05/kWh)
	- Chemical consumptions and its unit costs	See attached.	Yearly cost is indicated above	USD 0.11/m3
	- Sea Water SRP treatment package operating costs ($ / treated sea water bbl.)	0.60 - 0.66	Later	Please refer to attcahment 2 .
	- Filter elements (UF, NF) replacement requirements, frequency and cost	Incl in above	Frequency of replacement depends on the operating procedures followed during the service. Suez WTS is open to discuss with ADNOC a service agreement with guaranteed performances of the installed membranes during a period of 10 years, or more.	USD 0.05/m3 (Membrane replacement every 5 years)
	- Man Power / labor (operation) - rate, number and duration	Incl in above	Later	USD 0.02/m3
	- Maintenance cost ($ / treated seawater bbl.)	Incl in above	Later	Please refer to attcahment 2 .
	- Spares cost ($ / treated seawater bbl.)	Incl in above	Later	Please refer to attcahment 2 .
	- Specify other requirement (if any)	N/A		Please refer to attcahment 2 .
	Mirfa	Industry Norm Only Values		US $80 million / cluster . 4 clusters of sea water treatment package are required for this site.

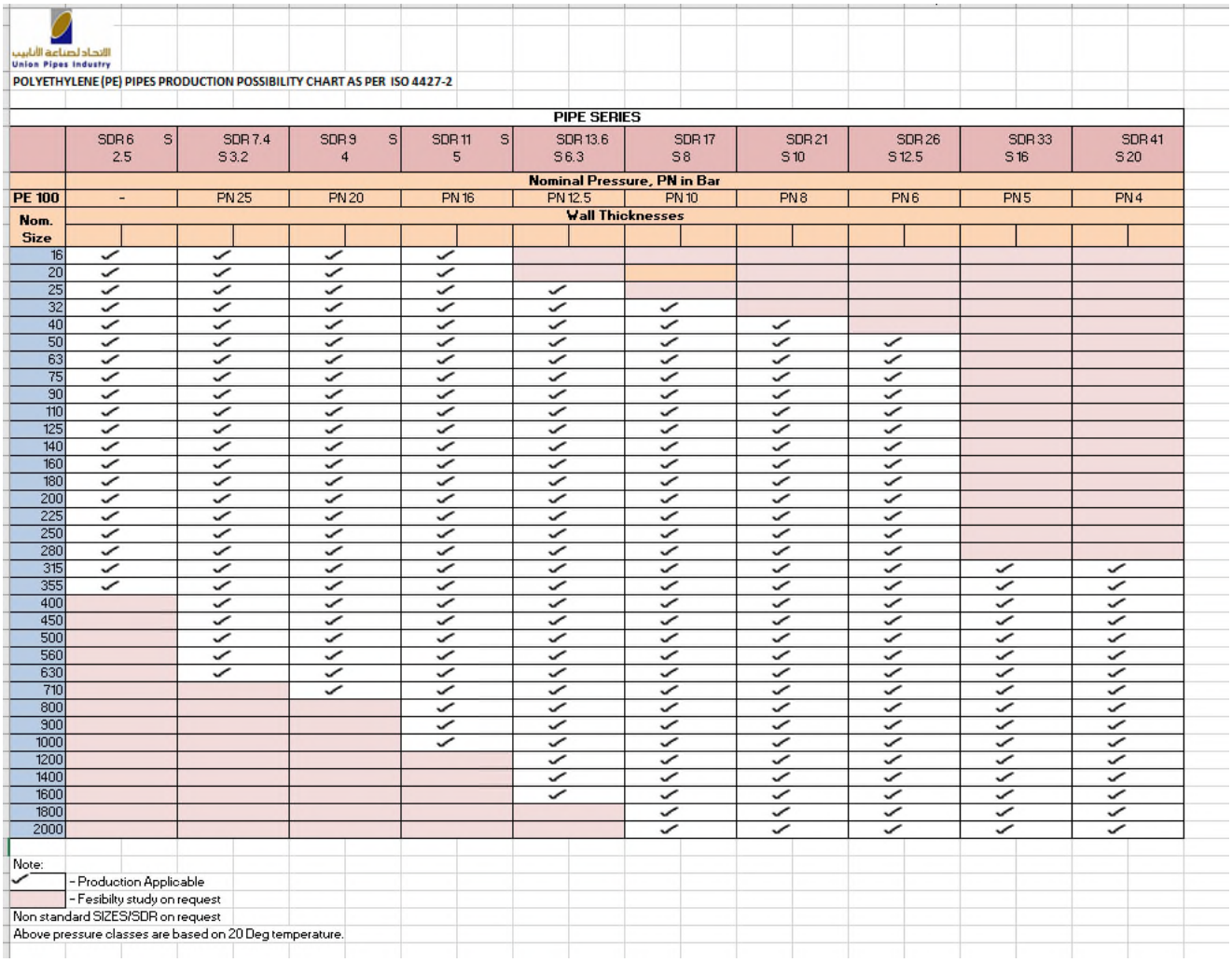
ADNOC Class

Sea Water Treatment Package - ADNOC Onshore - Concept stage - P30280				
Summary of Package Equipment, Details and Requirement		**Veolia (mail dt:31.07.2019)**	**Suez (mail dt: 02.08.2019)**	**Petreco International (Middle East) Ltd. (SLB) (mail dt: 04.08.2019)**
Commercial Capacity (M3/DAY) Budgetary quote , CAPEX (USD)	Ruwais	Mirfa / Ruwais - $438MM each		US $80 million / cluster . 4 clusters of sea water treatment package are required for this site. (price is not including brine treatment at this stage)
	Dy:	Dy - $404MM		US $75 million / cluster . 4 clusters of sea water treatment package are required for this site.
Commercial Capacity (M3/DAY) OPEX Cost (USD)	Mirfa	$28.5MM per annum		Estimate $0.32 per m3 treated (cost reductions possible due to size of chemical orders plus power cost assumed).
	Ruwais	$28.5MM per annum		As Mirfa (but proposed brine treatment may result in savings)
	Dy:	$26.6MM per annum		As Mirfa
Delivery period and Location	Vendor to specify	Highly dependent on scope and would require considerably better understanding of client expectations. Manufacturing capacity would most likley contstrain delivery to minimum 48 months for Mirfa plant for example. Phased delivery could enable 500kBWPD trains to be delivered in 14 months.		Estimate total delivery period of 120 weeks; FCA UAE fabrication yard
Guarantee, Warranty	Vendor to specify	For negiotation. Minimum would be mechancial warranty from equipment vendors. We would be pleased to discuss improved warranty conditions.		1 year performance warranty, 3/5 year SR/UF pro-rata membrane warranty
EXCLUSIONS FROM SCOPE OF SUPPLY-PRELIMINARY	Vendor to specify	None identifed at this preliminary stage.		SW intake and outfall, site works, package delivery to site, site installation, hookups, SAT. Detailed list to follow with firm bid

APPENDIX-D: GRE SIZE VERSUS PRESSURE LIMITS (MULTIPLE VENDORS)

			FPI GRE WAVISTRONG					NOV BONDSTRAND		SARPLAST			
PIPE-ID (MM)	NPS (Inch)	Installation Condition	SHELL Max. Pressure		API Max. Pressure		Design Temp	AWWA AND SHELL Max. Pressure	Design Temp	AWWA	ISO 14692	1000hr test?	Design Temp
			Piping	Pipeline	Piping	Pipeline	Piping/Pipeline						
50	2	Underground	50	50	60	70	50	70	93	50	40	N	---
80	3	Underground	50	50	60	70	50	70	93	---	---	---	---
100	4	Underground	50	120	60	70	50	70	93	50	40	N	---
150	6	Underground	50	120	60	70	50	70	93	50	40	N	---
200	8	Underground	50	50	60	70	50	70	93	40	40	Y	---
250	10	Underground	50	50	60	70	50	60	93	40	40	N	---
300	12	Underground	50	50	50	60	50	60	93	32	32	N	---
350	14	Underground	50	50	50	60	50	60	93	32	32	N	---
400	16	Underground	50	50	50	60	50	52	93	32	32	Y	---
450	18	Underground	50	50	50	60	50	52	93	25	25	N	---
500	20	Underground	50	50	50	60	50	52	93	25	25	N	---
600	24	Underground	50	50	50	60	50	50	93	25	22	Y	---
700	28	Underground	40	40	40	50	50	42	93	21	21	N	---
750	30	Underground	40	40	40	50	50	42	93	21	21	N	---
900	36	Underground	32	32	32	40	50	42	93	21	21	N	---
1000	40	Underground	32	32	32	40	50	25	93	21	21	Y	---
1050	42	Underground	25	25	25	32	50	16	93	16	16	N	---
1200	48	Underground	25	25	25	32	50	16	93	16	16	N	---
1250	50	Underground	25	25	25	32	50	- - -	- - -	---	---	---	---
1300	52	Underground	20	20	20	25	50	16	93	16	16	N	---
1400	56	Underground	20	20	20	25	50	- - -	- - -	16	16	N	---
1500	60	Underground	- - -	- - -	- - -	- - -	- - -	16	93	---	---	---	---

APPENDIX-E: VENDOR INPUTS ON HDPE PIPE LIMITATIONS



Union Pipes Industry

POLYETHYLENE (PE) PIPES PRODUCTION POSSIBILITY CHART AS PER ISO 4427-2

	PIPE SERIES									
	SDR 6 S 2.5	SDR 7.4 S 3.2	SDR 9 S 4	SDR 11 S 5	SDR 13.6 S 6.3	SDR 17 S 8	SDR 21 S 10	SDR 26 S 12.5	SDR 33 S 16	SDR 41 S 20
	Nominal Pressure, PN in Bar									
PE 100	-	PN 25	PN 20	PN 16	PN 12.5	PN 10	PN 8	PN 6	PN 5	PN 4
Nom. Size	Wall Thicknesses									
16	✓	✓	✓	✓						
20	✓	✓	✓	✓						
25	✓	✓	✓	✓	✓					
32	✓	✓	✓	✓	✓	✓				
40	✓	✓	✓	✓	✓	✓	✓			
50	✓	✓	✓	✓	✓	✓	✓	✓		
63	✓	✓	✓	✓	✓	✓	✓	✓		
75	✓	✓	✓	✓	✓	✓	✓	✓		
90	✓	✓	✓	✓	✓	✓	✓	✓		
110	✓	✓	✓	✓	✓	✓	✓	✓		
125	✓	✓	✓	✓	✓	✓	✓	✓		
140	✓	✓	✓	✓	✓	✓	✓	✓		
160	✓	✓	✓	✓	✓	✓	✓	✓		
180	✓	✓	✓	✓	✓	✓	✓	✓		
200	✓	✓	✓	✓	✓	✓	✓	✓		
225	✓	✓	✓	✓	✓	✓	✓	✓		
250	✓	✓	✓	✓	✓	✓	✓	✓		
280	✓	✓	✓	✓	✓	✓	✓	✓		
315	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
355	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
400		✓	✓	✓	✓	✓	✓	✓	✓	✓
450		✓	✓	✓	✓	✓	✓	✓	✓	✓
500		✓	✓	✓	✓	✓	✓	✓	✓	✓
560		✓	✓	✓	✓	✓	✓	✓	✓	✓
630		✓	✓	✓	✓	✓	✓	✓	✓	✓
710			✓	✓	✓	✓	✓	✓	✓	✓
800				✓	✓	✓	✓	✓	✓	✓
900				✓	✓	✓	✓	✓	✓	✓
1000				✓	✓	✓	✓	✓	✓	✓
1200					✓	✓	✓	✓	✓	✓
1400					✓	✓	✓	✓	✓	✓
1600					✓	✓	✓	✓	✓	✓
1800						✓	✓	✓	✓	✓
2000						✓	✓	✓	✓	✓

Note:

✓ - Production Applicable

- Fesibilty study on request

Non standard SIZES/SDR on request

Above pressure classes are based on 20 Deg temperature.

APPENDIX-F: PIPELINE SCHEMATICS FOR SELECTED BAB OPTION



NOTES

1. CO-ORDINATES ARE BASED ON A UNIVERSAL TRANSVERSE MERCATOR PROJECTION. CLARKE 1880 (MOD) SPHEROID. NAHRWAN DATUM AND GRID ZONE 39.
2. ALL CO-ORDINATES ARE IN METRES UNLESS NOTED OTHERWISE.
3. CONTINUATION OF ELECTRICAL & TELECOM LINE IS NOT AVAILABLE & IT WILL BE CAPTURED IN DUE COURSE OF TIME.
4. REFER PIPELINE ROUTING PLANS FOR ROUTING DETAILS, REFER PIPELINE SCHEDULE FOR PIPELINE LIST, DESIGN CODE, SIZE, LENGTH ETC.
5. Eb-249 IVC AND NORTH BAB INJECTION PIG TRAP LOCATION AND DIMENSION SHALL BE BASED ON AS BUILT SITE CONDITION.
6. THE OFF PAD WATER INJECTION WELLS ARE CONNECTED TO NEW CLUSTERS No. 42/43/44.
7. FINAL ROUTING OF ALL PIPELINES IN PROJECT SCOPE SHALL BE AGREED WITH ADNOC ONSHORE BMP TEAM DURING EPC STAGE.

LEGEND:

AREA-IRRIGATION
BOUNDARY-CDAST
BOUNDARY-CONCESSION
BOUNDARY-FIELD
BOUNDARY-INTL
DATA
ELEC-OHL-11kV
ELEC-OHL-132kV
ELEC-OHL-220kV
ELEC-OHL-33kV
ELEC-OHL-FO
ELEC-UG
ETISALAT-FO-UG
ETISALAT-TEL-PCM-UG
ETISALAT-TEL-UG
TEL-FO-UG
FO
FENCE
GAS
OIL
WATER
ROAD-CENTER
ROAD-RIG-CROSS
TRACK
ROAD
TEL-PCM-UG
TEL-UG
PIPELINE-CORRIDOR
RAILWAY LINE
MAJOR-GRID
MINOR-GRID
REF-N
GAS-WELL
OIL-WELL
WAC-WELL
ADCO WATER INJECTION WELL
ADCO AQUIFER OBSERVATION-WELL
ADCO WATER DISPOSAL-WELL
ADCO SUSPENDED-WELL
ADCO RESERVOIR OBSERVATION-WELL
ADCO DRILLING-WELL
ADCO PLUGGED AND ABANDONED-WELL
ADCO GAS INJECTION-WELL
ADCO WATER SUPPLY-WELL
SURVEY
TRIG
BUILDING
ROAD CROSSING
FENCE CROSSING
CABLE CROSSING
TRACK CROSSING
OVER HEAD CROSSING
PIPELINE CROSSING
RIG CROSSING
BARRIER CROSSING
SEA WATER LOW PRESSURE HEADER
SEA WATER HIGH PRESSURE HEADER
SEA WATER INTAKE FROM MIRFA
SEA WATER SUB HEADER
SEA WATER SUB HEADER

SEA WATER HEADER DETAILS

Sl NO	DESCRIPTION	LENGTH (In Km)
1	24" SEA WATER LOW PRESSURE HEADER (LP-1) (NORTH SIDE)	48
2	24" SEA WATER LOW PRESSURE HEADER (LP-1) (SOUTH SIDE)	77.7
3	24" SEA WATER LOW PRESSURE HEADER (LP-2) (NORTH SIDE)	37
4	24" SEA WATER LOW PRESSURE HEADER (LP-2) (SOUTH SIDE)	44.5
5	30" SEA WATER LOW PRESSURE HEADER (LP-2) (NORTH SIDE)	7.5
6	30" SEA WATER LOW PRESSURE HEADER (LP-2) (SOUTH SIDE)	7.5
7	20" SEA WATER HIGH PRESSURE HEADER (NORTH SIDE)	37
8	20" SEA WATER HIGH PRESSURE HEADER (SOUTH SIDE)	44.5
9	30" SEA WATER HIGH PRESSURE HEADER (NORTH SIDE)	7.5
10	30" SEA WATER HIGH PRESSURE HEADER (SOUTH SIDE)	7.5

CLOUDED PORTION DENOTES : THE SCOPE OF WORK UNDER THE PROJECT P30280

THIS DRAWING DEVELOPED FROM MASTER OVERALL FIELD LAYOUT-BAB. DWG NO.11-99-02-0102 REV. 28 , FIELD LAYOUT OVERALL FACILITIES BAB -EPC FOR INTEGRATED FACILITIES PROJECT(BFP). DWG NO.11-99-02-1602 REV. A & OVERALL FIELD LAYOUT FOR WATER INJECTION SYSTEM-BAB DWG NO.11-99-02-1603 REV. A

DRAWING REFERENCE

TITLE	DRG. No.
ADCO FACILITIES-MASTER PLAN	30-99-11-1000
LINE ROUTING PLAN - BAB	11-99-07-0601

REV.	DATE	DR'N.	CH'D.	AP'D.	DESCRIPTION
1	28.08.2019	SSA	OOS	AS	ISSUED FOR CONCEPT DESGN
A	29/04/2019	SSA	OOS	AS	ISSUED FOR REVIEW

SCALE: 1:66000 | LOCATION: BAB/HABSHAN | PROJECT No. P30280

أدنوك البرية
ADNOC Onshore

CONSULTANT / CONTRACTOR / VENDOR
ADNOC ONSHORE - TC ENGINEERING

DRAWING No. -

PROJECT: CONCEPT
SEA WATER INJECTION

DRG. TITLE:
OVERALL FIELD LAYOUT
WATER INJECTION PIPELINES
BAB

DRG No. 11 (AREA) 99 (P/AREA) SK (DOC. CODE) 0701 (SERIAL No.) 1 (REV.) 1/1 (SHT OF SHT)

P30280-11-99-SK-0701-1.DWG

FORM_ADNOC_Onshore_A0.dwg_(REV.1)

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APPENDIX-G: DETAILED BREAKDOWN OF DEMOLITION SCOPE IN BAB

Existing Clusters:

Existing Clusters					
Cluster No	Year of Commissioning		Size (Inches)	Grade (Thickness (mm))	Lengths (KM)
1 to 21 (Except 15 &16)	1987		8	API 5L Gr. B (18.26)	110
			6	API 5L Gr. B (14.27)	298
22 to 32	2012		8	API 5L Gr. B (18.26)	91.1
			6	API 5L Gr. B (14.27)	263
33 to 35	2015		8	API 5L Gr. B (18.26)	20
			6	API 5L Gr. B (14.27)	85
BIFP Scope					
Cluster No	Year of Commissioning	Lengths (KM)	Size (Inches)	Grade (Thickness (mm))	Lengths (KM)
36		Header	10	API 5L Gr.X52 (20.62)	1.1
		Sub-header	8	API 5L Gr.X52 (18.26)	6.4
		Sub-header	6	API 5L Gr.X52 (15.88)	3.6
		Flowline	4	API 5L Gr.X52 (13.49)	0.6
38		Header	10	API 5L Gr.X52 (20.62)	0.9
		Sub-header	8	API 5L Gr.X52 (18.26)	6.2
		Sub-header	6	API 5L Gr.X52 (15.88)	3.1
		Flowline	4	API 5L Gr.X52 (13.49)	0.1
39		Header	10	API 5L Gr.X52 (20.62)	2.2
		Sub-header	8	API 5L Gr.X52 (18.26)	4.6
		Sub-header	6	API 5L Gr.X52 (15.88)	3
		Flowline	4	API 5L Gr.X52 (13.49)	3.4
41		Header	10	API 5L Gr.X52 (20.62)	2.1
		Sub-header	8	API 5L Gr.X52 (18.26)	10.1
		Sub-header	6	API 5L Gr.X52 (15.88)	6.1
		Flowline	4	API 5L Gr.X52 (13.49)	5.6
Sub- Headers /Flow lines to Existing Cluster					
		Sub-header	8	API 5L Gr.X52 (18.26)	11.2
		Sub-header	6	API 5L Gr.X52 (15.88)	71.3
		Flowline	4	API 5L Gr.X52 (13.49)	23.5
BAB 485 MBOPD SUSTAINABLE FACILITIES PROJECT Scope:					
Cluster No	Year of Commissioning	Lengths (KM)	Size (Inches)	Grade (Thickness (mm))	Lengths (KM)
42		Header	10	API 5L Gr.X60 (18.26)	13.7
		Sub-header	6	API 5L Gr.X60 (14.27)	0.6
		Flowline	4	API 5L Gr.X60 (11.3)	1.8
43		Header	10	API 5L Gr.X60 (18.26)	17.3
		Sub-header	6	API 5L Gr.X60 (14.27)	17.6
		Flowline	4	API 5L Gr.X60 (11.3)	0.3
44		Header	10	API 5L Gr.X60 (18.26)	5.1
		Sub-header	6	API 5L Gr.X60 (14.27)	12.4
		Flowline	4	API 5L Gr.X60 (11.3)	17.3
Flowlines to Existing Cluster		Flowline	4	API 5L Gr.X60 (11.3)	49.6

Note:
All pipelines are surface laid.

ADNOC Classification: Internal

Notes
1. Provide the number and names of any future Cluster and Wells
2. Provide the injection fluid type Seawater or Produced water

380 existing wells

Cluster / Capacity / Equipment	(CLS life/Age) Design Life / Year of Commissioning	Completion / Well Count	Reservoir	Flowline Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 001	1987	BAB-0109-WI-TB	THAM BIV+BV	32	SWI	2022	Please provide the description of the current on	1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0122-WI-TB	THAM BIV		SWI	2022			
		BAB-0146-WI-TB	THAM BIV		SWI	2022			
		BAB-0149-WI-TB	THAM BIV		SWI	2022			
		BAB-0154-WI-TB	THAM BIV		SWI	2022			
		BAB-0157-WI-TB	THAM BIV		SWI	2022			
		BAB-0158-WI-LS	THAM BIV+BV+BVI		SWI	2022			
		BAB-0158-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0178-WI-TB	THAM BIV		SWI	2022			
		BAB-0432-WI-TB	THAM BIV		SWI	2022			
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 002	1987	BAB-0098-WI-LS	THAM BIV+BV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0098-WI-SS	THAM BII+BIII		SWI	2022			
		BAB-0101-WI-TB	THAM BIIIL+BIV		SWI	2022			
		BAB-0139-WI-TB	THAM BIV		SWI	2022			
		BAB-0179-WI-TB	THAM BIV		SWI	2022			
		BAB-0184-WI-TB	THAM BIV		SWI	2022			
		BAB-0694-WI-TB	THAM BIV+BV		SWI	2022			
		BAB-1114-WI-TB	THAM BIVL		SWI	2022			
		BAB-1158-WI-TB	THAM B		SWI	2022			
		Completion / Well Count		**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 003	1987	BAB-0120-WI-TB	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0138-WI-TB	THAM BIV		SWI	2022			
		BAB-0181-WI-TB	THAM BIII+BIV+BV		SWI	2022			
		BAB-0325-WI-TB	THAM BIV		SWI	2022			
		BAB-0522-WI-TB	THAM BIV		SWI	2022			
		BAB-1194-WI-LS	THAM B		SWI	2022			
		BAB-1194-WI-SS	THAM B		SWI	2022			
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 004	1987	BAB-0185-WI-TB	THAM BL	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 005	1987	BAB-0117-WI-TB	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0135-WI-LS	THAM BIV+BV		SWI	2022			
		BAB-0135-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0805-WI-TB	THAM BIV		SWI	2022			
		BAB-0831-WI-TB	THAM BIV		SWI	2022			
		IASC005	THAM A						
		ICSC006	THAM A						
		IASC003	THAM A						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 006	1987	BAB-0100-WI-LS	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0100-WI-SS	THAM BII+BIIIJ		SWI	2022			
		BAB-0119-WI-LS	THAM BIV+BV+BVI		SWI	2022			
		BAB-0119-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0148-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0148-WI-SS	THAM BII		SWI	2022			
		BAB-0515-WI-TB	THAM BIII+BIV		SWI	2022			
		BAB-0825-WI-TB	THAM BIV		SWI	2022			
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 007	1987	BAB-0121-WI-LS	THAM BIV+BV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0121-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0132-WI-LS	THAM BIV+BV		SWI	2022			
		BAB-0132-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0170-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0170-WI-SS	THAM BII		SWI	2022			
		BAB-0704-WI-TB	THAM BIV		SWI	2022			
		BAB-0740-WI-TB	THAM BIV+BV		SWI	2022			
		IBSC017	THAM A						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 008	1987	BAB-0078-WI-TB	THAM BIV+BV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0123-WI-TB	THAM BIII+BIV+BV		SWI	2022			
		BAB-0134-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0134-WI-SS	THAM BII		SWI	2022			
		BAB-0176-WI-LS	THAM BIV+BV+BVI		SWI	2022			
		BAB-0176-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0177-WI-TB	THAM BIV+BV+BVI		SWI	2022			
		BAB-0217-WI-LS	THAM BIV+BV		SWI	2022			
		BAB-0217-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0726-WI-TB (OLD1)	THAM BIV		SWI	2022			
		BAB-1168-WI-TB	THAM G		SWI	2022			

ADNOC Classification: Internal

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 009	1987	BAB-0126-WI-LS	THAM BIV+BV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0126-WI-SS	THAM BII+BIIIJ		SWI	2022			
		BAB-0130-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0130-WI-SS	THAM BII		SWI	2022			
		BAB-0174-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0174-WI-SS	THAM BII		SWI	2022			
		BAB-0529-WI-TB	THAM BIV		SWI	2022			
		BAB-0808-WI-TB	THAM BIV		SWI	2022			
		BAB-1214-WI-TB	THAM G		SWI	2022			
		BB-1463	THAM G						
		BB-1268	THAM A						
		BB-1275	THAM A						

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 010	1987	BAB-0111-WI-LS	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0111-WI-SS	THAM BII+BIIIJ		SWI	2022			
		BAB-0155-WI-LS	THAM BIV+BV+BVI		SWI	2022			
		BAB-0155-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0160-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0160-WI-SS	THAM BII		SWI	2022			
		BAB-0162-WI-TB	THAM BII+BIIIJ		SWI	2022			
		BAB-0164-WI-TB	THAM BIIIJ		SWI	2022			
		BAB-0548-WI-TB	THAM BIV		SWI	2022			
		BAB-0806-WI-TB	THAM BIV		SWI	2022			
		BAB-0849-WI-TB	THAM BIV		SWI	2022			

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 011	1987	BAB-0106-WI-TB	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0118-WI-TB	THAM BIV		SWI	2022			
		BAB-0167-WI-TB	THAM BIV+BV+BVI		SWI	2022			
		BAB-0236-WI-TB	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0530-WI-TB	THAM BIV		SWI	2022			
		BAB-0858-WI-TB	THAM BIV		SWI	2022			
		BAB-0860-WI-TB	THAM BIV		SWI	2022			

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 012	1987	BAB-0140-WI-LS	THAM BIV+BV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0140-WI-SS	THAM BIIIJ		SWI	2022			
		BAB-0153-WI-LS	THAM BIII+BIV+BV+BVI		SWI	2022			
		BAB-0153-WI-SS	THAM BII		SWI	2022			
		BAB-0532-WI-TB	THAM BIV		SWI	2022			
		BAB-0540-WI-TB	THAM BIV		SWI	2022			
		BAB-1087-WI-TB	THAM G		SWI	2022			

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 013	1987	BAB-0104-WI-TB	THAM BIV+BV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0145-WI-TB	THAM BII+BIIIJ		SWI	2022			
		BAB-0147-WI-TB	THAM BIIIJ		SWI	2022			
		BAB-0168-WI-LS	THAM BIII+BIV+BV		SWI	2022			
		BAB-0168-WI-SS	THAM BII		SWI	2022			
		BAB-0169-WI-TB	THAM BIII+BIV+BV		SWI	2022			
		BAB-0534-WI-TB	THAM BIV+BV		SWI	2022			
		BAB-0541-WI-TB	THAM BIV		SWI	2022			
		BAB-1070-WI-TB	THAM H		SWI	2022			
		BAB-1136-WI-TB	THAM G		SWI	2022			
		Bb-1230	THAM H						

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 014	1987	BAB-0345-WI-TB	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0351-WI-TB	THAM BIV		SWI	2022			
		BAB-0985-WI-TB	THAM BIV		SWI	2022			
		BAB-1134-WI-TB	THAM G		SWI	2022			
		BAB-1187-WI-TB	THAM BIVL		SWI	2022			

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 015	1987	BAB-0261-WI-TB	THAM BIV+BV	32	PWRI	NFA		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0344-WI-TB	THAM BIV		PWRI	NFA			
		BAB-0350-WI-TB	THAM BIV		PWRI	NFA			
		BAB-0423-WI-TB	THAM BIV		PWRI	NFA			

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 016	1987	BAB-0188-WI-TB	THAM BL	32	PWRI	NFA		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0332-WI-TB	THAM BIV		PWRI	NFA			
		BAB-0339-WI-TB	THAM BIV		PWRI	NFA			
		BAB-0768-WI-TB	THAM BIV		PWRI	NFA			

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 017	1987	BAB-0208-WI-TB	THAM BIV	32	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0323-WI-TB	THAM BIV+BV		SWI	2022			
		BAB-0330-WI-TB	THAM BIVL		SWI	2022			
		BAB-0340-WI-TB	THAM BIV+BV		SWI	2022			
		BAB-1198-WI-TB	THAM B		SWI	2022			

ADNOC Classification: Internal

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 018	**1987**	BAB-0221-WI-TB	THAM BIV		SWI	2022			
		BAB-0331-WI-TB	THAM BIV+BV		SWI	2022			
		BAB-0343-WI-LS	THAM BII/ HABSHAN 2/ BIV	**32**	SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0343-WI-SS	THAM BII		SWI	2022			
		BAB-1115-WI-TB	THAM G		SWI	2022			
		BAB-1146-WI-TB	THAM G		SWI	2022			
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 019	**1987**	BAB-0326-WI-TB	THAM BIV+BV		SWI	2022			
		BAB-0337-WI-TB	THAM BII/ HABSHAN 2/ BIV		SWI	2022			
		BAB-0341-WI-TB	THAM BIV	**32**	SWI	2022			
		BAB-1000-WI-TB	THAM G		SWI	2022			
		BAB-1213-WI-TB	THAM BIV		SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BB-1072	THAM H						
		BB-1424	THAM B						
		BB-1258	THAM H						
		BB-1324	THAM H						
		BB-1334	THAM H						
		BB-1346	THAM H						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 020	**1987**	BAB-0223-WI-LS	THAM BII/ HABSHAN 2/ BIV		SWI	2022			
		BAB-0223-WI-SS	THAM BII		SWI	2022			
		BAB-0257-WI-LS	THAM BII/ HABSHAN 2/ BIV		SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-0257-WI-SS	THAM BII	**32**	SWI	2022			
		BAB-0333-WI-LS	THAM BII/ HABSHAN 2/ BIV		SWI	2022			
		BAB-0333-WI-SS	THAM BII		SWI	2022			
		BAB-0989-WI-TB	THAM BV		SWI	2022			
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 021	**1987**	BAB-0328-WI-TB	THAM BL		SWI	2022			
		BAB-0329-WI-TB	THAM BII/ HABSHAN 2/ BIV		SWI	2022			
		BAB-0763-WI-TB	THAM BIV		SWI	2022			
		BAB-0789-WI-TB	THAM BIV	**32**	SWI	2022			
		BAB-0956-WI-TB	THAM H		SWI	2022		1.Bab Integrated Facilities Project 2.Process Control and Power System Upgrade Project	
		BAB-1029-WI-TB	THAM G		SWI	2022			
		BAB-1098-WI-TB	THAM G		SWI	2022			
		Bb-1342	THAM H						
		Bb-1462	HABSHAN 2						
		Bb-1488	HABSHAN 2						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 022	**2012**	BAB-0680-WI-TB	THAM G						
		BAB-0714-WI-TB	THAM G						
		BAB-0724-WI-TB	HABSHAN 2						
		BAB-0872-WI-TB	HABSHAN 2						
		BAB-0873-WI-TB	HABSHAN 2						
		BAB-0952-WI-TB	THAM G	**7**					
		BAB-1045-WI-TB	THAM G						
		BAB-1089-WI-TB	THAM G						
		BAB-1120-WI-TB	THAM G						
		BAB-1144-WI-TB	THAM G						
		BAB-1152-WI-TB	HABSHAN 2						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 023	**2012**	BAB-0669-WI-TB	THAM G						
		BAB-0683-WI-TB	THAM G						
		BAB-0684-WI-TB	THAM G						
		BAB-0732-WI-TB	THAM G						
		BAB-0747-WI-TB	THAM G	**7**					
		BAB-0751-WI-TB	THAM G						
		BAB-0784-WI-TB	THAM G						
		BAB-0812-WI-TB	THAM G						
		BAB-0870-WI-TB	HABSHAN 2						
		Bb-1308	THAM B						
		Bb-759	HABSHAN 2						
		Bb-1401	THAM H						
		Bb-1470	THAM G						
		Bb-1485	THAM G						
		N_UPI_02	THAM B						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 024	**2012**	BAB-0654-WI-TB	HABSHAN 2						
		BAB-0686-WI-TB	HABSHAN 2						
		BAB-0758-WI-TB	HABSHAN 2						
		BAB-0759-WI-TB	HABSHAN 2						
		BAB-0820-WI-TB	HABSHAN 2						
		BAB-0821-WI-TB	HABSHAN 2						
		BAB-0822-WI-TB	HABSHAN 2	**7**					
		BAB-0827-WI-TB	HABSHAN 2						
		BAB-0829-WI-TB	HABSHAN 2						
		BAB-0832-WI-TB	HABSHAN 2						
		BAB-0847-WI-TB	HABSHAN 2						
		BAB-0865-WI-TB	HABSHAN 2						
		BAB-0874-WI-TB	HABSHAN 2						
		BAB-0877-WI-TB	HABSHAN 2						

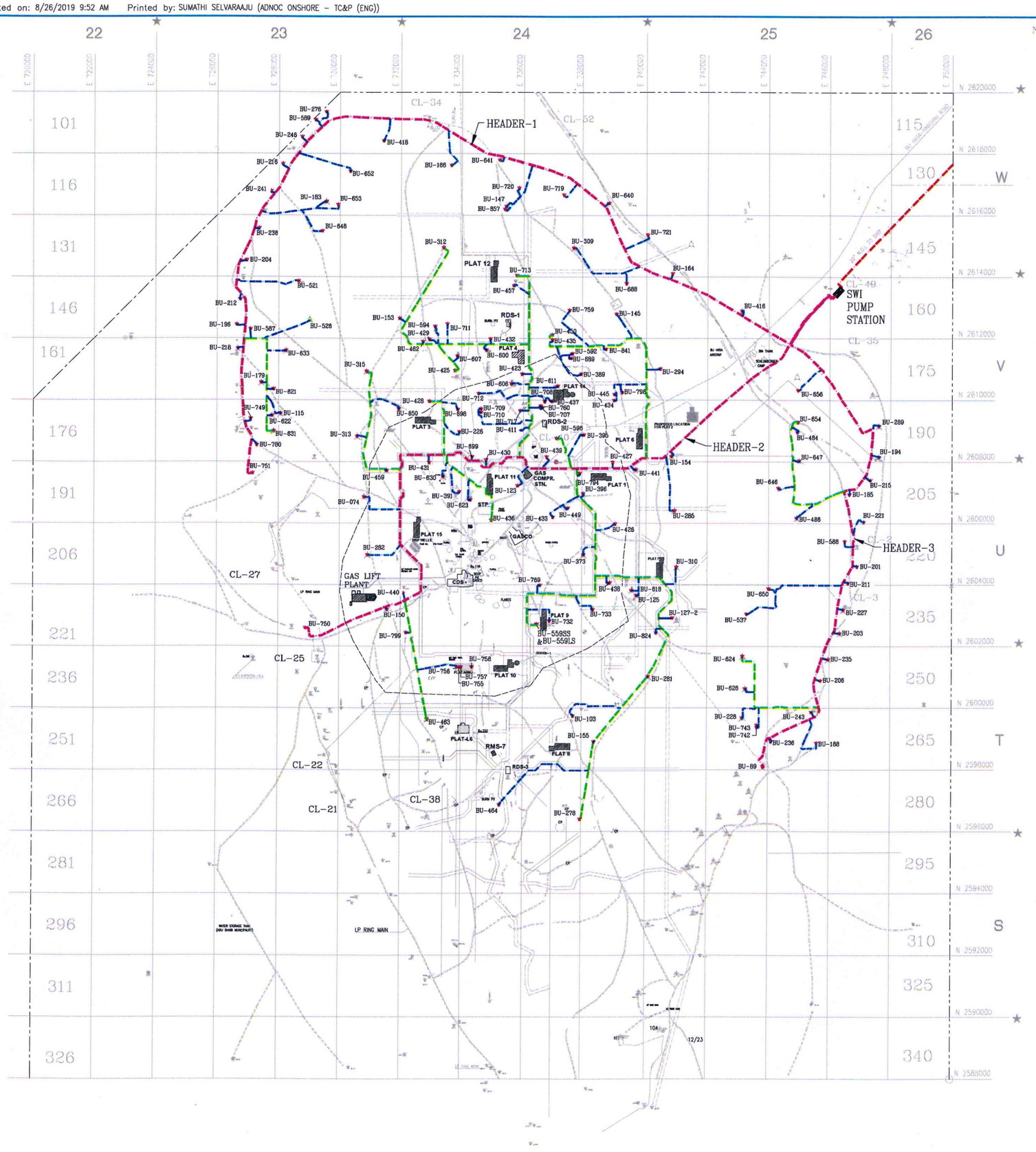
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 025	2012	BAB-0738-WI-TB	HABSHAN 2	7					
		BAB-0773-WI-TB	HABSHAN 2						
		BAB-0819-WI-TB	HABSHAN 2						
		BAB-0828-WI-TB	HABSHAN 2						
		BAB-0836-WI-TB	HABSHAN 2						
		BAB-0859-WI-TB	HABSHAN 2						
		BAB-0863-WI-TB	HABSHAN 2						
		BAB-0864-WI-TB	HABSHAN 2						
		BAB-0876-WI-TB	HABSHAN 2						
		BAB-1189-WI-TB	HABSHAN 1						
		Bb-1162	HABSHAN 1						
		Bb-1296	HABSHAN 1						
		Bb-1465	HABSHAN 1						
		Bb-1456	HABSHAN 1						
		Bb-1467	HABSHAN 2						
		Bb-1481	HABSHAN 2						
		W_UPI_11	THAM B						
		S_UPI_22	THAM B						
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 026	2012	BAB-0672-WI-TB	THAM G	7					
		BAB-0681-WI-TB	THAM G						
		BAB-0787-WI-TB	THAM G						
		BAB-0910-WI-TB	THAM A						
		BAB-1027-WI-TB	THAM G						
		BAB-1028-WI-TB	THAM G						
		BAB-1038-WI-TB	THAM G						
		BAB-1172-WI-TB	THAM G						
		BAB-1199-WI-TB	THAM G						
		BAB-1217-WI-TB	THAM B						
		BAB-1300-WI-TB	THAM G						
		Bb-1291	THAM G						
		Bb-1402	THAM A						
		Bb-1434	THAM A						
		Bb-1381	THAM A						
		Bb-1473	THAM G						
		Bb-1479	THAM G						
		IASC027	THAM A						
		ICSC004	THAM A						
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 027	2012	BAB-0671-WI-TB	THAM G	7					
		BAB-0703-WI-TB	THAM G						
		BAB-0717-WI-TB	THAM G						
		BAB-0776-WI-TB	THAM G						
		BAB-1040-WI-TB	THAM A						
		BAB-1043-WI-TB	THAM B/VL						
		BAB-1180-WI-TB	THAM B						
		Bb-1302	THAM A						
		Bb-1303	THAM G						
		Bb-1307	THAM A						
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 028	2012	BAB-0605-WI-TB	THAM G	7					
		BAB-0725-WI-TB	THAM G						
		BAB-0729-WI-TB	HABSHAN 2						
		BAB-0753-WI-TB	THAM G						
		BAB-0953-WI-TB	THAM G						
		BAB-0977-WI-TB	THAM A						
		BAB-0999-WI-TB	THAM G						
		BAB-1156-WI-TB	THAM G						
		Bb-1363	THAM H						
		IDW025	THAM A						
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 029	2012	BAB-0688-WI-TB	THAM G	7					
		BAB-0720-WI-TB	THAM G						
		BAB-0772-WI-TB	THAM G						
		BAB-0970-WI-TB	THAM G						
		BAB-0979-WI-TB	THAM H						
		BAB-1079-WI-TB	THAM G						
		BAB-1102-WI-TB	HABSHAN 1						
		BAB-1119-WI-TB	THAM G						
		Bb-1404	THAM H						
		Bb-1412	THAM H						
		Bb-1490	HABSHAN 2						
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 030	2012	BAB-0405-WI-TB	THAM B/V+BV+BVI	7					
		BAB-0407-WI-TB	THAM B/V						
		BAB-0408-WI-TB	THAM B/V+BV+BVI						
		BAB-0901-WI-TB	THAM B/V						
		BAB-0902-WI-TB	THAM B/V						
		BAB-0906-WI-TB	THAM B/V						
		BAB-1054-WI-TB	THAM B/VL						
		BAB-1055-WI-TB	THAM B/VU						
		BAB-1105-WI-TB	HABSHAN 1						
		BAB-1204-WI-TB	HABSHAN 1						
		Bb-1474	HABSHAN 1						
		Bb-1492	THAM H						
		Bb-1394	THAM H						
		Bb-724	HABSHAN 2						
		Bb-1269	THAM H						
		Bb-1366	THAM H						

ADNOC Classification: Internal

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 031	**2012**	BAB-0409-WI-TB	THAM BIV+BV+BVI	**7**					
		BAB-0410-WI-TB	THAM BIV+BV+BVI						
		BAB-0412-WI-TB	THAM BIV+BV+BVI						
		BAB-0904-WI-TB	THAM BIV						
		BAB-0905-WI-TB	THAM BIV						
		BAB-1157-WI-TB	HABSHAN 2						
		Bb-1272	THAM H						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 032	**2012**	BAB-0406-WI-TB	THAM BIV+BV+BVI	**7**					
		BAB-0411-WI-TB	THAM BIV+BV+BVI						
		BAB-0903-WI-TB	THAM BIV						
		BAB-0907-WI-TB	THAM BIV						
		BAB-0908-WI-TB	THAM BIV						
		BAB-1001-WI-TB	THAM H						
		BAB-1061-WI-TB	HABSHAN 1						
		BAB-1096-WI-TB	HABSHAN 1						
		BAB-1228-WI-TB	THAM B						
		Bb-1445	THAM H						
		Bb-1484	HABSHAN 1						
		E_UPI_08	THAM B						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 033	**2015**	BAB-0818-WI-TB	HABSHAN 1	**4**					
		BAB-0834-WI-TB	HABSHAN 1						
		BAB-0939-WI-TB	HABSHAN 1						
		BAB-0941-WI-TB (OLD1)	HABSHAN 1						
		BAB-0944-WI-TB	HABSHAN 1						
		BAB-0945-WI-TB	HABSHAN 1						
		BAB-1062-WI-TB	HABSHAN 1						
		BAB-1064-WI-TB	HABSHAN 1						
		BAB-1086-WI-TB	THAM G						
		BAB-1088-WI-TB	THAM G						
		BAB-1154-WI-TB	HABSHAN 1						
		BAB-1160-WI-TB	HABSHAN 2						
		BAB-1190-WI-TB	HABSHAN 1						
		Bb-1141	THAM G						
		Bb-1257	THAM H						
		Bb-1277	THAM G						
		Bb-1279	THAM B						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 034	**2015**	BAB-0875-WI-TB	HABSHAN 2	**4**					
		BAB-0943-WI-TB	HABSHAN 1						
		BAB-0946-WI-TB (OLD1)	HABSHAN 1						
		BAB-0947-WI-TB (OLD1)	HABSHAN 1						
		BAB-0948-WI-TB	HABSHAN 1						
		BAB-0949-WI-TB	HABSHAN 1						
		BAB-1095-WI-TB	THAM E						
		BAB-1104-WI-TB	HABSHAN 1						
		BAB-1142-WI-TB	THAM G						
		BAB-1164-WI-TB	THAM G						
		BAB-1202-WI-TB	THAM G						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 035	**2015**	BAB-0938-WI-TB	HABSHAN 1	**4**					
		BAB-0940-WI-TB	HABSHAN 1						
		BAB-0942-WI-TB	HABSHAN 1						
		BAB-1063-WI-TB	HABSHAN 1						
		BAB-1101-WI-TB	HABSHAN 1						
		BAB-1155-WI-TB	HABSHAN 2						
		BAB-1273-WI-TB	HABSHAN 2						
		BAB-1293-WI-TB	HABSHAN 2						
		BAB-1314-WI-TB	THAM B						
		Completion / Well Count	**Reservoir**	**Life/AGE**	**Conversion to SWI / PWRI**	**Year of Conversion to SWI/PWRI**	**Interface Project**	**Interface Project EPC**	**Remarks**
BAB CLUSTER 036,	**2020**	BB-1446	THAM B	30					
		BB-1495	THAM B						
		E_UPI_02	THAM B						

		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 038,	2020	BB-1377	THAM B	30	SWI				
		BB-1459	THAM G		SWI				
		Bb-1342	THAM H		SWI				
		Bb-1462	HABSHAN 2		SWI				
		Bb-1488	HABSHAN 2		SWI				
					SWI				
					SWI				
					SWI				
					SWI				
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 039,	2020	BB-1449	THAM B	30	SWI				
		BB-1295	HABSHAN 1		SWI				
		BB-1284	THAM B		SWI				
		BB-1263	THAM B		SWI				
		BB-1262	THAM B		SWI				
		BB-1261	THAM B		SWI				
		ICSC002	THAM A		SWI				
		IDSC031	THAM A		SWI				
					SWI				
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 041, FUTURE	Q4 2022	BB-1489	THAM G	30	SWI				
		BB-1403	THAM B		SWI				
		BB-1383	THAM A		SWI				
		BB-1373	THAM A		SWI				
		Bb-1347	THAM A						
		BB-1325	THAM A		SWI				
		BB-1441	THAM H		SWI				
		BB-1440	THAM H		SWI				
		BB-1435	THAM H		SWI				
		BB-1425	THAM A		SWI				
		BB-1430	THAM A		SWI				
		BB1396	THAM A		SWI				
		BB-1439	THAM A		SWI				
		BB-1071	THAM A		SWI				
		BB-1364	THAM A		SWI				
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 042, FUTURE	Q4 2022	N_UPI_04	THAM B	30	SWI				
		N_UPI_05	THAM B		SWI				
		IBN006	THAM A		SWI				
		N_UPI_08	THAM B		SWI				
					SWI				
					SWI				
					SWI				
					SWI				
					SWI				
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 043, FUTURE	Q4 2022	IASC001	THAM A	30	SWI				
		IBSC030	THAM A		SWI				
		IAN011	THAM A		SWI				
					SWI				
					SWI				
					SWI				
					SWI				
					SWI				
					SWI				
		Completion / Well Count	Reservoir	Life/AGE	Conversion to SWI / PWRI	Year of Conversion to SWI/PWRI	Interface Project	Interface Project EPC	Remarks
BAB CLUSTER 044, FUTURE	Q4 2022	IDSW006	THAM A	30	SWI				
		IDSC016	THAM A		SWI				
		ICW017	THAM A		SWI				
		IBW026	THAM A		SWI				
		N_UPI_06	THAM B		SWI				
		N_UPI_09	THAM B		SWI				
		N_UPI_10	THAM B		SWI				
					SWI				
					SWI				

APPENDIX-H: PIPELINE SCHEMATICS FOR SELECTED BU HASA OPTION



NOTES:

1. ★ THESE COORDINATES & THE ALPHA NUMERALS CORRESPOND WITH THE GRID ELEMENTS SHOWN ON ADCO FACILITIES MASTER PLAN 30.99.11.100
2. ALL THE COORDINATES ARE IN UTM ZONE 39 DATUM:NAHRWAN
3. THIS DRAWING SHOWS PRELIMINARY PIPELINE ROUTING BETWEEN PADS / CDS / CAS PLANT / EXIST. WIC & PADS FOR RESPECTIVE OIL TRANSFER, GASLIFT, WI & PWRI PIPELINE NETWORKS WHICH ARE PART OF EPC SOW
4. REFER PIPELINE ROUTING PLANS FOR ROUTING DETAILS. REFER PIPELINE SCHEDULE FOR PIPELINE LIST, DESIGN CODE, SIZE, LENGTH DETAIL ETC.
5. FOR PROPOSED NEW CATCH ROAD BETWEEN CDS AND GAS LIFT COMPRESSOR STATION, REFER TO DRAWINGS P12474-12-99-82-0601-1 TO 5 & P12474-12-99-SK-0661 FOR EXACT ROUTING AND LOCATION OF THE ROAD.
6. PRODUCED WATER DISPOSAL TIE IN SHALL BE VERIFIED DURING EPC.
7. REFER TB-31 FOR WI PIPELINE SCOPE DETAILS. EXACT TIE-IN LOCATION ON EXISTING WATER INJECTION HEADER SHALL BE VERIFIED AND CONFIRMED BY EPC CONTRACTOR.

LEGEND:

SWI	SEA WATER INJECTION
BU-XXX	SWI WELL(P30280 SCOPE)
	SWI HEADER
	SWI SUB HEADER
	SWI FLOWLINE
	SWI INTAKE
	SWI PUMP STATION

PIPELINE DETAILS-P30280

HEADERS

SL NO.	FROM	TO	LENGTH IN KM
1	28" HEADER-1	BU-751	32.800
2	28" HEADER-2	BU-750	26.600
3	24" HEADER-3	BU-89	19.600
		TOTAL	79.000
4	SUB-HEADERS	-	70.000
5	FLOWLINE	-	90.000

THIS DRAWING DEVELOPED FROM MASTER-12-99-02-0003-1 REV.9

CLOUDED PORTION DENOTES : THE SCOPE OF WORK UNDER PROJECT P30280

NOTES

LEGEND

- TRIANGULATION POINT (SURVEY CONTROL POINT) NUMBER & ELEVATION (TOP OF MONUMENT)
- INTERNATIONAL BOUNDARY
- CONCESSION BOUNDARY
- FIELD BOUNDARY
- METTALLED ROAD
- TRACK (CATCH)
- TRACK (SAND)
- OVERHEAD POWER LINE INDICATING VOLTAGE
- CAP / RIG CROSSING
- OIL PIPELINE (INDICATING SIZE)
- WATER PIPELINE (INDICATING SIZE)
- GAS PIPELINE (INDICATING SIZE)
- PIPELINE (ROUTE UNCERTAIN)
- TELECOMMUNICATION MAST
- OIL WELL (INDICATING WELL NUMBER)
- GAS INJECTION WELL
- WATER INJECTION WELL
- WATER SUPPLY WELL
- PLUGGED AND ABANDONED WELL
- RESERVOIR OBSERVATION WELL
- AQUIFER OBSERVATION WELL
- WATER DISPOSAL WELL
- AQUIFER WATER SUPPLY WELL
- COMPLETION SUSPENDED
- EXPLORATION WELL
- OIL WELL WITH ARTIFICIAL LIFT
- BU HASA WELL NO ELEVATION-TOP OF WELL CELLAR (Bu.234, 143.93)
- WATER SUPPLY WELL Bu.361-CLUSTER 35 (Bu.361(35))
- CICPA FENCE
- PIPELINE CORRIDOR
- REVISION CLOUD

- GASLIFT-NEW-2021-2030
- GASLIFT-EXISTING-BY 2020(EPC SCOPE)
- GASLIFT-2021-2030
- GASLIFT-NEW-BY 2020
- OIL WELLS
- OIL WELLS ON PAD
- WI WELLS ON PAD
- PORTABLE WATER
- WAG WELL
- WI WELLS OFF PAD
- BLOCK VALVE STATION(BU-40, 515,709 & PAD-14)
- PROPOSED PLATS

EXISTING WATER INJECTION CLUSTERS
- OIL NORTH HEADER (HEADER-1)
- OIL CENTER HEADER (HEADER-2)
- OIL SOUTH HEADER (HEADER-3)
- LIFT GAS INJECTION FLOWLINES
- 28" GAS SUPPLY PIPELINE
- 10" CONDENSATE PIPELINE
- 10" VAPOR RETURN PIPELINE
- OIL TRUNK LINES FROM PAD TO HUBS
- OIL TRUNK LINES FROM HUBS TO CDS
- BLOWDOWN PIPELINES
- NITROGEN PIPELINES
- WATER INJECTION HEADER
- PRODUCED WATER DISPOSAL PIPELINES

DRAWING REFERENCE

TITLE	DRG. No.
ADCO FACILITIES MASTER PLAN	30.99.11.0100
SITE LAYOUT-BU HASA CENTRAL FACILITIES	12.80.03.0010
PIPELINE ROUTING PLANS	12.78.07.0001
PIPELINE SCHEDULE	12.99.17.0601
FIELD LAYOUT (GAS LIFT NETWORKS)	12.99.02.0602
FLOWLINE RE-ROUTE & DEMOLITION	12.99.22.0601

REV.	DATE	DR'N.	CH'D.	AP'D.	DESCRIPTION
1	26/08/2019	SS	MJK/KN	AS	ISSUED FOR CONCEPT DESIGN
A	21/05/2019	SS	MJK/KN	AS	ISSUED FOR REVIEW

SCALE: 1:66000 | LOCATION: BU HASA | PROJECT No. P30280

أدنوك البرية
ADNOC Onshore

CONSULTANT / CONTRACTOR / VENDOR
ADNOC ONSHORE - TC ENGINEERING

DRAWING No.

PROJECT: CONCEPT
SEA WATER INJECTION

DRG. TITLE:
OVERALL FIELD LAYOUT-MIRFA INTAKE OPTION 3B-1A
CENTERALIZED PUMPING AT FIELD EDGE
BU HASA

DRG.No. 12 | 99 | SK | 1701 | 1 | 01/01
AREA | F/AREA | DOC. CODE | SERIAL No. | REV. | SHT | OF | SHT

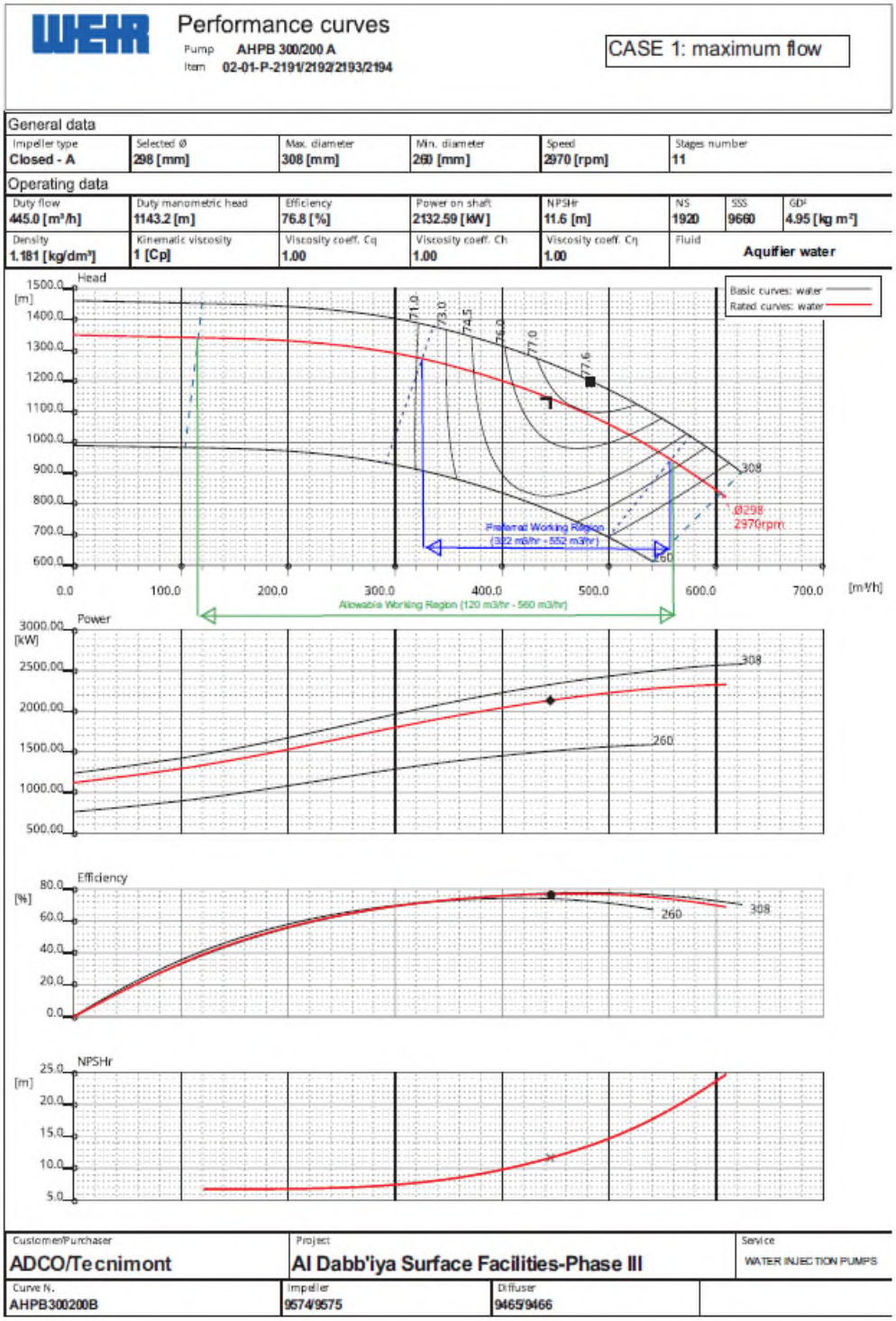
FORM_ADNOC_Onshore_A0.dwg_(REV.1)

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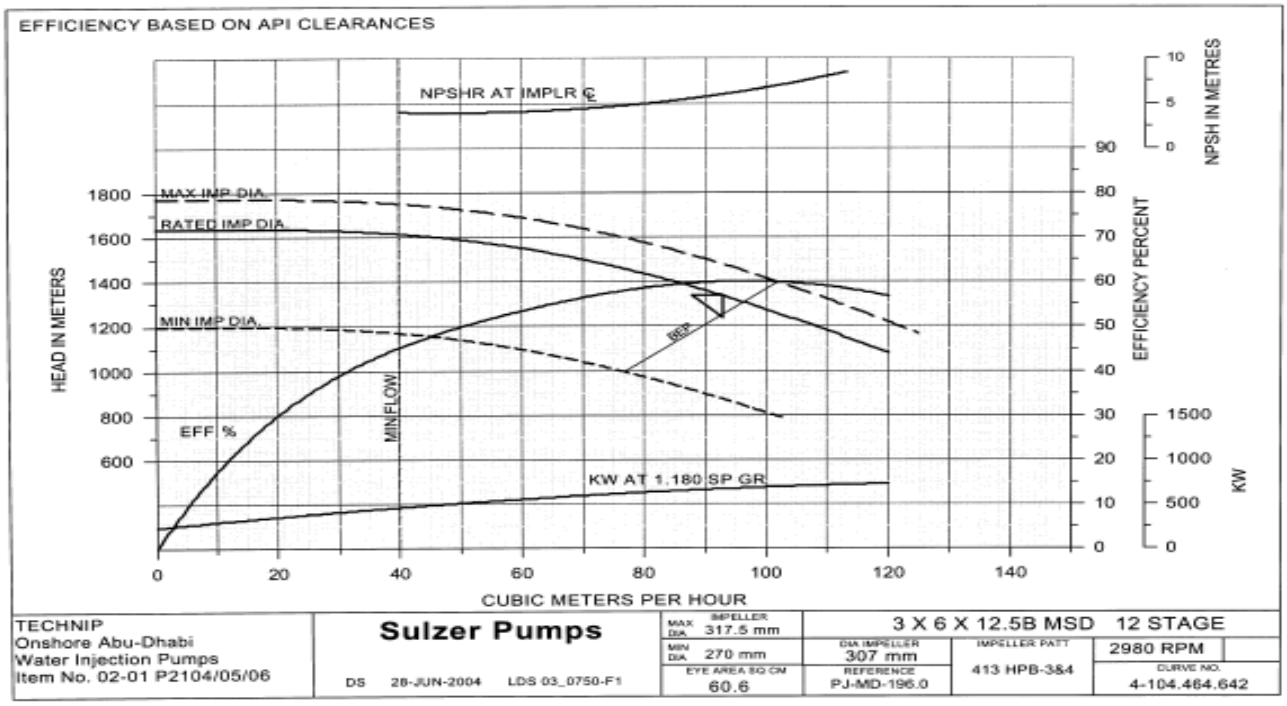
P30280-12-99-SK-1701-1.DWG

APPENDIX-I: DABBIYA EXISTING PUMPS PERFORMANCE CURVES

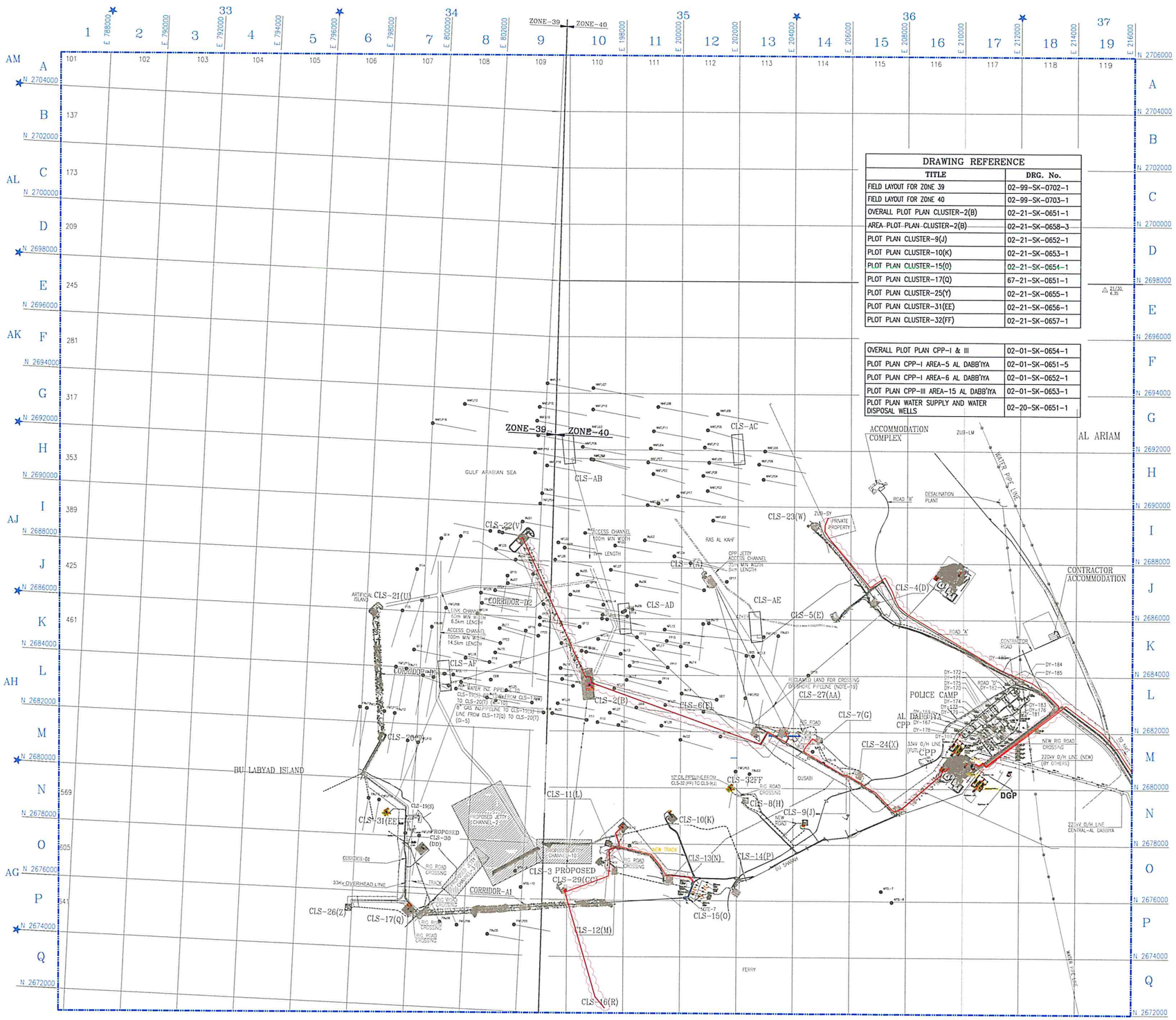
Phase III- P2191/2192/2193/2194



Phase I pumps P2104/2105/2106



APPENDIX-J: DABBIYA FIELD LAYOUT & CPP PLOT PLAN



DRAWING REFERENCE

TITLE	DRG. No.
FIELD LAYOUT FOR ZONE 39	02-99-SK-0702-1
FIELD LAYOUT FOR ZONE 40	02-99-SK-0703-1
OVERALL PLOT PLAN CLUSTER-2(B)	02-21-SK-0651-1
AREA PLOT PLAN CLUSTER-2(B)	02-21-SK-0658-3
PLOT PLAN CLUSTER-9(J)	02-21-SK-0652-1
PLOT PLAN CLUSTER-10(K)	02-21-SK-0653-1
PLOT PLAN CLUSTER-15(0)	02-21-SK-0654-1
PLOT PLAN CLUSTER-17(Q)	67-21-SK-0651-1
PLOT PLAN CLUSTER-25(Y)	02-21-SK-0655-1
PLOT PLAN CLUSTER-31(EE)	02-21-SK-0656-1
PLOT PLAN CLUSTER-32(FF)	02-21-SK-0657-1
OVERALL PLOT PLAN CPP-I & III	02-01-SK-0654-1
PLOT PLAN CPP-I AREA-5 AL DABB'IYA	02-01-SK-0651-5
PLOT PLAN CPP-I AREA-6 AL DABB'IYA	02-01-SK-0652-1
PLOT PLAN CPP-III AREA-15 AL DABB'IYA	02-01-SK-0653-1
PLOT PLAN WATER SUPPLY AND WATER DISPOSAL WELLS	02-20-SK-0651-1

CLOUDED PORTION DENOTES : THE SCOPE OF WORK UNDER THE PROJECT P30280

THIS DRAWING DEVELOPED FROM ADCO PROJECT NO. P02093 DWG. No. 02-99-SK-0701-1 REV 1

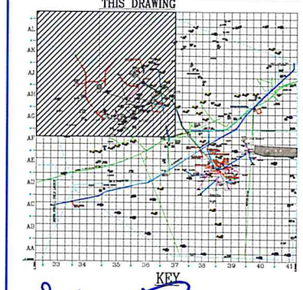
NOTES

1. CO-ORDINATES ARE BASED ON A UNIVERSAL TRANSVERSE MERCATOR PROJECTION CLARKE 1880 (MOD) SPHEROID NAHRWAN DATUM AND GRID ZONE 39 & 40.
2. ALL DIMENSIONS AND CO-ORDINATES ARE IN METERS UNLESS OTHERWISE SPECIFIED IN THE DRAWING.
3. THIS DRAWING IS DEVELOPED FOR EPC FOR AL DABB'IYA PHASE III FIELD DEVELOPMENT PROJECT BASED ON LATEST TOPO SURVEY AND FINALIZED PIPELINE ROUTING.
4. ALL TIE-IN INDICATED SHALL BE SITE VERIFIED BY EPC CONTRACTOR.
5. ALL THE NEW PIPELINE BRANCHES GOING TO THE CLUSTER SHALL BE FINALIZED DURING FEED STAGE AFTER PIPELINE STRESS ANALYSIS.
6. ALL PIPELINE CROSSING SHALL BE FINALIZED AFTER SUPER IMPOSING TRACK/RIG ROADS FROM DRILLING TEAM DURING FEED STAGE.
7. PIPELINE ROUTING INSIDE CLS-15(0) OF 12" OIL PIPELINE FROM CLS-10(K) TO PIG RECEIVER TO BE FINALIZED DURING FEED STAGE.
8. WATER SUPPLY AND DISPOSAL WELLS LOCATIONS ARE TENTATIVE AND TO BE FINALIZED DURING FEED STAGE.
9. CPP AREA WATER SUPPLY & DISPOSAL WELLS LOCATIONS ARE TENTATIVE AND TO BE FINALIZED DURING FEED STAGE.

LEGEND

PROPOSED-PRODUCTION OIL PIPELINE
PROPOSED-WATER INJ. PIPELINE
PROPOSED-GAS INJECTION PIPELINE
KILOMETER POINT — KP
EXISTING RIG CROSSING ON EXISTING PIPELINE CORRIDOR (SAME SHALL BE EXTENDED TO NEW PIPELINES CORRIDOR)
NEW RIG ROAD CROSSING ON NEW PIPELINES CORRIDOR
OVERHEAD LINE TOWER — T_02
THIRD AND LOWER ORDER — 13/10
GPS — NUMBER 6145, ALTITUDE 16.97
TOWER — ZUB-LM
SPOT HEIGHT (HIGH) IN METRES — +123
SPOT HEIGHT (LOW) IN METRES — +97
INTERNATIONAL BOUNDARY
CONCESSION BOUNDARY
FIELD BOUNDARY
MATCHLINE
ASPHALT ROAD (DUAL CARRIAGE)
ASPHALT ROAD (SINGLE CARRIAGE)
TRACK (GATCH)
TRACK (NEW)
TRACK (EXISTING)
TRACK (ETIHAD RAILWAY)
OVERHEAD POWER LINE INDICATING VOLTAGE — 400KV
GAP / RIG CROSSING
OIL PIPELINE (INDICATING SIZE)
WATER PIPELINE (INDICATING SIZE)
GAS PIPELINE (INDICATING SIZE)
PIPELINE (ROUTE UNCERTAIN)
FENCE
WALL — W
BUILDINGS
COASTLINE (H.W.M.)
TREES
PALM TREES
CONTOUR (VJ 5 METRES)
SABKHA
GRAVEL OUTCROP
CULTIVATED AREA — Cult
SAND DUNE
OIL WELL (INDICATING WELL NUMBER) — Ra-12
GAS WELL
GAS INJECTION WELL
WATER INJECTION WELL
WATER SUPPLY WELL
RESERVOIR OBSERVATION WELL
AGRICULTURAL WATER SUPPLY WELL
WATER DISPOSAL WELL
WAG WELL
CHANNEL
SCOPE OF WORK P30280

THIS DRAWING



REV.	DATE	DR'N.	CH'D.	AP'D.	DESCRIPTION
1	29/08/2019	SSA	WMH	AS	ISSUED FOR CONCEPT DESIGN

SCALE: 1 : 1250 | LOCATION: AL DABBIYA | PROJECT No. P30280

أدنوك البرية
ADNOC Onshore

CONSULTANT / CONTRACTOR / VENDOR
ADNOC ONSHORE - TC ENGINEERING

DRAWING No. -

PROJECT: CONCEPT FOR SEAWATER INJECTION SYSTEM

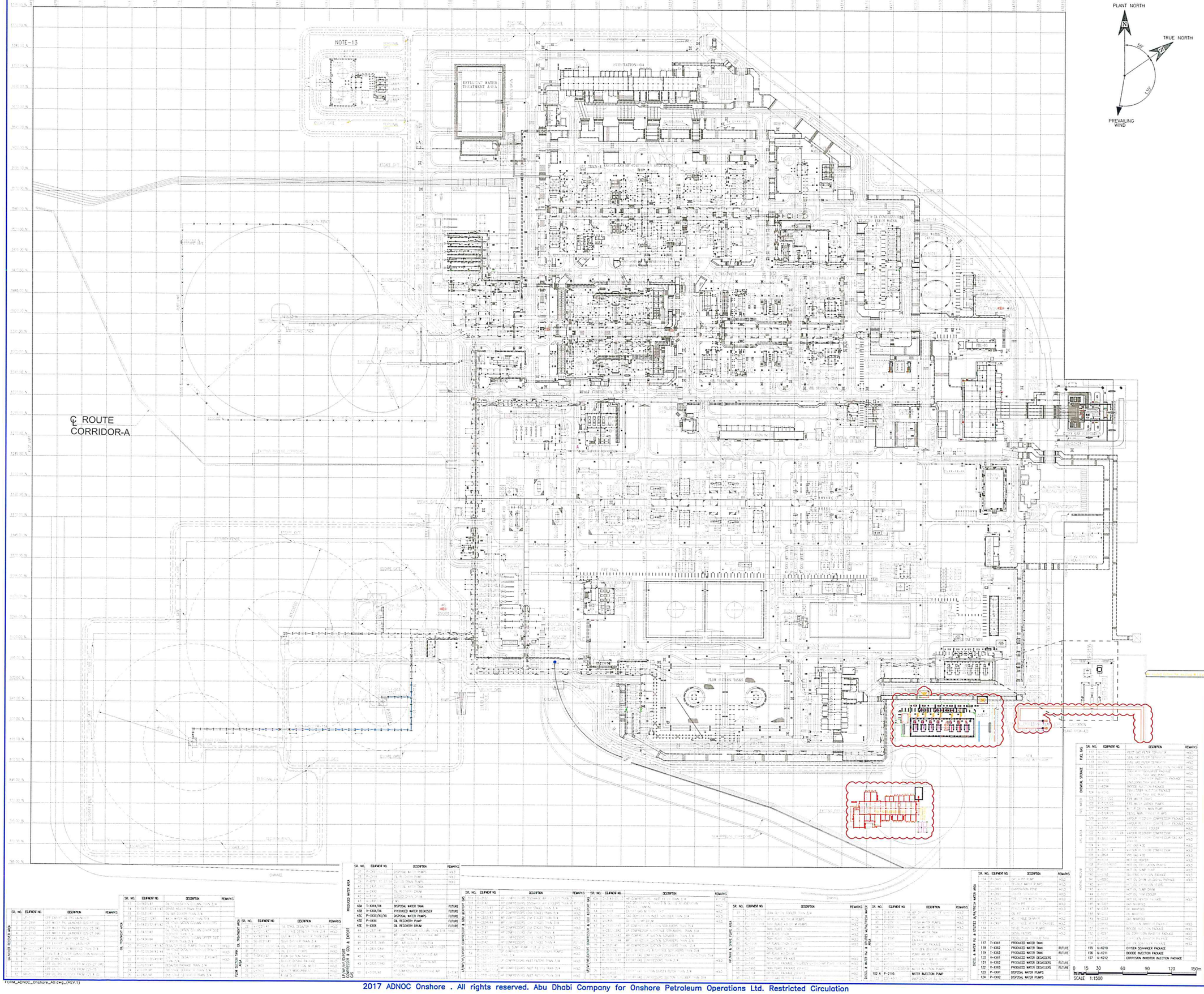
DRG. TITLE:
OVERALL FIELD LAYOUT OIL GATHERING, GAS AND WATER INJECTION PIPELINES

DRG.No.	AREA	P/AREA	DOC. CODE	SERIAL No.	REV.	SHT	OF	SHT
	02	99	SK	0701	1	1/1		

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P30280-02-99-SK-0701-1 REV.1.DWG

PLOTTED ON: 9/23/2019 9:26 AM PLOTTED BY: SHAIK SHAKEEL AHMED (ADNOC ONSHORE - TC&P (ENG))



NOTES

1. PLANT DATUM CO-ORDINATES 1000.000 E ; 1000.000 N ARE EQUIVALENT TO UTM ZONE CO-ORDINATES 209928.772 E ; 2690436.964 N.
2. ALL DIMENSIONS ARE IN MILLIMETERS. CO-ORDINATES AND ELEVATIONS ARE IN METERS UNLESS SPECIFIED OTHERWISE.
3. ELEVATIONS 100.000m. CORRESPONDS TO ABSOLUTE VALUE +2.85 m.
4. FOR EQUIPMENT CO-ORDINATES & ELEVATIONS, ELEVATED PLATFORM DETAILS & STAIR, LAYDOWN AREAS, HANDLING DETAILS, DROP-OUT ZONES WILL BE SHOWN IN RESPECTIVE U PLOT PLANS.
5. DELETED.
6. FOR THE LOCATION DISTANCE OF EACH AREA REFER UNIT PLOT PLAN.
7. SPACE FOR FUTURE HP COMPRESSOR.
8. SPACE FOR FUTURE EXPORT GAS COMPRESSOR.
9. CABLE TRENCH CORRIDOR INTERCONNECTING EXISTING CPP AREA AND GREEN FIELD AREA (ITR-06) DRAWING ARE 3844-AQ-DA-PI00026, 3844-AQ-DA-PI00027, 3844-AQ-DA-PI00028.
10. FOR UG CONSTRUCTION DETAILS REFER TO AQ-DA SERIES DRAWINGS.
11. DELETED.
12. EXISTING CHANNEL TO BE RE-ROUTED AS SHOWN. EPC CONTRACTOR TO REVIEW ENVIRONMENTAL IMPACT IF ANY BASED ON EIA REPORT PERFORMED AS PART OF HSEIA.
13. THIS SPACE IS ALLOCATED FOR FUTURE PW FACILITY FOR 2030 AND 2043 AS PER PROCE REQUIREMENT.

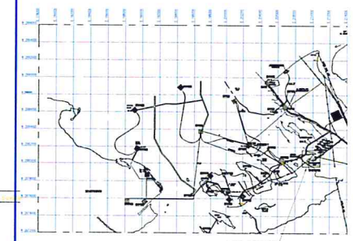
LEGEND

HPP- HIGH POINT OF PAVING	FENCE
TOC- TOP OF CONCRETE	WS WIND SOCK
FGL- FINISH GRADE LEVEL	SKID FOR DELUGE VALVE
TOS- TOP OF STEEL	BURIED CABLE TRENCH (INSTRUMENT
TOG- TOP OF GROUT	CONCRETE CABLE TRENCH (INST.)
IPE- INTERLOCK TILES PAVING EL.	BURIED CABLE TRENCH (ELECTRICAL)
EL (ELEVATION)	CONCRETE CABLE TRENCH (ELECT.)
SKID	CATCH ROAD
SHED	ROAD
INTERLOCKING TILES WALK WAY	VALVE IN PIT
INTERLOCKING TILES HEAVY LOAD	WEIR BOX
CONCRETE PAVING	MANHOLE
GRAVEL	CATCH BASIN
SAFETY SHOWER	ELECTRICAL LINE
ASPHALT ROAD	FW HYDRANT
DROP ZONE	

DRAWING REFERENCE

TITLE	DRG. No.
FIELD LAYOUT ZONE 40 FOR PRODUCTION OIL PIPELINES, WATER INJECTION & GAS INJECTION AL DABBIYA : NEB FIELD	02.99.SK.0703.1
PLOT PLAN AREA-5 CPP: AL DABBIYA : NEB FIELD	02.01.SK.0651.5
PLOT PLAN AREA-6 CPP: AL DABBIYA : NEB FIELD	02.01.SK.0652.1
PLOT PLAN AREA-15 CPP: AL DABBIYA : NEB FIELD	02.01.SK.0653.1

KEYPLAN



THIS DRAWING

CLOUDED PORTION DENOTES : THE SCOPE OF WORK UNDER THE PROJECT P.30280

THIS DRAWING DEVELOPED FROM ADCO PROJECT DWG No. 02-01-SK-0654-1 REV-02 PROJECT NO.P02093

REV.	DATE	DR'N.	CH'D.	AP'D.	DESCRIPTION
1	28/08/2019	SSA	WMH	AS	ISSUED FOR CONCEPT DE

SCALE: 1:1500 | LOCATION: AL DABBIYA | PROJECT No. P30280

ADNOC دنوك البرية ADNOC Onshore

CONSULTANT / ~~CONTRACTOR / VENDOR~~:
ADNOC ONSHORE – TC ENGINEERING

DRAWING No. –

PROJECT: CONCEPT FOR SEAWATER INJECTION SYSTEM

DRG. TITLE:
OVERALL PLOT PLAN
CENTRAL PROCESSING PLANT (CPP)
AL DABB'IYA NEB FIELD

DRG No.	0.2	0.1	SK	0651	1	1/1
	AREA	P/AREA	DOC. CODE	SERIAL No.	REV.	SHT OF S

0 15 30 60 90 120 150m
SCALE 1:1500

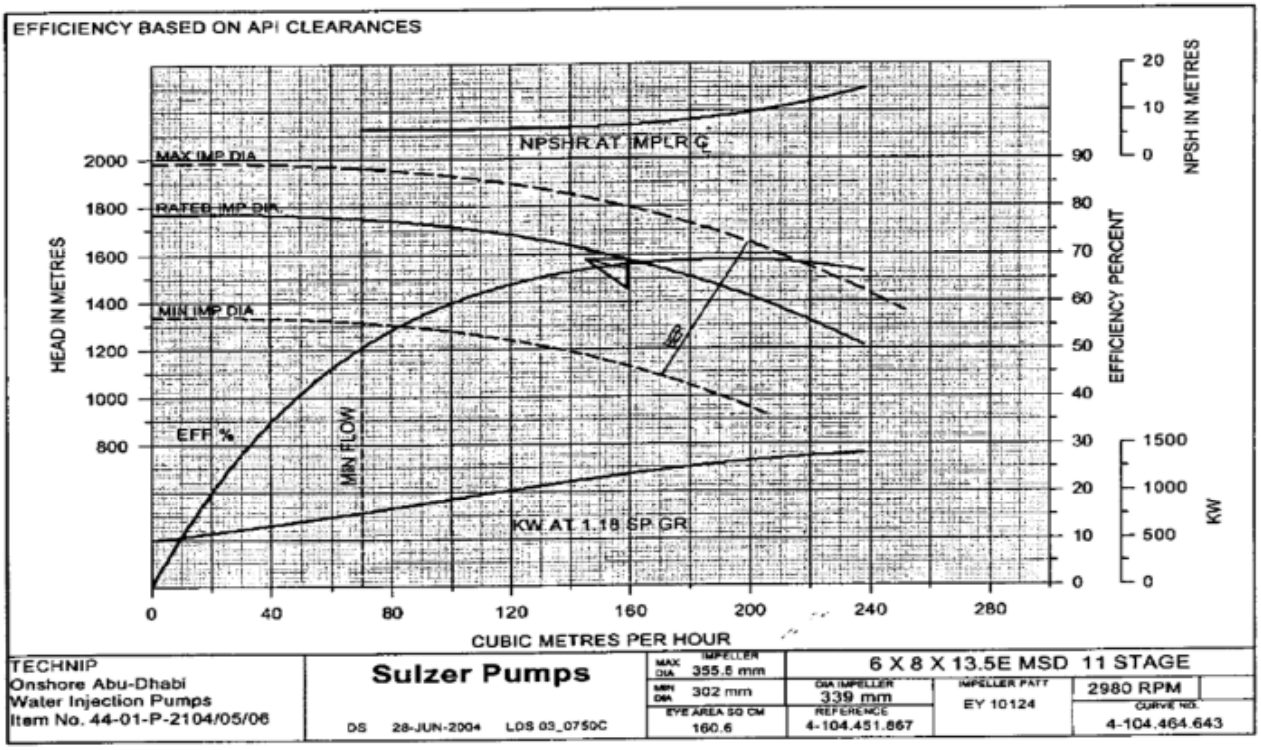
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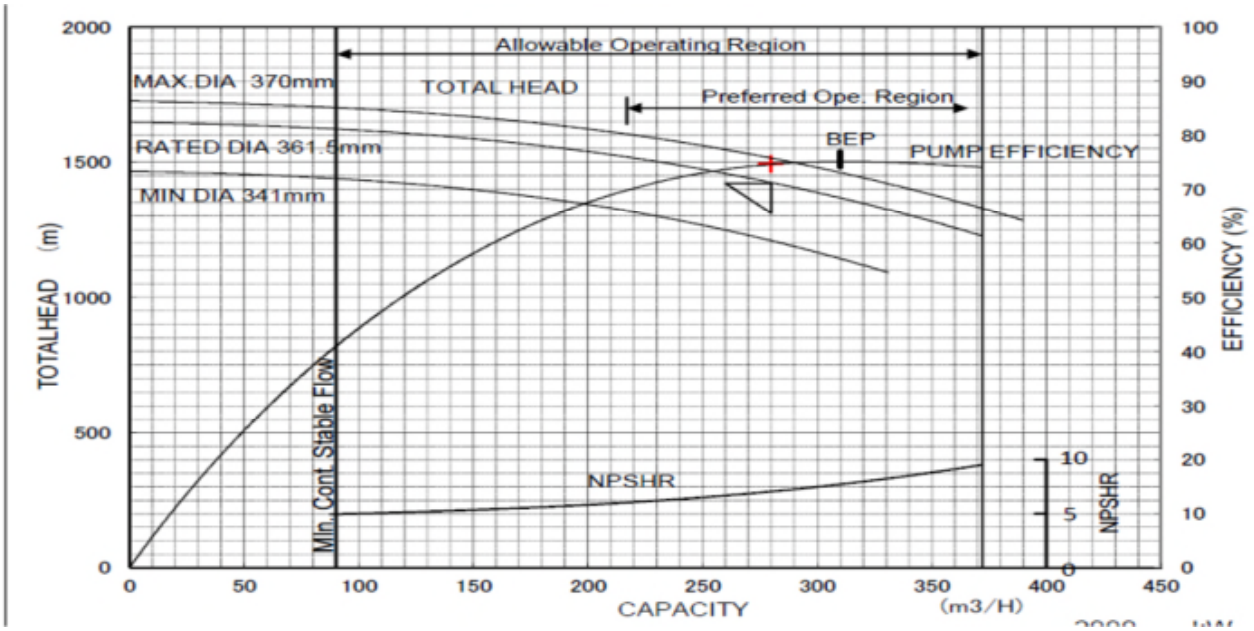
P30280-02-01-SK-0651-1 REV 1

APPENDIX-K: RUMAITHA EXISTING PUMPS PERFORMANCE CURVE

PHASE I



PHASE III



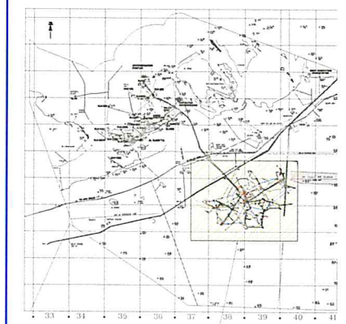
APPENDIX-L: RUMAITHA FIELD LAYOUT & CPP PLOT PLAN

NOTES

1. CO-ORDINATES ARE BASED ON A UNIVERSAL TRANSVERSE MERCATOR PROJECTION, CLARKE 1880 (MOD) SPHEROID, NAHRWAN DATUM, AT GRID ZONE 40.
2. ALL CO-ORDINATES ARE IN METERS UNLESS NOTED OTHERWISE.
3. THIS FIELD LAYOUT UNDER PROJECT SCOPE SHOWING PIPELINES FROM/TO CLUSTER CLS-JJ, CLS-FH, EXISTING CLS-GG, CPF & NEW WATER SUPPLY WELLS.
4. PIPELINE BASHA CONSTRUCTION SHALL BE FOLLOWED AS PER TOPOGRAPH GEOTECHNICAL SURVEY DURING DETAL ENGINEERING

LEGEND

- TRACK (SAND/GATCH/RIG)
- ASPHALT ROAD
- FENCE
- BARRIER
- BUILDING/STRUCTURE
- INTERSECTION POINT
- WATER INJECTION WELL
- GAS WELL
- GAS INJECTION WELL
- OIL WELL
- RESERVOIR OBSERVATION WELL
- AGRICULTURAL WATER SUPPLY WELL
- WATER DISPOSAL WELL
- WAG WELL
- ABANDONED WELL
- WELL
- SURVEY CONTROL POINT
- PERMANENT BENCHMARK
- SURVEY REFERENCE
- JUNCTION BOX
- PROTECTION BOLLARD
- TELEPHONE LINE MARKER
- WATER VALVE
- VENT PIPE
- TERMINATION DOUBLE POLE
- PYLON
- ELECTRIC POST
- ROAD SIGN
- MARKER POST
- CABLE MARKER POST
- PIEZO METER
- PIPELINE MARKER
- SIGN BOARD
- DEPTH BELOW GROUND
- TEMPORARY BENCHMARK
- UNDER CONSTRUCTION
- R/C ROAD CROSSING
- SLOPE
- SCOPE OF PROJECT
- GATE
- PIPELINE CULVERT
- EPC TRIAL PIT
- FEED TRIAL PIT
- EPC CPT(CONE PENETRATION TEST)
- NEW TRACK CONSTRUCTION LIMIT
- FEED CONE PENETRATION TEST
- FOC SPLICING PIT
- REVISION CLOUD
- INTERNATIONAL BOUNDARY
- CONCESSION BOUNDARY
- FIELD BOUNDARY
- WATERLINE
- COASTLINE (H.W.M.)
- EXCLUSION LIMIT
- WATER (INJ./AID/SUP.)
- GAS (INJ./LIFT)
- PRODUCTION OIL PIPE
- PIPELINE UNIDENTIFIED
- PIPELINE – FERMED
- OVERHEAD POWER L (EXISTING)
- PROPOSED POWER
- U/G FIBER OPTIC C
- U/G TELEPHONE LIN
- U/G INSTRUMENT CA
- CATHODIC PROTECTION
- ELECTRIC CABLE
- GAP/RIG CROSSING
- A/G ABOVE GROUND
- U/G UNDERGROUND
- WIDTH IN METERS
- FOOTING
- SHED
- ELECTRIC MARKER
- CATHODIC PROTECTIO TOWER
- TREES
- PALM TREES
- GRAVEL OUTCROP
- CULTIVATED AREA
- SAND DUNE
- MAJOR CONTOUR
- MINOR CONTOUR
- BORE HOLE
- EPC – SANDY TERRAI
- EPC – DRY SABKHA
- OIL PIPELINE
- GAS INJECTION PIPELI
- WATER INJECTION PIPE



THIS DRAWING

KEY PLAN

CLOUDED PORTION DENOTES : THE SCOPE OF WORK UNDER THE PROJECT P30280

THIS DRAWING DEVELOPED FROM PROJECT No. P44021
DWG NO. P44021-44-99-02-0601-1 REV.2 SHT. 1/1

REV.	DATE	DR'N.	CH'D.	AP'D.	DESCRIPTION
1	28/08/19	SSA	WMH	AS	ISSUED FOR CONCEPT DESIGN

SCALE: 1:25000 | LOCATION: RUMAITHA | PROJECT No. P44021

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CONSULTANT / ~~CONTRACTOR / VENDOR~~
ADNOC ONSHORE E&P – TECHNICAL CENTE

DRAWING No.

PROJECT: CONCEPT FOR SEAWATER INJECTION SYSTEM

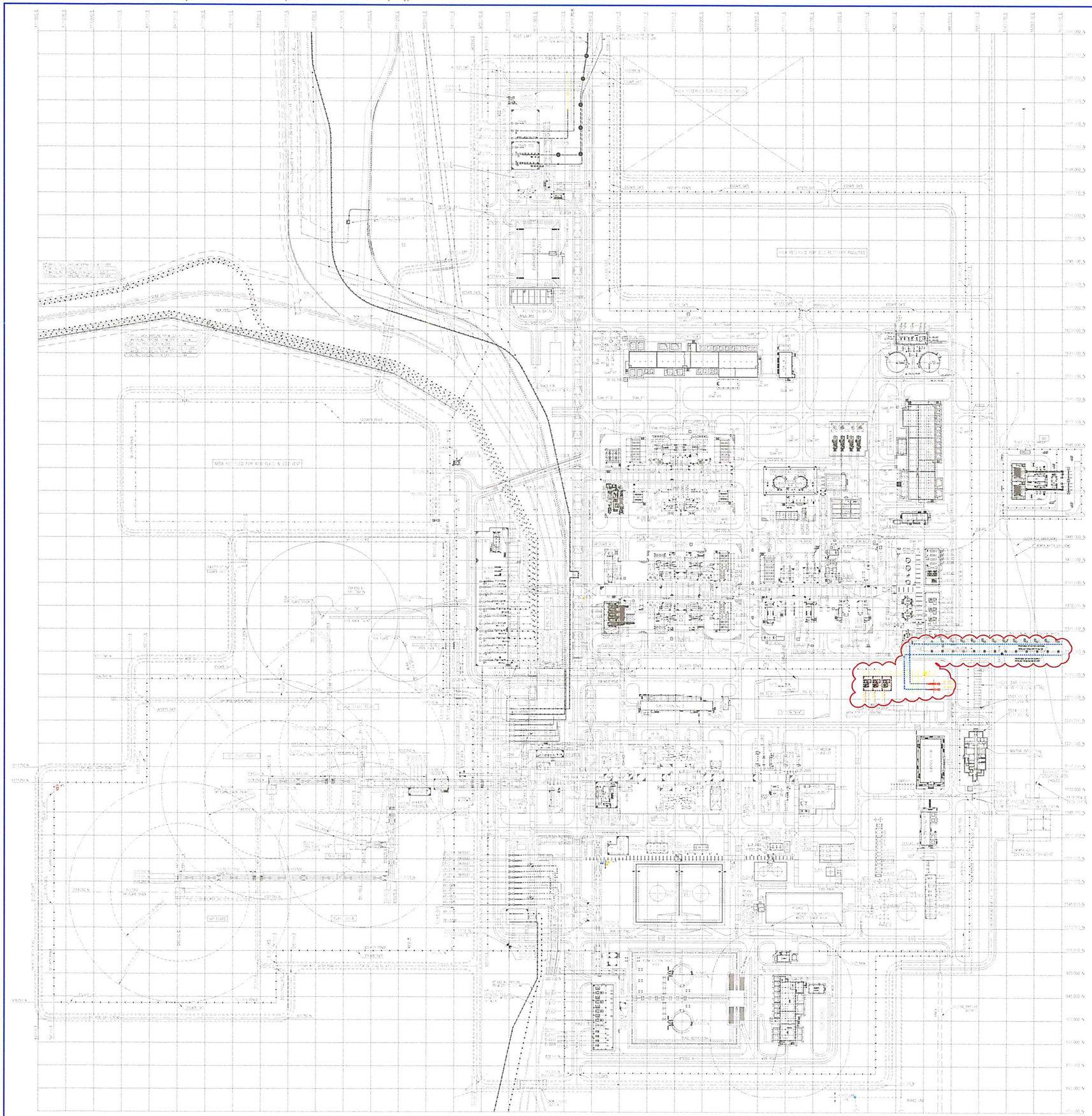
DRG. TITLE:

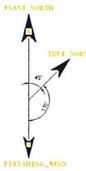
OVERALL FIELD LAYOUT FOR CLUSTERS & WELLS AT RUMAITHA

DRG No.	44	99	SK	0701	1	1/1
	AREA	P/AREA	DOC. CODE	SERIAL No.	REV.	SHT OF

P30280-44-99-SK-0701-1 REV 1

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NOTES

1. PLANT DATUM CO-ORDINATES 1000.000 E ; 1000.000 N ARE EQUIVALI TO UTM CO-ORDINATES 227646.447 E ; 2663303.518 N.
2. ALL DIMENSIONS ARE IN MILLIMETERS. CO-ORDINATES AND ELEVATIONS IN METERS UNLESS SPECIFIED OTHERWISE.
3. PHASE I AREA ELEVATIONS 100.000m REFERRED TO HPP (HIGH POINT PAVING), WHICH IS CORRESPONDING TO 18.85m ABU DHABI DATUM AN 118.800m OF EXISTING PHASE I DATUM.
4. PHASE III AREA ELEVATIONS 100.200m REFERRED TO HPP (HIGH POINT PAVING), WHICH IS CORRESPONDING TO 19.05m ABU DHABI DATUM AN 119.000m OF EXISTING PHASE I DATUM.
5. OVERHEAD CRANE TO BE CONSIDER FOR MECHANICAL HANDLING OF TH PUMP.
6. FOR PIPELINE APPROACH REFER: P44021-44-01-03-0601.
7. DETAILS IN THIS DRAWING SHALL BE CONSIDERED AS MINIMUM REQUIREMENTS.
8. PUMPS SIZE- DIMENSIONS SHALL BE VALIDATED DURING FURTHER ENGINEERING & DEVELOPMENT IN CONNECTION WITH SHED SIZE IS PRELIMINARY & SHALL BE VERIFIED BASED ON ACTUAL PUMP VENDOR DRAWING.
9. DETAIL DESIGN SHALL ENSURE MECHANICAL HANDLING FOR EQUIPMENT COVERED.

EQUIPMENT LIST

SR NO	EQUIPMENT NO	DESCRIPTION	REMARKS
1	01-P-2101	WATER INJECTION PUMP	FUTURE
2	U-P-XXXX	WATER INJECTION PUMP	FUTURE
3	01-P-XXXX	DISPOSAL WATER PUMP	FUTURE
4	01-P-XXXX	DISPOSAL WATER PUMP	FUTURE
5	U-XXXX	SLUG CATCHER	FUTURE

ABBREVIATIONS

WS – WIND STOCK
FSA – FIRE AND SAFETY ASSESMENT
QRA – QUANTITATIVE RISK ASSESMENT
OHL – OVER HEAD LINE
ACWC – AIR COOLED WATER CHILLER

GRAPHIC SCALE 1:1500
0 12 20 40 60 80 1K

LEGEND

- SKID
- SHED
- INTERLOCKING TILES
- CONCRETE PAVING
- GRAVEL
- ASPHALT ROAD
- FENCE
- CATCH ROAD
- ELECTRICAL LINE
- SAFETY SHOWER & EYE SHOWER

DRAWING REFERENCE

TITLE	DRG. No.
PIPELINE FIELD LAYOUT-EXPORT OIL PIPELINES TO MP-21	30.99.02.2604
EQUIPMENT LIST PACKAGE-1	44.99.11.1601
OVERALL PLOT PLAN, CO2 RECOVERY FACILITIES.	44.01.04.0649
OVERALL FIELD LAYOUT FOR CLUSTERS & WELLS AT RUMAITHA	P44021.30.99.02.060
TYPICAL SLOPE STABILIZATION DETAILS AND CPP GRADING SECTION.	30.99.76.1816
KEY PLAN	44.01.04.1670
BLOCK FLOW DIAGRAM RUMAITHA EXPANSION	44-99-08-0611
PFD WATER INJECTION FACILITY CPP RUMAITHA	44-01-08-0601

CLOUDED PORTION DENOTES : THE SCOPE OF WORK UNDER THE PROJECT P30280

THIS DRAWING DEVELOPED FROM ADCO PROJECT DWG No. 44.01.04.0601 REV.A SHT.1/1 PROJECT No. P44024

REV.	DATE	DR'N.	CH'D.	AP'D.	DESCRIPTION
1	26/09/2019	SSA	WME	AS	ISSUED FOR CONCEPT DESIGN

SCALE: 1:1500 | LOCATION: RUMAITHA | PROJECT No. P3028

ADNOC Onshore

CONSULTANT / ~~CONTRACTOR / VENDOR~~
ADNOC ONSHORE – TC ENGINEERING

DRAWING No. –

PROJECT: CONCEPT FOR SEAWATER INJECTION SYSTEM

DRG. TITLE:
OVERALL PLOT PLAN
CENTRAL PROCESSING PLANT (CPP)
RUMAITHA

DRG.No.	44	01	SK	0651	1	1/1
	AREA	P/AREA	DOC. CODE	SERIAL No.	REV.	SHT OF

P30280-44-01-SK-0651-1 REV.

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Appendix 2: Equipment List (Doc. no 30.99.26.0601)

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ADNOC Onshore

Project No. P30280

PROJECT WAVE

Document No: 30-99-26-0601

EQUIPMENT LIST

COMPONENTS: 1 , 2 & 3

THIS EQUIPMENT LIST ADDRESSES PROJECT WAVE SCOPE FOR ALL FIELDS: NEB, BAB, BU HASA & SE

REV	DATE	PREPARED	CHECKED	REVIEWED	APPROVED	DESCRIPTION
A	22-08-19	SMA	SIA	MAN	AQL	Issued For Review

ORIGINATOR	ADCO - TECHNICAL CENTER - INHOUSE ENGINEERING		
PROJECT TITLE: PROJECT WAVE	LOCATION/AREA: ALL ASSETS	PROJ. No.: P30280	
DOCUMENT NAME :	EQUIPMENT LIST		
DOCUMENT NO. 30-99-26-0601	Rev. A	SHEET 1 OF 7	

أدنوك
ADNOC

PROJECT WAVE

COMPONENT-1 & 2 (Mirfa & Dy)

Project No.	:	P30280
Doc. No.	:	30-99-26-0601
Revision	:	A
Date	:	22-08-19

TAG NUMBER					TAG No.	DESCRIPTION	TYPE	MANUFACTURER		DESIGN / RATED CAPACITY	SIZE	SERVICE	RATING/MOC	WEIGHT DRY TONNES	MECHANICAL DATA SHEET NO.	REFERENCE P&ID NO.	CRITICALITY RATING	REMARKS	REV
EQPT. CODE	SYS. CODE	UNIT NO.		SEQ. NO.				NAME	SERIAL NUMBER										
COMPOENT-1 SEA WATER TREATMENT PLANT - MIRFA																			
P	XX	XX		01/02/03/04/05		SEA WATER LIFTING PUMP STATION	PUMP			Capacity per pump: 7500 m3/hr Power per Pump: 2.8 MW Discharge Pressure= 10 barg		SEA WATER	SDSS					• 3 PUMPS ARE INVESTED IN 2023 AND 1 PUMP INVESTED IN 2028. • 1 SPARE PUMP.	A
U	XX	XX		BY VENDOR		SULFUR TREATMENT PLANT	PACKAGE			CAPACITY AT PACKAGE BATTERY LIMIT = 3004 MBWPD INTAKE CAPACITY: 4292 MBWPD OUTFALL REJECT CAPACITY : 1287 MBWPD	NUMBER OF TRAINS TO BE CONFIRMED BY VENDOR	SEA WATER	BY VENDOR					• PACKAGE DETAILS ARE TO BE DEVELOPED BY VENDORS. • ESTIMATED INTAKE CAPACITY IS BASED ON 425 MARGIN. • PRELIMINARY NUMBER OF TRAINS AS FOLLOWS: - 10+1 SPARE BY VEOLIA - 4 CLUSTERS BY SLB • PACKAGE INCLUDES THE FOLLOWING UNITS: 1) Filtration unit: which coarse cartridge filtration followed by Ultra-filtration units. 2) Sulfur Reducing Unit (SRU): consists of nano-filtration membranes for sulphur removal 3) Vacuum deaeration for 99.9% oxygen removal. 4) Chemical Injection Packages (biocide, coagulants, flocculants, oxygen scavengers and corrosion inhibitor, etc) 5) Associated systems for back wash (CIP, CEB, etc) 6) Electro chlorinator package	A
COMPOENT-2 SEA WATER TSUPPLY SYSTEM - MIRFA TO BAB & BU HASA																			
P	XX	XX		01/02/03/04/05/06/07/08		SEA WATER SUPPLY PUMPS	PACKAGE			Capacity per pump: 2850 m3/hr Power per Pump: 7.5 MW Discharge Pressure= 56.4 barg		SEA WATER	SDSS					• 64" PIPELINE FROM MIRFA TO BAB (55 Km) & 48" FROM BAB TO BU HASA (45 Km).	A
LP	XX	XX				MRIFA SEA WATER PIPELINE PIG LAUNCHER	PIG TRAP			MAJOR BARREL : 68" MINOR BARREL: 64"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM MIRFA TO BAB (55 Km) & 48" FROM BAB TO BU HASA (45 Km).	A
RP	XX	XX				MRIFA SEA WATER PIPELINE PIG RECEIVER AT BAB	PIG TRAP			MAJOR BARREL : 68" MINOR BARREL: 64"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM MIRFA TO BAB (55 Km) & 48" FROM BAB TO BU HASA (45 Km).	A
LP	XX	XX				SEA WATER PIPELINE PIG LAUNCHER FROM BAB TO BU HASA	PIG TRAP			MAJOR BARREL : 52" MINOR BARREL: 48"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM MIRFA TO BAB (55 Km) & 48" FROM BAB TO BU HASA (45 Km).	A
RP	XX	XX				BAB SEA WATER PIPELINE PIG RECEIVER AT BU HASA	PIG TRAP			MAJOR BARREL : 52" MINOR BARREL: 48"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM MIRFA TO BAB (55 Km) & 48" FROM BAB TO BU HASA (45 Km).	A
COMPOENT-1 SEA WATER TREATMENT PLANT - DY- NEB																			
P	XX	XX		01/02/03/04		SEA WATER LIFTING PUMP STATION	PUMP			Capacity per pump: 3700 m3/hr Power per Pump: 1.25 MW Discharge Pressure= 10 barg		SEA WATER	SDSS					• 42PUMPS ARE INVESTED IN 2023, 1 PUMP INVESTED IN 2028. 1 SPARE PUMP. AND 1 PUMP IS INSTALLED IN 2041. • 1 SPARE PUMP.	A
U	XX	XX		BY VENDOR		SULFUR TREATMENT PLANT	PACKAGE			CAPACITY AT PACKAGE BATTERY LIMIT = 1242 (WITHOUT SE) & 2696 (WITH SE) MBWPD INTAKE CAPACITY: 1615 MBWPD (WITHOUT SE) & 3851 (WITH SE) MBPWD. OUTFALL REJECT CAPACITY : 485 MBWPD (WITHOUT SE) AND 1155 MBWPD (WITH SE).	NUMBER OF TRAINS TO BE CONFIRMED BY VENDOR	SEA WATER	BY VENDOR					• PACKAGE DETAILS ARE TO BE DEVELOPED BY VENDORS. • ESTIMATED INTAKE CAPACITY IS BASED ON 425 MARGIN. • PRELIMINARY NUMBER OF TRAINS AS FOLLOWS: - 4+1 SPARE BY VEOLIA - 4 CLUSTERS BY SLB • PACKAGE INCLUDES THE FOLLOWING UNITS: 1) Filtration unit: which coarse cartridge filtration followed by Ultra-filtration units. 2) Sulfur Reducing Unit (SRU): consists of nano-filtration membranes for sulphur removal 3) Vacuum deaeration for 99.9% oxygen removal. 4) Chemical Injection Packages (biocide, coagulants, flocculants, oxygen scavengers and corrosion inhibitor, etc) 5) Associated systems for back wash (CIP, CEB, etc) 6) Electro chlorinator package	A
COMPOENT-2 SEA WATER TSUPPLY SYSTEM - DY TO NEB ONLY																			
P	XX	XX		01/02/03		SEA WATER SUPPLY PUMPS	PACKAGE			Capacity per pump: 4500 m3/hr Power per Pump: 6 MW Discharge Pressure= 35 barg		SEA WATER	SDSS					• 42" PIPELINE FROM TREATMENT PLANT TO DABBIYA (10 KM) AND 30" PIPELINE FROM DABBIYA TO RUMAITHA (25 KM).	A
LP	XX	XX				DABBIYA SEA WATER PIPELINE PIG LAUNCHER TO DABBIYA	PIG TRAP			MAJOR BARREL : 48" MINOR BARREL: 42"		SEA WATER	CARBON STEEL					• 42" PIPELINE FROM TREATMENT PLANT TO DABBIYA (10 KM) AND 30" PIPELINE FROM DABBIYA TO RUMAITHA (25 KM).	A

PROJECT WAVE

COMPONENT-1 & 2 (Mirfa & Dy)

Project No.	:	P30280
Doc. No.	:	30-99-26-0601
Revision	:	A
Date	:	22-08-19

TAG NUMBER					TAG No.	DESCRIPTION	TYPE	MANUFACTURER		DESIGN / RATED CAPACITY	SIZE	SERVICE	RATING/MOC	WEIGHT DRY TONNES	MECHANICAL DATA SHEET NO.	REFERENCE P&ID NO.	CRITICALITY RATING	REMARKS	REV
EQPT. CODE	SYS. CODE	UNIT NO.		SEQ. NO.				NAME	SERIAL NUMBER										
RP	XX	XX				DABBIYA SEA WATER PIPELINE PIG RECEIVER AT DABBIYA	PIG TRAP			MAJOR BARREL : 48" MINOR BARREL: 42"		SEA WATER	CARBON STEEL					• 42" PIPELINE FROM TREATMENT PLANT TO DABBIYA (10 KM) AND 30" PIPELINE FROM DABBIYA TO RUMAITHA (25 KM).	A
LP	XX	XX				DABBIYA SEA WATER PIPELINE PIG LAUNCHER FROM DABBIYA TO RUMAITHA	PIG TRAP			MAJOR BARREL : 36" MINOR BARREL: 30"		SEA WATER	CARBON STEEL					• 42" PIPELINE FROM TREATMENT PLANT TO DABBIYA (10 KM) AND 30" PIPELINE FROM DABBIYA TO RUMAITHA (25 KM).	A
RP	XX	XX				DABBIYA SEA WATER PIPELINE PIG RECEIVER AT RUMAITHA	PIG TRAP			MAJOR BARREL : 36" MINOR BARREL: 30"		SEA WATER	CARBON STEEL					• 42" PIPELINE FROM TREATMENT PLANT TO DABBIYA (10 KM) AND 30" PIPELINE FROM DABBIYA TO RUMAITHA (25 KM).	A
COMPOENT-2 SEA WATER TSUPPLY SYSTEM - DY TO SE																			
P	XX	XX		01/02/03/04/05/06/07/08/09/10		SEA WATER SUPPLY PUMPS	PACKAGE			Capacity per pump: 1575 m3/hr Power per Pump: 6 MW Discharge Pressure= 95 barg		SEA WATER	SDSS					• DEDICATED SEA WATER PUMPS AND PIPELINE TO SE (ASAB,SAHIL,SHAH, QW, MENDER)	A
LP	XX	XX				SEA WATER PIPELINE PIG LAUNCHER TO SAHIL	PIG TRAP			MAJOR BARREL : 68" MINOR BARREL: 64"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM TREATMENT PLANT FROM DY TO SAHIL 79 KM	A
RP	XX	XX				SEA WATER PIPELINE PIG RECEIVER AT SAHIL	PIG TRAP			MAJOR BARREL : 68" MINOR BARREL: 64"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM TREATMENT PLANT FROM DY TO SAHIL 79 KM	A
LP	XX	XX				SEA WATER PIPELINE PIG LAUNCHER FROM SAHIL TO ASAB	PIG TRAP			MAJOR BARREL : 68" MINOR BARREL: 64"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM TREATMENT PLANT FROM SAHIL TO ASAB 54 KM	A
RP	XX	XX				SEA WATER PIPELINE PIG RECEIVER AT ASAB	PIG TRAP			MAJOR BARREL : 68" MINOR BARREL: 64"		SEA WATER	CARBON STEEL					• 64" PIPELINE FROM TREATMENT PLANT FROM SAHIL TO ASAB 54 KM	A
LP	XX	XX				SEA WATER PIPELINE PIG LAUNCHER FROM ASAB TO SHAH	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 30"		SEA WATER	CARBON STEEL					• 30" PIPELINE FROM TREATMENT PLANT FROM ASAB TO SHAH 52 KM	A
RP	XX	XX				SEA WATER PIPELINE PIG RECEIVER AT SHAH	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 30"		SEA WATER	CARBON STEEL					• 30" PIPELINE FROM TREATMENT PLANT FROM ASAB TO SHAH 52 KM	A
LP	XX	XX				SEA WATER PIPELINE PIG LAUNCHER FROM ASAB TO QUSAWAIRAH	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					• 20" PIPELINE FROM TREATMENT PLANT FROM ASAB TO QW 80 KM	A
RP	XX	XX				SEA WATER PIPELINE PIG RECEIVER AT QUSAWAIRAH	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					• 20" PIPELINE FROM TREATMENT PLANT FROM ASAB TO QW 80 KM	A
LP	XX	XX				SEA WATER PIPELINE PIG LAUNCHER FROM QW TO MENDER	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					• 20" PIPELINE FROM TREATMENT PLANT FROM QW TO MENDER 44 KM	A
RP	XX	XX				SEA WATER PIPELINE PIG RECEIVER AT MENDER	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					• 20" PIPELINE FROM TREATMENT PLANT FROM QW TO MENDER 44 KM	A

PROJECT WAVE

COMPONENT-3 (BAB & BU HASA)

Project No.	:	P30280
Doc. No.	:	30-99-26-0601
Revision	:	A
Date	:	22-08-19

TAG NUMBER					TAG No.	DESCRIPTION	TYPE	MANUFACTURER		DESIGN / RATED CAPACITY	SIZE	SERVICE	RATING/MOC	WEIGHT DRY TONNES	MECHANICAL DATA SHEET NO.	REFERENCE P&ID NO.	CRITICALITY RATING	REMARKS	REV
EQPT. CODE	SYS. CODE	UNIT NO.		SEQ. NO.				NAME	SERIAL NUMBER										
COMPONENT-3 BAB FIELD																			
P	XX	XX		01/02/03/04/05/06/07/08/09/10/11		LOW PRESSURE PUMPS AT CL-9	PUMP			Capacity per pump: 993 m3/hr Power per Pump: 7.7 MW Discharge Pressure= 230 barg		SEA WATER	2500#SDSS					• 2 PUMPS ARE STANDBY SPARE.	A
P	XX	XX		01/02/03/04/05		HIGH PRESSURE PUMPS AT CL-9	PUMP			Capacity per pump: 663 m3/hr Power per Pump: 6.3 MW Discharge Pressure= 260 barg		SEA WATER	2500# SDSS					• 1 PUMP IS STANDBY SPARE.	A
LP	XX	XX				PIG LAUNCHER TO OUTER LP NORTH 24" HEADER AT CL-9	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP NORTH OUTER RING IS 48 KM TOTAL IN LENGTH.	A
RP	XX	XX				PIG RECEIVER FOR OUTER LP NORTH 24" HEADER AT CL-9	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP NORTH OUTER RING IS 48 KM TOTAL IN LENGTH.	A
LP	XX	XX				PIG LAUNCHER TO OUTER LP SOUTH 24" HEADER AT CL-9	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP SOUTH OUTER RING IS 77 KM TOTAL IN LENGTH.	A
RP	XX	XX				PIG RECEIVER FOR OUTER LP SOUTH 24" HEADER AT CL-9	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP SOUTH OUTER RING IS 77 KM TOTAL IN LENGTH.	A
LP	XX	XX				PIG LAUNCHER TO INNER LP RING 28" AT CL-9 FROM PUMPING STATION	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 28"		SEA WATER	CARBON STEEL					PUMP DISCHARGE PIPELINE IS 7.5 KM	A
RP	XX	XX				PIG RECEIVER AT INNER LP NORTH 28" HEADER AT CL-9 FROM PUMPING STATION	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 28"		SEA WATER	CARBON STEEL					PUMP DISCHARGE PIPELINE IS 7.5 KM	A
LP	XX	XX				PIG LAUNCHER TO INNER LP NORTH 24" HEADER AT CL-9 FROM PUMPING STATION	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP NORTH INNER RING IS 37 KM TOTAL IN LENGTH.	A
RP	XX	XX				PIG RECEIVER AT INNER LP NORTH 24" HEADER AT CL-9 FROM PUMPING STATION	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP NORTH INNER RING IS 37 KM TOTAL IN LENGTH.	A
LP	XX	XX				PIG LAUNCHER TO INNER LP SOUTH 24" HEADER	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP SOUTH INNER RING IS 37 KM TOTAL IN LENGTH.	A
RP	XX	XX				PIG RECEIVER AT INNER LP SOUTH 24" HEADER	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					LP SOUTH INNER RING IS 44.5 KM TOTAL IN LENGTH.	A
LP	XX	XX				PIG LAUNCHER TO INNER HP NORTH 20" HEADER	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					HP SOUTH INNER RING IS 37 KM TOTAL IN LENGTH.	A
RP	XX	XX				PIG RECEIVER TO INNER HP NORTH 20" HEADER	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					HP SOUTH INNER RING IS 44.5 KM TOTAL IN LENGTH.	A
LP	XX	XX				PIG LAUNCHER TO INNER HP SOUTH 20" HEADER	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					HP SOUTH INNER RING IS 37 KM TOTAL IN LENGTH.	A
RP	XX	XX				PIG RECEIVER TO INNER HP SOUTH 20" HEADER	PIG TRAP			MAJOR BARREL : 24" MINOR BARREL: 20"		SEA WATER	CARBON STEEL					HP SOUTH INNER RING IS 44.5 KM TOTAL IN LENGTH.	A
COMPONENT-3 BU HASA FIELD																			
P	XX	XX		01/02/03/04/05/06/07/08/09/10/11/12		INJECTION PUMPS AT FIELD EDGE (CLUSTER-49)	PUMP			Capacity per pump: 1020 m3/hr Power per Pump: 7.5 MW Discharge Pressure= 220 barg		SEA WATER	2500#SDSS					• 2 PUMPS ARE STANDBY SPARE.	A
LP	XX	XX				PIG LAUNCHER TO 28" South Header	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 28"		SEA WATER	CARBON STEEL					• 28" South Header – 32.73 Km	A
RP	XX	XX				PIG RECEIVER FOR 28" South Header	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 28"		SEA WATER	CARBON STEEL					• 28" South Header – 32.73 Km	A
LP	XX	XX				PIG LAUNCHER TO 28" CENTRAL HEADERS	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 28"		SEA WATER	CARBON STEEL					• 28" Central Header – 26.65 Km	A
RP	XX	XX				PIG RECEIVER FOR 28" CENTRAL HEADERS	PIG TRAP			MAJOR BARREL : 32" MINOR BARREL: 28"		SEA WATER	CARBON STEEL					• 28" Central Header – 26.65 Km	A
LP	XX	XX				PIG LAUNCHER TO 24" NORTH HEADER	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					• 24"North Header – 19.58 Km	A
RP	XX	XX				PIG RECEIVER FORTO 24" NORTH HEADER	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					• 24"North Header – 19.58 Km	A

PROJECT WAVE

COMPONENT-3 NEB

Project No.	:	P30280
Doc. No.	:	30-99-26-0601
Revision	:	A
Date	:	22-08-19

TAG NUMBER					TAG No.	DESCRIPTION	TYPE	MANUFACTURER		DESIGN / RATED CAPACITY	SIZE	SERVICE	RATING/MOC	WEIGHT DRY TONNES	MECHANICAL DATA SHEET NO.	REFERENCE P&ID NO.	CRITICALITY RATING	REMARKS	REV
EQPT. CODE	SYS. CODE	UNIT NO.		SEQ. NO.				NAME	SERIAL NUMBER										
COMPONENT-3 DABBIYA FIELD																			
P	XX	XX		01/02/03/04/05/06/07		INJECTION PUMPS AT DY CPP PH-III	PUMP			Capacity per pump: 795 m3/hr Power per Pump: 5 MW Discharge Pressure= 165 barg		SEA WATER	2500#SDSS					• 1 PUMP IS STANDBY - 4 PUMPS ARE INSTALLED IN 2023 AND 3 PUMPS DEFERRED TO 2028.	A
P	XX	XX		01/02		INJECTION PUMPS AT DY CPP PH-I	PUMP			Capacity per pump: 199 m3/hr Power per Pump: 1.2 MW Discharge Pressure= 162 barg		SEA WATER	2500# SDSS					• 1 PUMP IS STANDBY	A
LP	XX	XX				PIG LAUNCHER FROM CLS-AA TO CLS-B	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					OFFSHORE PIPELINE (8KM)	A
RP	XX	XX				PIG RECEIVER AT CLS-B FROM CLS-AA	PIG TRAP			MAJOR BARREL : 28" MINOR BARREL: 24"		SEA WATER	CARBON STEEL					OFFSHORE PIPELINE (8KM)	A
LP	XX	XX				PIG LAUNCHER FROM CLS-B TO CLS-V	PIG TRAP			MAJOR BARREL :14" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					OFFSHORE PIPELINE (7KM)	A
RP	XX	XX				PIG RECEIVER AT CLS-V FROM CLS-B	PIG TRAP			MAJOR BARREL :14" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					OFFSHORE PIPELINE (7KM)	A
LP	XX	XX				PIG LAUNCHER FROM CPP PH-I TO CLS-G	PIG TRAP			MAJOR BARREL :14" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 5 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-G	PIG TRAP			MAJOR BARREL :14" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 5 KM	A
						FUTURE SCOPE	PIG TRAP S											- PIPELINE FROM CPP TO CLS-AA 24" PIPELINE (TOTAL LENGTH=9.1 KM) - PIPELINE FROM CPP TO CLS-O 24" PIPELINE (TOTAL LENGTH=12 KM) - PIPELINE TO CLS-E (6"-1.7 KM)	A
COMPONENT-3 RUMAITHA FIELD																			
P	XX	XX		01/02/03/04		INJECTION PUMPS ATCPP RUMAITHA PHASE III	PUMP			Capacity per pump: 470 m3/hr Power per Pump: 3.7 MW Discharge Pressure= 198 barg		SEA WATER	2500#SDSS					• 1 PUMP IS STANDBY - 3 PUMPS INSTALLED IN 2023 AND 1 PUMP DEFERRED TO 2028.	A
LP	XX	XX				PIG LAUNCHER FROM CLS-T TO CLS-P	PIG TRAP			MAJOR BARREL :14" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 9 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-P	PIG TRAP			MAJOR BARREL :14" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 9 KM	A
LP	XX	XX				PIG LAUNCHER FROM CPP TO CLS-Y	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 13.2 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-Y	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 13.2 KM	A
LP	XX	XX				PIG LAUNCHER FROM CPP TO CLS-T	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 2 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-T	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 2 KM	A
LP	XX	XX				PIG LAUNCHER FROM CLS-T TO CLS-V	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 10.5 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-V	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 10.5 KM	A
LP	XX	XX				PIG LAUNCHER FROM CLS-V TO CLS-Z	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 3 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-Z	PIG TRAP			MAJOR BARREL :16" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 3 KM	A
LP	XX	XX				PIG LAUNCHER FROM CLS-W TO CLS-G	PIG TRAP			MAJOR BARREL :10" MINOR BARREL: 8"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 6 KM	A
RP	XX	XX				PIG RECEIVER AT CLS-G	PIG TRAP			MAJOR BARREL :10" MINOR BARREL: 8"		SEA WATER	CARBON STEEL					ONSHORE PIPELINE 6 KM	A

PROJECT WAVE

COMPONENT-3 SOUTH EAST FIELDS (ASAB, SAHIL,SHAH, QW & MENDER)

Project No.	:	P30280
Doc. No.	:	30-99-26-0601
Revision	:	A
Date	:	22-08-19

TAG NUMBER					TAG No.	DESCRIPTION	TYPE	MANUFACTURER		DESIGN / RATED CAPACITY	SIZE	SERVICE	RATING/MOC	WEIGHT DRY TONNES	MECHANICAL DATA SHEET NO.	REFERENCE P&ID NO.	CRITICALITY RATING	REMARKS	REV
EQPT. CODE	SYS. CODE	UNIT NO.		SEQ. NO.				NAME	SERIAL NUMBER										
COMPONENT-3 SOUTH EAST FIELDS																			
P	XX	XX		01/02/03/04/05/06/07/08/09/10		INJECTION PUMPS ATASAB NEAR CDS	PUMP			Capacity per pump: 1010 m3/hr @ 185 BARS Power per Pump: 7.5 MW		SEA WATER	2500#/SDSS					2 PUMPS ARE STANDBY	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-1	PIG TRAP			MAJOR BARREL : 18" MINOR BARREL: 16"		SEA WATER	CARBON STEEL					PIPELINE IS 90 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 1	PIG TRAP			MAJOR BARREL : 18" MINOR BARREL: 16"		SEA WATER	CARBON STEEL					PIPELINE IS 40 KM	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-2	PIG TRAP			MAJOR BARREL : 16" MINOR BARREL: 14"		SEA WATER	CARBON STEEL					PIPELINE IS 40 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 2	PIG TRAP			MAJOR BARREL : 16" MINOR BARREL: 14"		SEA WATER	CARBON STEEL					PIPELINE IS 90 KM	A
P	XX	XX		01/02/03		INJECTION PUMPS ATNORTH SAHIL FIELD	PUMP			Capacity per pump: 680 m3/hr @ 170 BARS Power per Pump: 4.6 MW		SEA WATER	2500#/ SDSS					• 1 PUMP IS STANDBY	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-1	PIG TRAP			MAJOR BARREL : 14" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					PIPELINE IS 78 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 1	PIG TRAP			MAJOR BARREL : 14" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					PIPELINE IS 78 KM	A
P	XX	XX		01/02/03		INJECTION PUMPS AT SHAH FIELD NEAR CDS	PUMP			Capacity per pump: 9125 m3/hr @ 170 BARS Power per Pump: 6.2 MW		SEA WATER	2500#/ SDSS					• 1 PUMP IS STANDBY	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-1	PIG TRAP			MAJOR BARREL : 14" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					PIPELINE IS 11.7 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 1	PIG TRAP			MAJOR BARREL : 14" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					PIPELINE IS 11.7 KM	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-2	PIG TRAP			MAJOR BARREL : 16" MINOR BARREL: 14"		SEA WATER	CARBON STEEL					PIPELINE IS 18 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 2	PIG TRAP			MAJOR BARREL : 16" MINOR BARREL: 14"		SEA WATER	CARBON STEEL					PIPELINE IS 18 KM	A
P	XX	XX		01/02		INJECTION PUMPS AT QUSAWAIRAH CENTER NEAR CDS	PUMP			Capacity per pump: 900 m3/hr @ 165 BARS Power per Pump: 5.9 MW		SEA WATER	2500#/ SDSS					• 1 PUMP IS STANDBY	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-1	PIG TRAP			MAJOR BARREL : 14" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					PIPELINE IS 36 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 1	PIG TRAP			MAJOR BARREL : 14" MINOR BARREL: 12"		SEA WATER	CARBON STEEL					PIPELINE IS 36 KM	A
P	XX	XX		01/02		INJECTION PUMPS AT MENDER FIELD EDGE	PUMP			Capacity per pump: 570 m3/hr @ 165 BARS Power per Pump: 3.7 MW		SEA WATER	2500#/ SDSS					• 1 PUMP IS STANDBY	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-1	PIG TRAP			MAJOR BARREL : 12" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					PIPELINE IS 10.3 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 1	PIG TRAP			MAJOR BARREL : 12" MINOR BARREL: 10"		SEA WATER	CARBON STEEL					PIPELINE IS 10.3 KM	A
LP	XX	XX				FROM PUMPING STATION TO HEADER-2	PIG TRAP			MAJOR BARREL : 10" MINOR BARREL: 8"		SEA WATER	CARBON STEEL					PIPELINE IS 6.5 KM	A
RP	XX	XX				PIG RECEIVER FOR HEADER 2	PIG TRAP			MAJOR BARREL : 10" MINOR BARREL: 8"		SEA WATER	CARBON STEEL					PIPELINE IS 6.5 KM	A

Appendix 3 Project Philosophies (Doc. no. 30.99.91.0622)

أدنـوك
ADNOC

Conceptual study

For

PROJECT WAVE

Project No. : P30280

Document No. : 30-99-91-0622

PROJECT PHILOSOPHIES

REV.	DATE	ORIGINATOR	REVIEWED	APPROVED	PEM	DESCRIPTION
A	31/07/2019	MN/SMA	IA	MAN	AQL	Issued for Review

THIS DOCUMENT IS INTENDED FOR THE USE BY ADNOC ONSHORE AND ITS NOMINATED CONTRACTORS, MANUFACTURERS AND SUPPLIERS.

ORIGINATOR: TECHNICAL CENTER (ENGINEERING)	
ORIGINATOR Document No.: 30-99-91-0622	

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List of HOLDs

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Abbreviations

Barg	Bar gauge
SRP	Sulphur Reducing Plant
NEB	North East BAB
BLPD	Stock tank barrels of liquid per day
BOPD	Stock tank barrels of oil per day
RRE	Ruwais Refinery East
RRW	Ruwais Refinery West
RAS	Ruwais Area Service
CBCD	Carbon Black Delayed Coker
CPP	Central Processing Plant
CO2	Carbon Dioxide
DBB	Double Block and Bleed
DEP	Shell Design & Engineering Practice
EOR	Enhanced Oil Recovery
EPC	Engineering, Procurement & Construction
HSE	Health Safety & Environment
LC	Lock Closed
ppm	Parts per Million
HIPPS	High Integrity Pressure Protection System
MP	Medium Pressure
TERV	Thermal Expansion Relief Valve
DCS	Distributed Control System
ESD	Emergency Shutdown System
IPS	Instrumented Protective System
WIC	Water Injection Cluster

1.0 Introduction

ADNOC Onshore operates crude production facilities at ASAB, Sahil, Shah, Bab, Bu Hasa and NEB (Dy/Ra). The crude production from these stations is routed to MP-21, and from there to the export terminals at Jebel Dhanna and Fujairah. Provisions exist for supply of crude to refineries at Umm Al Nar (Abu Dhabi) and Ruwais.

ADNOC ONSHORE is currently producing around 1.8 MMBOPD of crude oil. With several planned modifications in all the ADNOC ONSHORE fields, ADNOC ONSHORE is planning to increase the oil production to a sustainable level of approximately 2 MMBOPD by year 2020. ADNOC Onshore future plan (Year 2028) includes to increase the sustainable production by 2.4 MMBOPD.



Figure 1-1: ADNOC Onshore Fields locations

As part of pressure maintenance aquifer water injection and produced water re-injections are being employed. Regional ground water aquifers have been under depletion for over 40 years and the sustainability of using aquifer water to support future water injection requirement is uncertain. Sea Water injection project represents ADNOC initiatives for seeking an additional source of water injection in ANDOC Onshore fields.

BAB Field Description

The Bab field is located in a desert area, approximately 160 km southwest of Abu Dhabi city. The field covers an area of approximately 45 km by 25 km. The main processing facilities are located around Bab Habshan.

The field is sour with high H2S content. The wells to the northeast of Bab field exhibit generally higher H2S content than wells to the southwest.

Currently, Bab injects aquifer water into the producing zones as the pressure maintenance strategy. Associated water will be injected back to Thamama-B reservoir under ongoing project. Associated gas separated at BCDS is delivered to ADNOC Gas Processing for processing and processed Crude Oil is pumped to ADNOC Onshore export network.

NEB Field Description

The NEB development comprises three major structures (fields) namely Al Dabb'iya, Rumaitha and Shanayel. Within these structures there are two main Hydrocarbon reservoirs; Thamama zones 'B' and 'C' together with additional thinner reservoirs Thamama zones 'F' & 'G' and other zones 'A', 'D' & 'E'. The Al Dabb'iya field lies on a coastal/shallow marine area while the Rumaitha/Shanayel structures are onshore close to the coast line South West of Abu Dhabi as shown in Figure 1-1.

The NEB fields are located in one of the most environmentally sensitive areas of all ADCO's licenses and as such the current development addresses the many challenges associated with such areas through application of state of the art engineering concepts and technologies. Future development within the NEB fields will continue to follow and build upon this strategy to eliminate environmental impact.

Bu Hasa Field Description

Bu-Hasa field is located 200 kilometers south west of Abu Dhabi as shown in figure 1-1. It is ADNOC Onshore's most western producing field. It was discovered in 1962 and was put on production in May 1965. In Bu-Hasa currently there are three Remote Degassing Stations (RDS-1/2/3) and two satellite stations BQ & HW.

Production from oil wells completed in Shuaiba, Thamama B, Thamama F, BQ & HW is routed through individual flow lines to three Gathering stations (RDS-1, RDS-2, RDS-3), BQ and HW stations in various parts of the field. The combined production from the wells at each these stations is routed to Central Degassing Stations (CDS) via transfer lines ranging in sizes from 16" to 26". In addition, some wells in the central part of the field are connected directly to the CDS.

Figure 1-1 also shows the strategic interfaces between ADNOC Onshore fields with offshore sea water supply sources. Potential sea water supply sources are allocated, analyzed and selected as part of the concept's study.

2.0 Project Objective

Potential benefits of utilizing seawater as a complimentary source of water for injection demand includes:

- Sustainable source for water injection
- Contain aquifer depletion and adverse impacts of pressure decline
- Improve Injectivity in marginal, low permeability reservoirs
- Conceptually reduce simulation cost of injectors due to lower TSS
- Reduce future CAPEX & OPEX by reducing the number of Water Injection Clusters, ESP's pulling hoist, manpower, power consumption, etc.
- Improve operational efficiency, reduce injection downtime and improve system efficiency through centralization of treatment facility
- Potentially improve reservoir ultimate recovery through reducing Oil/Rock interfacial tensions and adhesive forces

3.0 Project Scope

The project's scope mainly involves the following:

- Building a seawater filtration plant and Sulphate Reduction Plant (SRP) with a network of pipelines to bring treated, filtered, low-sulphate sea water to Bu Hasa, Bab & NEB. Provision should be considered to include future sea water injection extension to Asab.
- Building and commissioning new sea water injection pump station and injection network
- Building a pipe network to distribute such sea water to existing or new injector wells
- Full conversion of existing aquifer water to sea water injection, including decommissioning and P&A of associated water supply well, decommissioning of surface pump and associated chemical treatment, etc.
- Produced water re-injection clusters will remain as it is.
- Field de-congestion of existing water injection clusters.

4.0 Document Objectives

This document defines project philosophies for Sea Water Injection Project which will be used to design the various facilities at various locations such as sea water supply sources, sea water treatment plant, seawater distribution and injection facilities at BAB, NEB & Bu Hasa. This is a live document and will be updated as the projects progresses time to time.

5.0 Project Description

Considering the wide extent of project's scope and the multiple items to be covered under project's conceptual design, the project has been broken down into components, each component caters for a specific design area which requires individual assessment, analysis and selection. Refer to Figure 5-1 below for project's components:

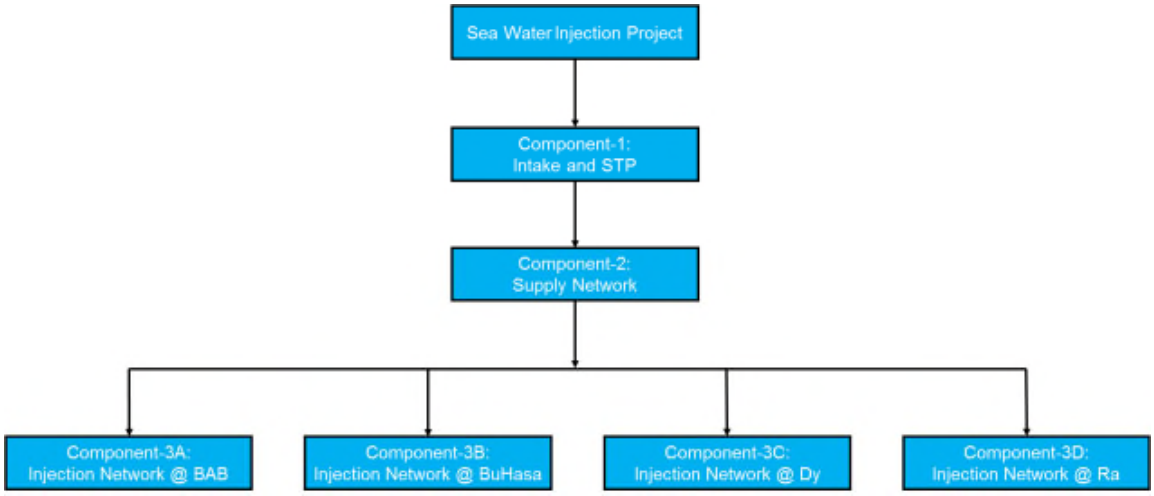


Figure 5-1: Sea Water project components breakdown

Project's design components are described as the following:

Component-1: caters for the selection of the sea water supply intake source as well as the location of the sea water treatment plant. The distribution from the sea water treatment plant to the individual fields is captured as part of component-2. The battery limit of this component starts from the sea water/ reject water intake source and terminates at the sea water treatment plant's outlet.

Component-2: caters for the selection of the supply pipeline network scheme with respect to number of pipeline, intermediate pumping as well as pipeline's metallurgy. The battery limit of this component starts from the outlet of the sea water treatment plant and terminates at the inlet of the receiving fields.

Component-3: caters for the design of the sea water injection pumping and injection pipeline distribution network. The battery limit of this components starts from the tie-in with the sea water supply pipeline and terminates at the inlet of the injection pumping stations. Additionally, this component involves the greenfield design of the sea water injection network distributing the injection water to the wells/clusters. Known future developments are also catered in the design. De-congesting the existing water injection clusters and associated facilities (by demolition) is also considered, as applicable.

Refer to Figure 5-2 below for the overall segregation of each component's definitions:

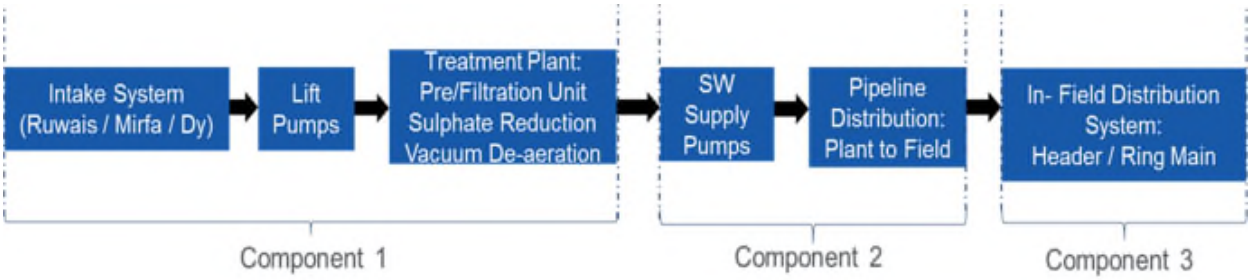


Figure 5-2: Components limits definition

6.0 Isolation Philosophy

Isolation philosophy shall clearly explain the means for valved isolation and positive isolation in accordance with SHELL DEP 31.38.01.11- General Piping Requirements as well as ADNOC Onshore amendments to DEP 31.40.00.10, Doc. No. 30.99.00.0040.

In general, sequence of activities for isolation of equipment / piping / instrument / pipeline and associated systems for maintenance is as follows:

- Isolate the equipment using the appropriate valves.
- Depressurize the equipment to relief header (in case of hydrocarbon system) or to atmosphere as appropriate and drain liquid to closed drain or open drain as appropriate.
- Purge the equipment or piping with nitrogen to make it hydrocarbon free, if required.
- Positively isolate the equipment from live system if vessel entry is envisaged by means of removable spools or blinds. In case of instruments / piping / equipment where vessel entry is not envisaged the isolation should be adequate to ensure safe removal/installation of the component.

6.1 Isolation Methods & Application

Following isolation method will be employed based on the concerned case as explained in subsequent sections.

6.1.1 Positive Isolation

Positive isolation must be employed where entry into a confined space is to be undertaken or equipment to be opened or removed whilst the remainder of the unit is still in operation or hot works are to be carried out or where high risk fluids are to be contained. Positive isolation shall be achieved in one of the following three ways:

- Removal of a spool piece and blanking of open ends.
- The turning to blind position of a spectacle blind.
- The insertion of a spade (blind) between flanges or replacement of a spacer with line blind.

Spectacle blind / spade / spacer / blind flange shall have the same ASME rating class as relevant piping, or higher.

6.1.2 Valved Isolation

Valve isolation is the standard way of separating systems. This type of isolation is provided in all cases where no specific tightness requirements are justified and where planned use of the isolation can be foreseen during the design stage. Valved isolation is used to maintain containment and is an acceptable option in low risk, non entry situations.

Where a bleed valve is provided, the purpose of the bleed is to verify if the valve has seated and tightness has been reached before spading and to provide a means of draining or depressurising the volume between spade/blind and isolation valve.

The preferred take off point of the bleed is at the top of the line, especially in fouling systems. Integrity of double valve isolation without intermediate bleed is only considered as single valve, because of inability to confirm integrity of upstream valve.

Type of valves to be considered for seawater shall be as per the Table-6.1 below.

Table-6.1 : Valves for Seawater Service

Seawater	Upto 2”	Gate
Seawater	Above 2”	Butterfly
Seawater (Firewater)	Upto 2”	Gate
Seawater (Firewater)	Above 2”	Butterfly
Seawater (Injection)	All	Ball

Details of double and single valve isolation schemes are explained below:

(A) Double Valve Isolation:

This arrangement comprises of two block valves. Wherever possible, valve to valve flanges shall be used to minimize pipe lengths between the valves to mitigate venting requirements in between the valves.

Bleeds shall be provided at following instances.

1. Wherever double block valves are provided for isolation, provide a bleed connection, in between, with a valve, for line sizes 6 inches and above. For line size of 4 inch or below a separate bleed valve is not required as per ADNOC Onshore amendments to DEP 31.40.00.10-Gen, Doc. No. 30.99.00.0040.
2. For non-toxic and non-flashing services at control valve with a bypass.
3. For non-toxic and non-flashing services where a bleed shall be provided to safely turn a spectacle blind or insert a spade while both the ends remain under process conditions.
4. Pipeline bleeds valve size to be considered as 2" minimum.

Double Block and Bleed (referred as DBB):

Piping for systems / services in which contamination cannot be tolerated is provided with double block & bleed valves.

This arrangement comprises of two block valves with an intermediate bleed valve. All bleeds in hydrocarbon and toxic services shall be routed to closed system. i.e vents shall be routed to flare system and drains shall be routed to closed drain system. No local venting and bleed collection using exterior containment shall be allowed for hydrocarbon and toxic services. Security measures to prevent inadvertent operation of valves are mandatory and shall follow the appropriate operational permitting systems.

The following schematics indicate representation of double block and bleed arrangement along with spectacle blind.

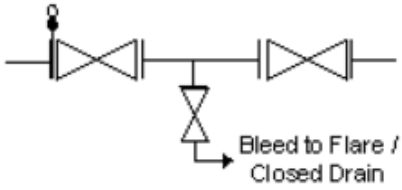


Figure-6.1: DBB arrangement with positive isolation

Shutdown Valves (SDV), Emergency Shutdown Valves (ESDV), Remote Operated Valves (ROV) and Motor Operated Valves (MOV) in combination with manual valve and bleed valves in between can be considered as a double block and bleed isolation, provided they can be reliably fixed in closed position. In such case, SDV/ESDV/MOV/ROV shall be equipped with local / remote reset buttons.

In case SDV, ESDV, ROV and MOV is considered as a part of the double block valve arrangement, such valve shall be located as close to the manual block valve as possible.

(B) Single Valve Isolation:

This arrangement comprises of a single block valve with or without a bleed. Single valve isolation shall be limited to fluids not classed as toxic and fluids not containing hydrogen and fluids that are non-flashing, in pressure classes 600# and below; and flashing fluids in pressure classes 300# and below.

Water injection and other non-hydrocarbon utility system that is not connected to the process shall be provided with single valve isolation valve as per ADNOC Onshore amendments to DEP 31.40.00.10-Gen, Doc. No. 30.99.00.0044.

6.2 Process System Isolation

In general, Isolation valve shall be provided for spare equipment. No separate isolation provision will be considered for non-spared equipment. Isolation of these equipment can only be carried out along with the isolation of the respective system.

Maintenance on equipment is achieved after system shutdown and depressuring.

6.2.1 Vessels

Every nozzle except connections to atmosphere (e.g. local vents, drains and utility connections) on major process vessels shall be provided with spectacle blinds, removable spool or valves both inlet and outlet of the vessel to enable hydrostatic testing and personnel entry. Manholes are provided on vessel to facilitate personnel entry.

Where inlet or outlet piping is arranged as manifold, such in case of connection to more than one nozzle on the vessel, a single positive isolation means located at the manifold isolation valve is acceptable rather than positively isolating each vessel nozzle, provided that the isolation means is clearly visible from the vessel.

6.2.2 Packaged Equipment (other than Compression Trains)

A package is expected to be taken offline for maintenance as a full unit; no maintenance isolation between equipment within the package is envisaged. However, if certain equipment are spared within a package, then the equipment will be provided with isolation as per the philosophy.

For the packages, all vent / drain / flare / utility connections will be grouped within the package and provided with common isolation at the package battery limit.

6.2.3 Pumps

Pumps are generally spared. Individual pumps isolation at suction and discharge line shall be considered, including positive isolation. For non-toxic hydrocarbon rating lower than 600#, spectacle blinds is not required.

6.2.4 Battery Limit Isolation

Battery limit isolation between process plants / units for hydrocarbon and toxic services shall be provided with double block and bleed with spectacle blind / spacer to ensure positive isolation. For non-hydrocarbon and non-toxic services single valve with positive isolation shall be provided.

Wherever there is a tie-in with existing system, it should be considered as Battery Limit and isolation shall be provided as per above.

6.2.5 Pig Traps

A mechanical key exchange type interlock shall be provided on the pig trap inlet valve, kicker line valve, vent valves, drain valve and pig trap door to prevent opening of the trap under pressure and to avoid release of hazardous fluids. Pig trap isolation requirements shall be considered as per ADNOC Onshore specification 30-99-00-0103.

Each pig launcher & receiver will have tell-tale valve, located upstream of manual drain valve. The purpose of this valve is to ensure that pig traps are drained completely before opening of pig trap door.

Vents and PSV discharge for all water injection pig traps are routed to safe location and to local pit.

6.3 Instruments

All online instruments and offline instruments will be provided with isolation valves in accordance with philosophy set in Section 6.1.

For isolation of pressure instruments, integral double block is recommended. If this is not possible, normal double block and bleed can be used.

6.3.1 Control Valves Assembly

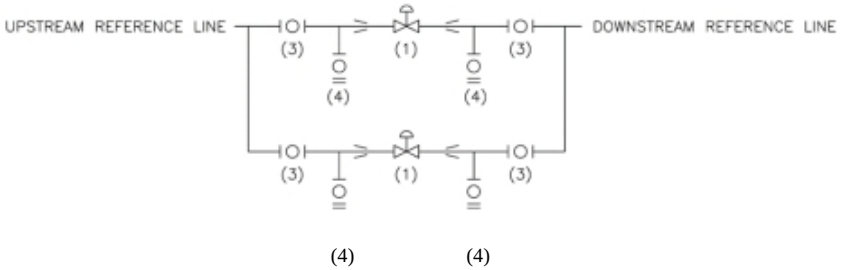
Where parallel control valves are provided, due to the severity of duty, both the control valves shall be provided with isolation valves and drain valves.

For control valves whose availability is critical for the plant availability, the installation of a second control valve in parallel may be considered to allow maintenance of the first control valve while the plant is in operation. The criticality can be identified based on process operation.

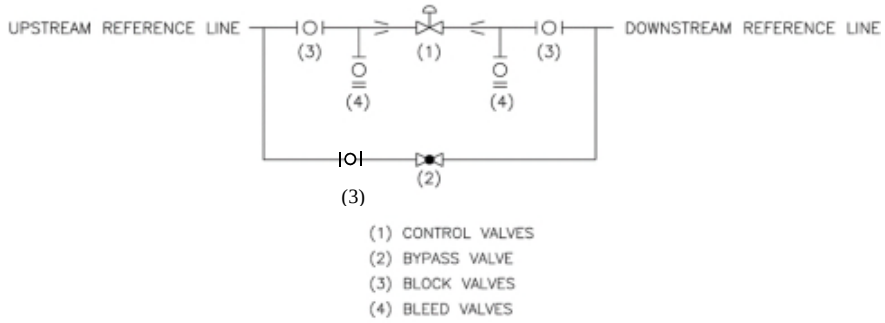
Where it is considered necessary to bypass a control valve, bypass arrangements around the control valve shall be installed to permit maintenance of the control valve without the need to shut down the process unit. Such bypasses will contain a manually operated globe valve along with necessary block valves.

Minimum drain branch and valve size shall be 2" or main pipe size, whichever is less when the control valve is located on low point. Minimum vent branch and valve size shall be 1" or main pipe size, whichever is less when the control valve is located on high point.

a. Parallel Control valve in severe service



b. Control valve with bypass



6.3.2 Relief Valves arrangement

Shell DEP 80.45.10.10 Section 2.1.3 shall be followed for the requirement of PSV on equipment.

Spare PSV is not required for spared equipment, for 2 X100% configuration and for thermal relief and thermal expansion relief devices.

Relief valves with spare shall be equipped with locked block valves upstream and downstream. The block valves on both the relief valves shall be mechanically interlocked such that if one relief valve is isolated for maintenance, the other relief valve is automatically on line (key operated locking system, as per Shell DEP 80.46.30.11). Bleed valve is required upstream of the safety valve between inlet isolation valve and PSV inlet flange.

Block valve shall be avoided upstream of relief valve where a spare relief valve is not provided. For example, PSV's provided on discharge line of chemical injection dosing pumps don't have inlet isolation valve because pumps are 100% spared. Such relief valves will be isolated from the upstream vessels / piping by means of a removable spool piece. However, for thermal expansion relief valves, it is common practice to provide inlet isolation valve for these non-spared PSVs to facilitate PSV maintenance while the process is online.

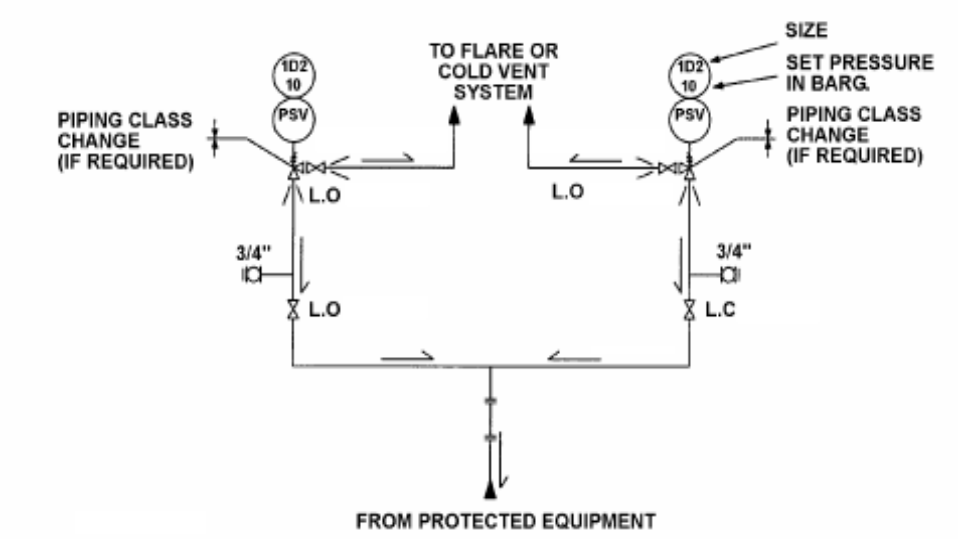
Thermal Relief Valves (TRV) / thermal expansion, which may be removed while the system is in operation, should be provided with upstream and downstream locked open isolation valves. Strict procedural controls should ensure that the line is not shut-in while the relief valve is out of service.

All isolation valves upstream / downstream of relief valve are full bore.

Double block isolation shall be provided on PSV outlet in case the PSV discharges back to the pipeline system instead of the vent system.

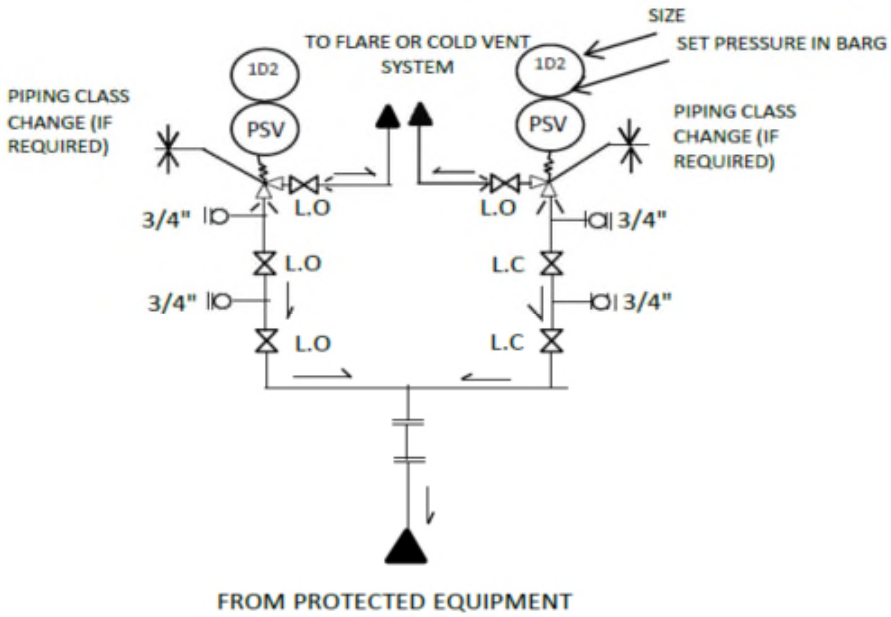
Pressure safety valves on the pig traps are designed for fire case scenario. As the pigging operation is intermittent and since the fire scenario is the only overpressure scenario, the PSV's on the pig traps are not provided with inlet isolation valve. Further the PSV's on the water injection line are not provided with isolation valve upstream or downstream as they are open to atmosphere.

a. Typical PSV's installation with one upstream isolating valve



Toxic and/or flammable discharges shall be routed to the flare and non-toxic, non-flammable discharges shall be routed to atmosphere at safe location (cold vent).

b. Typical PSV's installation with two upstream isolating valve with DBB



LEGEND

⋈	BLOCK VALVE, GATE VALVE OR FULL BORE BALL VALVE
◻	BALL VALVE
⟩	REDUCER
→	SLOPE
⊣⊢	SPOOL PIECE
L.C	LOCKED CLOSED
L.O	LOCKED OPEN

6.3.3 ESD Valves

All the battery limit ESD valves shall be provided with isolation upstream of the ESD valve if it is located upstream of the process and downstream of ESD valve if it is located downstream of the process i.e. ESD valve is isolated along with the unit. ESD valves within the process unit will not have isolation valves and if it is required to isolate for any maintenance reasons, the process unit has to be shutdown.

Pressurisation valves for the main SDVs shall be provided across the SDVs that help to pressurize the downstream side of the valve during start up scenario. Differential pressure indicator shall be provided across the valve that provides start permissive for the main SDV and inhibit its opening when the differential pressure across it is more than around 2 bars. ESD action that closes the main SDV shall also close the bypass SDV.

7.0 Operating and Control Philosophy

Seawater system is envisaged to be consisting of the following main processing units:

- Seawater intake system,
- Seawater/reject water lifting stations,
- Seawater lift pumps,
- Filtration unit consisting of multi-media filtration followed by coarse cartridge filtration,
- Sulfur Reducing Unit (SRU) consisting of nano-filtration membranes for sulphur removal (down to 1 nanometer),
- Vacuum deaeration for 99.9% oxygen removal,
- Chemical Injection Packages (biocide, coagulants, flocculants, oxygen scavengers and corrosion inhibitor etc),
- Seawater supply pumps,
- Seawater supply pipeline to individual fields,
- Field injection network.

Seawater Intake System can be with channels or with intake pipes. Typically seawater enters the facility through a set of inlet screen channels from where it emerges into a large Lift Station, where Sea Water Lift Pumps are provided.

Sea water taken by Seawater Lift Pumps will be sent to Ultra Filtration after filtration by automatic self-cleaning coarse filters. Slip stream from downstream of seawater lift pump will be sent to Electro Chlorination Package to generate and inject chlorine at suction of sea water lift pump for biocide. Screens will be installed inlet of seawater lift pump. The Lift Pumps can be VSD type, depending upon the energy review.

Seawater reject will normally be directed back to sea with other seawater returns. The Sea Water Lift Pumps will be initiated by operators through the DCS. The flow passes through Seawater Filter and the differential pressure will be monitored in the DCS. Flow and pressure will also be monitored in the DCS on the pump outlet.

Sulphur removal from seawater is crucially important for maintaining the stability of the formation clays and for preventing the formation of barium and strontium sulphates as a result of the interaction between formation water and sea water. Such sulphate components can be hardly removed and they tend to accumulate in wellbore tubings.

Reject discharge from the sulphur removal plant shall be directed to an outfall sump. Accordingly, the demand intake capacity to the inlet of the treatment plant shall consider 30-35% margin on the demand sea water at plant's outlet battery limit.

The sea water is transferred by Feed Pumps to be filtered through Ultrafiltration Unit designed typically to remove 98% of suspended solids greater than 2 microns. The system will consists of number of filters, each filter will be automatically backwashed on a programmed timed cycle by the PLC system. High differential pressure across the filter or manual intervention shall override the timer. The detail control scheme and filter configuration will be specified on filter vendor document.

The filtered sea water will be delivered to the Vacuum Deaerator tower where oxygen content will be reduced from the sea water, via both mechanical (to ~50 ppb typical) and chemical means (to ~20 ppb typical) by oxygen scavenger injection at recycle line from Water Injection Booster Pumps to Deaerator. Oxygen Scavenger catalyst can be injected typically at the rate of ~0.1 ppmv of water flow when the abnormal case to enhance the capability of oxygen scavenger. Antifoam and biocide injection (intermitten, as required), scale inhibitor injection (continuous) will require to be injected at the inlet of Deaerator to avoid corrosion and scale in the downstream carbon steel injection piping and to prevent growth of aero-bacteria.

Sea water feed could be controlled by level (at Deaerators) to flow (at the upstream of Ultrafiltration Unit) cascade control. An ejector and vacuum pump system pulls a vacuum to the tower to allow the separation process. Dissolved oxygen is released and removed from the water at the top, packed section, while the deaerated sea water settles down and is collected at the bottom section of the tower.

The seawater flows to parallel operated Sulphate Removal Units. The feed pressure to each SRU is controlled based on the permeate flow set point. The SRU produces 75% of the feed flow as low sulphate permeate Seawater. The low sulphate SW from each SRU is merged and then directed to the deaerator. The remaining 25% of the feed flow ends up as high sulphate content reject seawater and is directed to drain. A bypass is provided across the SRP pumps and trains to provide a blending line in order to achieve the required Sulphate levels in the product Seawater.

Oxygen scavenger solution is injected to further react with the residual amount of oxygen remaining in the deaerated sea water. A residence time of typically 5 minutes at full design flow is provided to allow adequate residence time for the reaction to take place.

The treated injection sea water from the deaerator bottom section will be pumped via the Water Injection Booster Pumps and Water Injection Pumps and pipeline to individual fields for distribution and injection into the wellheads. Required sea water delivery rate at the field battery limit could be

maintained by manual (via the DCS) adjustment of the choke valves on each of the injection wells at the fields. Pump minimum flow recycle back to the deaerator tower bottom section will be maintained by flow control.

Facilities consisting of manifolds and distribution pipe work and instrumentation located on the fields will allow remote operation and control of sea water distribution and injection to the various wellheads.

The number of Water Injection Pumps in operation will be varied based on injection water quantity requirement. Water Injection Pumps can be started and stopped manually. Water Injection Pumps will be equipped with individual minimum flow control valves. The injection pumps may also be provided with VSD type, depending upon the energy review.

Full monitoring, control and ESD systems shall be provided at each Sea Water Treatment Plant (SWTP). As a minimum monitoring will be provided at their respective fields. The fields may also have provisions to control the SWTP, however, this will be decided at the next stage of engineering. Monitoring and control for the Injection Pumps and Network shall be provided at each respective field.

8.0 Overpressure Protection Philosophy

Overpressure protection is required in various areas of sea water injection systems. Overpressure protection against thermal vapor relief and thermal expansion relief of liquid is required for the water injection flowlines. Thermal expansion of liquid can occur upon heat gain from the environment. A nominally sized PSV of D orifice is sufficient for liquid thermal expansion relief.

Thermal expansion relief of liquid is required when the piping system is operated with more than 95 % liquid full and which can be subject to the blocked in conditions (and also for pipe volumes more than 500 L) as per Shell DEP 80.45.10.11. TSVs normally discharge to atmosphere at safe location and shall have minimum inlet piping lengths to minimize inlet pressure losses and avoid chattering.

9.0 Vent Philosophy

All equipments which are required to be isolated positively, shall be provided with facility to depressurise in a safe and controlled manner. Vents in air and water service can be released into atmosphere but shall be carefully located to avoid injury to personnel. Vents for nitrogen shall be routed to elevated and well-ventilated areas located away from access platforms and walkways. All chemical storages are vented to atmosphere.

Vents/ exhaust from equipment to atmosphere shall be located so that the exhaust gases are not recirculated to their air intakes or air intakes of nearby buildings.

10.0 Drain Philosophy

The drainage from hazardous area shall be physically separated from the drains serving non-hazardous areas. This separation shall ensure that communication between hazardous and non-hazardous areas is prevented.

The open drainage system shall collect into a dedicated sump and shall include the spillage of paved areas as well as drip trays installed under some parts of the equipment.

Equipment drains to atmosphere shall also be provided to collect oily water after cleaning. These drains shall normally be blanked off and only used after the equipment has been made safe for vessel entry.

For water injection flowlines, they shall be drained to an environmentally safe area. Open Drain Pits collect the fluids (lube oil, chemicals, seal water and injection water) from water injection pumps, sample point collections and thermal relief valves.

Vacuum truck connection will be provided to remove the fluid from open drain pits for treatment / disposal. Open drain pit also includes a pipe vent to the atmosphere at safe location.

11.0 Emergency Shutdown Philosophy

ESD functionality shall be developed to prevent the risk of exceeding design conditions associated with the failure of the equipment and bring the plant or its sub-systems to a safe condition.

Generally, an ESD function will be a controlled shutdown of a specific unit; package or sub-system initiated by protective trips or operator action.

In dangerous situations, the specific unit shall be brought to a safe condition by means of a series of mainly automatic actions that could for instance:

- Isolate all inlet lines,
- Stop all the rotating machines (by switching off the power / fuel supply),
- Isolate the equipment containing considerable amount of hydrocarbons,
- Depressurise the equipment / piping containing gas.

The ESD levels for injection pumps will follow their respective field philosophy.

Three hierarchy levels of Emergency Shutdown are proposed.

Level 1 (ESD-1) - Plant shutdown.Usually caused by fire and gas, low instrument air pressure or by operator intervention.

Level 2 (ESD-2) – Train shutdown. Initiated by events such as electric power failure, or through operator intervention.

Level 3 — Localised equipment process trips caused by initiators such as low levels, high high levels, high pressures, etc.

To avoid spurious trips, a SIL analysis shall be conducted to evaluate Safety Instrumented Functions (SIF). Appropriate modifications shall be incorporated into the P&IDs and Cause & Effect Diagrams.

The ESD system shall be designed in compliance with the following:

- Shell DEP 32.01.20.10-Gen
- Shell DEP 32.80.10.30-Gen
- Shell DEP 80.45.10.11-Gen (paragraph 2.10.3)
- Shell DEP 31.40.00.10-Gen (paragraph 5.4)
- IEC 61508(where SIL 4 is applicable).

12.0 Sparing Philosophy

The sparing philosophy is intrinsically linked to the plant availability and the philosophy shall be re-evaluated following the resluts of the avaiulability study. The requirement of sparing of equipment is determined by the following factors :

- Realiability of equipment (whether it is prone or not prone to failure)
- Consequence of equipment failure (safety and financial implications)
- Cost of spare installation
- Service
- Maintenance requirement
- Availability of safe bypass mode operation.

Pumps

All types of pumps are considered to be susceptible to mechanical breakdown and generally shall have an installed spare with (n+1) operating philosophy i.e. ‘n’ number pumps operating with one spare. Pumps on intermittent service however shall be evaluated on case-by-case basis.

Air Coolers

Air coolers shall not be spared.

Filters

Filters shall be 100% spared.

Compressed Air System

The instrument air package shall have 3 x 50% air compressors. Each instrument air compressor will have a dedicated after cooler. 2 x 100% instrument air dryer packages shall be provided to ensure that dryer maitenance, filter changes etc. can be undertaken without affecting instrument air supply. Each air compressor package shall contain 2 x 100% pre-filters, 2 x 100% air dryers and 2 x 100% after-filters. Instrument air and plant air receiver shall be provided. No spare vessels will be considered.

Nitrogen System

Nitrogen system sparing shall be provided to ensure a supply of inert and purge gas. 2 x 100% nitrogen package shall be considered to ensure continuous supply of nitrogen is available.

Chemical Injection System

Chemicals requiring continuous injection shall be provided with spare pumps (n+1). The pumps within the package shall be spared.

Emergency Power Generation Package

Emergency power generation shall be provided by diesel generator. Emergency power generators shall not be spared.

Control Valves

Generally, control valves are not spared. However, critical control valves (i.e. those where failure would adversely affect production or the safety of the plant) will be spared. Control valve bypass shall be provided if control using manual bypass valve is practical (e.g. for valves below 6”). Spare control valves should be considered when control using a manual bypass valve is impractical.

Pressure Safety Valves

Generally pressure safety valves (PSV) shall be spared for standard process equipmen. PSVs installed solely for liquid thermal expansion cases do not require sparing. Where there is a spare equipment, or equipment which is not normally used, spare PSV is not required.

Upstream and downstream isolation valves shall be provided around relief valves to allow for testing. Spare PSV discharging directly to atmosphere through individual tailpipes (e.g. Instrument Air Receiver, Nitrogen Receiver) shall be provided with isolation valves only in the inlet pipes of the relief valves. These isolation valves shall suitably be locked open/closed during normal operationand shall be interlocked in accordance to Shell DEP 80.46.30.11-Gen (where two PSVs are installed).

Warehouse Spares

Availability and management of warehouse spares shall be in accordance with Shell DEP 70.10.90.11. This includes standardization of equipment, instruments and fittings in order to optimize the quantity of spare parts and hence reduce capital and operating expenditure.

13.0 Design Pressure and Temperature Philosophy

The design pressure, when used in conjunction with the corresponding design temperature, is used for calculation of minimum wall thickness and related aspects of vessels and pipes.

13.1 Design Pressure Determination

The design pressure for vessels including pressure vessels, heat exchangers, piping etc. shall not be less than:

- The maximum pressure which can be attained in service, where there is no relief valve.
- The relief valve set pressure. The design pressure of each vessel whose overpressure protection is achieved by relief valves shall be determined using the guidelines listed below in relation to its "Maximum Operating Pressure" (MOP).
- Where applicable, a separate set of design pressure and temperature conditions of 3.5 barg and 150 ^{o}C shall be specified to cater for steaming-out operations. Vessels that are subject to steam out shall be designed for full vacuum.

The design pressure of vessels shall be set as follows:

- For non-liquid full systems, the design pressure shall be taken as not less than shown in Table-13.1 below. This is based on Shell DEP, Definition of temperature, pressure and toxicity levels (DEP 01.00.01.30 - Gen).

Table-13.1: Design Pressures for non-liquid systems

Maximum Operating Pressure (MOP), barg	Design Pressure, barg
0 - 10.0 barg	MOP + 1.0 bar, but not less than 3.5 bar
> 10.0 barg	110% MOP

- Storage tanks operating at atmospheric pressure shall be designed for 0.07 barg plus the liquid static head.

- Equipment not protected by a pressure safety relief valve (PSV) and located downstream of a pump should be designed for the maximum pump shut off pressure.
- For vacuum condition: separators and coalesces which can be cooled significantly in a shut-in situation shall be designed for full internal vacuum.

Liquid Full / Pumped Systems

Liquid-full systems shall be designed to withstand pump shut-off pressure if they can be blocked in while pumps feeding them could continue to operate. In accordance with the Shell DEP, the shut-off pressure is the pressure at the discharge of the centrifugal pump with the suction pressure at the maximum possible value and the discharge system closed.

The shut-off pressure (SOP) is determined by:

SOP = SP + HPS + HPO - HPD

Where:

- SP = Set pressure of the pressure relief device on pump suction (for vessel open to atmosphere vessel design pressure to be considered as atmosphere)
- HPS = Hydrostatic pressure of the high liquid above pump suction
- HPO = Pump differential pressure at no flow at maximum pump speed and highest density (Estimated as 1.20 x normal differential head)
- HPD = Hydrostatic pressure of the liquid above pump discharge

In some cases, the pump suction relief pressure is set significantly higher than the normal operating pressure. This could give rise to an excessively high shut-off pressure. The discharge pressure shall be reviewed in such cases and revised if necessary.

MOP Determination

The MOP is a pressure sufficiently above the normal operating pressure to allow for variations and fluctuations in normal operation.

Table-13.2: Determination of MOP

Equipment/situation	Maximum Operating Pressure (MOP), barg	Notes
Typical pressure vessels	MOP = 105% OP	

etc.	MOP shall not be less than OP + 1.0 bar	Note-1
Centrifugal compressor without relief valve	MOP = Max operating suction pressure + 1.3 x normal differential pressure	Note-2
Vessels in utility & aux services	MOP = Max normal OP	Note-3

Notes :

1. Normally, centrifugal compressors have relief valves located on the discharge pipework. However, if a relief valve is not provided and the design is to be based on compressor shut off, then the approach should be as follows: when vendor compressor data is not available, the MOP (shut-in pressure) should be determined as the maximum operating suction pressure + 1.3 times the normal differential pressure developed by the compressor, to include for pressure rise at surge condition and maximum speed. For the compressor suction, the MOP is the maximum settle-out pressure.
2. For vessels in utility and auxiliary services, whose operating pressure is determined by the controlled supply of fluid from a pump / compressor etc, and which are not protected by high pressure shutdown instrumentation, the MOP shall be the maximum normal delivery pressure.
3. For pumps, the discharge side design pressure / rating shall be extended on the suction side up to and including the suction isolation valve.

13.2 Design Temperature Determination

Maximum Design Temperature

This is based on the Shell DEP, Definition of temperature, pressure and toxicity levels (DEP 01.00.01.30 - Gen). Generally, the maximum design temperature is obtained by adding 10 ^{o}C to the maximum operating temperature, with a minimum of 85 ^{o}C for piping or equipment operating at ambient conditions and exposed to solar radiation.

Where applicable, a separate set of design pressure and temperature conditions of 3.5 barg and 150 ^{o}C shall be specified to cater for steaming-out operations.

For shell and tube exchangers, the design temperature is determined by the fluid temperature on the tube and shell sides with appropriate design margins applied.

For tubes in fired equipment the design temperature is the higher of the temperature determined by the rules above or the calculated maximum tube skin temperature.

Minimum Design Temperature

The minimum design temperature shall be the lower of:

- Minimum ambient temperature of 4 ^{o}C or 13 ^{o}C for buried lines
- 5 ^{o}C lower than the minimum operating temperature obtained during normal operation, start-up, shut-down or process upsets.
- The minimum temperature occurring on blowdown. This includes the scenario of cool down to minimum ambient temperature followed by depressurisation to atmospheric pressure per DEP 30.10.02313.2.

This calculation should allow for heat transfer between fluid and vessel.

14.0 Pigging Philosophy

Water supply and injection pipelines shall be piggable. No pigging is envisaged for the water injection flowlines. However, the pigging frequency is expected to be low since the treated water is deareated, desulphated and TSS are removed.

Certain requirements should be fulfilled to ensure pigging is a viable option and to minimize the risk of the pig becoming stuck in the line:

- Appropriate pig traps for launching and receiving the tool,
- Sufficient flow rate and pressure to provide the required tool speed and stability,
- Pipeline cleanliness - pipeline should be clean and free of obstructions,
- Evaluation of bore restrictions and over-bore pipe by means of gauging pig; this should be evaluated to ensure tool drive and minimum distances between sensors and pipe wall,
- Provide full bore valves to the connecting pipeline,
- Consideration of barred tees to avoid the tool becoming stuck inside the pipe,
- During construction various types of pigs to be used for cleaning purpose (scrapers), filling & dewatering (polyurethane or cup type), detection of dents (gauging/caliper pigs).

Pig launcher/receiver design shall be siuitable for launching/receiving of both cleaning/displacement pigs and intelligent pigs.

Non-intrusive type pig signallers will be considered at the pig trap to detect the pig entering or leaving the pig traps.