Department for
Business, Energy
& Industrial Strategy

Hewett Conclusive Report

Key Knowledge Document

NS051-SS-REP-000-00024

July 2021

Acknowledgements

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Any enquiries regarding this publication should be sent to us at:
enquiries@beis.gov.uk

Contents

1.0 Introduction / Foreword

The Net Zero Teesside (NZT) project in association with the Northern Endurance Partnership project (NEP) intend to facilitate decarbonisation of the Humber and Teesside industrial clusters during the mid-2020s. Both projects will look to take a Final Investment Decision (FID) in early 2023, with first CO2 capture and injection anticipated in 2026.

The projects address widely accepted strategic national priorities – most notably to secure green recovery and drive new jobs and economic growth. The Committee on Climate Change (CCC) identified both gas power with Carbon Capture, Utilisation and Storage (CCUS) and hydrogen production using natural gas with CCUS as critical to the UK's decarbonisation strategy. Gas power with CCUS has been independently estimated to reduce the overall UK power system cost to consumers by £19bn by 2050 (compared to alternative options such as energy storage).

1.1 Net Zero Teesside Onshore Generation & Capture

NZT Onshore Generation & Capture (G&C) is led by bp and leverages world class expertise from ENI, Equinor, and TotalEnergies. The project is anchored by a world first flexible gas power plant with CCUS which will compliment rather than compete with renewables. It aims to capture ~2 million tonnes of CO2 annually from 2026, decarbonising 750MW of flexible power and delivering on the Chancellor's pledge in the 2020 Budget to "support the construction of the UK's first CCUS power plant." The project consists of a newbuild Combined Cycle Gas Turbine (CCGT) and Capture Plant, with associated dehydration and compression for entry to the Transportation & Storage (T&S) system.

1.2 Northern Endurance Partnership Onshore/Offshore Transportation & Storage

The NEP brings together world-class organisations with the shared goal of decarbonising two of the UK's largest industrial clusters: the Humber (through the Zero Carbon Humber (ZCH) project), and Teesside (through the NZT project). NEP T&S includes the G&C partners plus Shell, along with National Grid, who provide valuable expertise on the gathering network as the current UK onshore pipeline transmission system operator.

The Onshore element of NEP will enable a reduction of Teesside's emissions by one third through partnership with industrial stakeholders, showcasing a broad range of decarbonisation technologies which underpin the UK's Clean Growth strategy and kickstarting a new market for CCUS. This includes a new gathering pipeline network across Teesside to collect CO2 from industrial stakeholders towards an industrial Booster Compression system, to condition and compress the CO2 to Offshore pipeline entry specification.

Offshore, the NEP project objective is to deliver technical and commercial solutions required to implement innovative First-of-a-Kind (FOAK) offshore low-carbon CCUS infrastructure in the UK, connecting the Humber and Teesside Industrial Clusters to the Endurance CO2 Store in the Southern North Sea (SNS). This includes CO2 pipelines connecting from Humber and Teesside compression/pumping systems to a common subsea manifold and well injection site at Endurance, allowing CO2 emissions from both clusters to be transported and stored. The NEP project meets the CCC's recommendation and HM Government's Ten Point Plan for at least two clusters storing up to 10 million tonnes per annum (Mtpa) of CO2 by 2030.

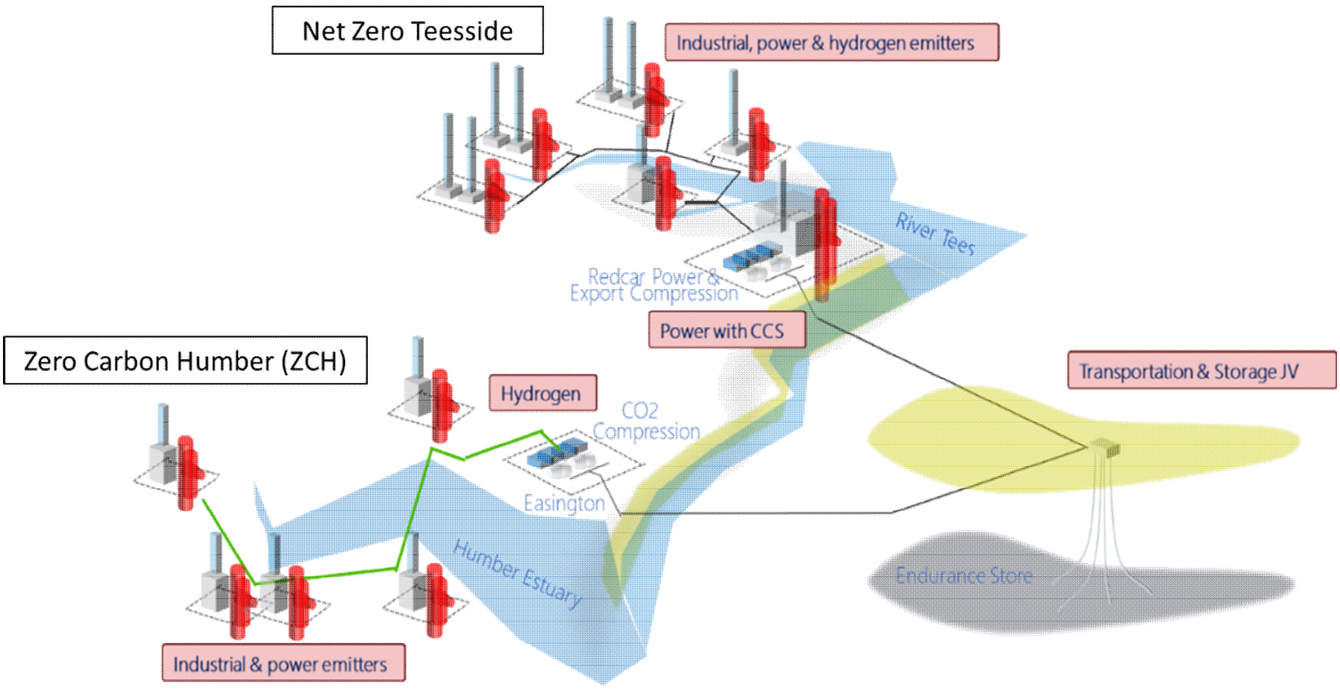


Figure 1: Overview of Net Zero Teesside and Zero Carbon Humber projects.

The project initially evaluated two offshore CO2 stores in the SNS: 'Endurance', a saline aquifer formation structural trap, and 'Hewett', a depleted gas field. The storage capacity requirement was for either store to accept 6+ Mtpa CO2 continuously for 25 years. The result of this assessment after maturation of both options, led to Endurance being selected as the primary store for the project. This recommendation is based on the following key conclusions:

- The storage capacity of Endurance is 3 to 4 times greater than that of Hewett
- The development base cost for Endurance is estimated to be 30 to 50% less than Hewett
- CO2 injection into a saline aquifer is a worldwide proven concept, whilst no benchmarking is currently available for injection in a depleted gas field in which Joule-Thompson cooling effect has to be managed via an expensive surface CO2 heating solution.

Following selection of Endurance as the primary store, screening of additional stores has been initiated to replace Hewett by other candidates. Development scenarios incorporating these additional stores will be assessed as an alternative to the sole Endurance development.

2.0 Executive Summary

The Clean Gas Project (as it was known at the time) was initially developed and funded by the ETI during 2016 and first half of 2017. In August 2017 the project was transferred from the ETI to OGCI CI.

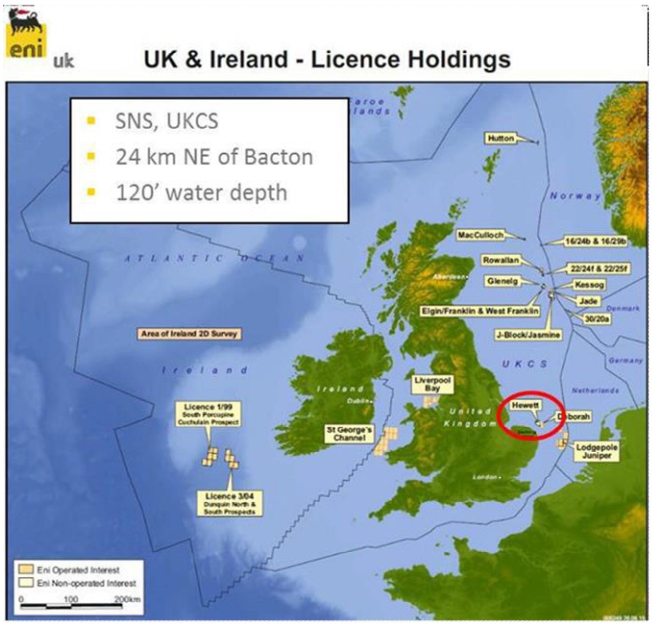
Following the peer review conducted with experts from OGCI CI members in early 2018, Teesside was selected as the location, and four stores were considered, and the following ranking emerged:

Criterion	Endurance	Hewett	Viking A	BC36	Scale 🟢	Scale 🟠	Scale 🔴	Comments
CO_2 appraisal maturity	🟢	🟠	🟠	🔴	Ready to submit	Studies needed	Samples required	Appraisal well needed for BC36?
Capacity	🟢	🟢	🟠	🟢	>150 Mt	50-150 Mt	<50 Mt	Viking A small & faulted
*SPE SRMS**	*CDOH*	*CUC*	*CUC*	*CUC or Prospect*				
Injectivity	🟠	🟢	🔴	🟠	>100mD; no risk	Halite risk	Low K_H (<100 mD)	Saline aquifer injectivity better with 100+ m interval & thermal frac
Containment	🟢	🔴	🔴	🟠	All wells assured	CCS P&A needed	Multiple P&A'd wells	All good geological seal; risk is legacy wells
Hydrodynamics	🟢	🟢	🟢	🟢	Physics Clear	More Clarity Needed	Physics Unclear	Saline aquifer: CO_2 ↑ crest
Monitorability	🟢	🟢	🟢	🟢	Required options viable	Limited MMV options viable	Insufficient MMV options viable	All good
Accessibility	🟠	🟠	🟠	🟠	Option secured	Talks needed	Inaccessible	Discussions with operators

Figure 2 - CDOH - Contingent Resource – Development on Hold, CUC - Contingent Resource – Development Unclarified

The Peer Review recommendation was to take forward one preferred store (Endurance, depending on accessibility) and one reserve store (Hewett or Bunter Closure 36, depending on legacy well integrity) through the stage gate, with confirmation of the selected store within 3 months.

In April 2019, BEIS committed to fund 47% (capped at £ 3.76 MM) of the subsurface and environmental components of CGP (today the Net Zero Teesside/Northern Endurance Partnership -NZT/NEP- project) for a period of 2 years, bounded by consideration of the Endurance (normally-pressured saline aquifer) and Hewett (a depleted former gas field) stores only.



Discovery Wells	48/29-1 (Arpet, 1966)	
	52/5-1 (Phillips, Agip partner)	
Number of Wells	5 exploratory	
	35 producers (7 ST’d)	
	2 never on stream	
OGIP (Tcf)	3,879	
Cum. Production (Tcf)	3,490	

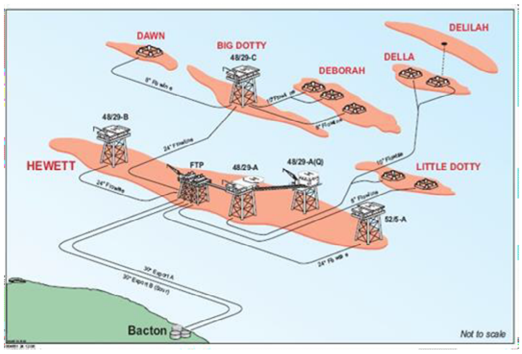


Figure 3 - Hewett field

The Hewett Field, a depleted gas offshore field, is located in the United Kingdom’s Southern North Sea (30 m water depth), straddling the Blocks 48/28, 48/29, 48/30, 52/4a, 52/5a.

Hewett, now operated by ENI, has ceased its production and has entered in the decommissioning phase.

The asset has 32 platform wells spread over 4 platforms plus 8 subsea production wells and one suspended subsea P&A well. All wells were drilled between 1967 and 2008 by different operators.

Eni has now started a decommissioning campaign of all the subsurface and surface infrastructures. The campaign will include the Plugging & Abandoning of all the 40 wells, the isolation of the subsea well flowlines and umbilicals to make the platforms hydrocarbon free and the dismantling of all the platforms.

OGCI has signed in 2019 a Technical Service Agreement with ENI to run some of the studies needed for upgrading the field as a valid candidate for CO2 storage: reservoir, wells integrity, flow assurance, engineering assessment studies. These studies have been completed and are part of this report in different annexes.

ENI studies proposed the following high-level principles of using Hewett as a store:

Total Injection Rate: 6 Mtpa (≈16500 tons/d CO2)

CO2 transported as liquid phase through a pipeline @Tamb

Liquid CO_2 at platform will be heated (to avoid the Joule Thompson effect) and laminated to:

- control initial pressure drops across sand face
- guarantee initial gas phase injection

All the relevant data and study details have been given in time to the NZT/NEP team to allow drawing the following conclusion:

A pipeline feeding the CO_2 to Hewett store in a gaseous phase would not have been conceivable with the proposed rate of 6 Mtpa. Its size, over 280 km, would have been unrealistic and non-economic. The only solution is to transport the CO_2 in dense phase leading to affordable pipeline sizing.

The CO_2 arriving on site with a pressure of 81 bars (WHP) has to be transferred to a highly depleted reservoir (4 bars, 40°), therefore storing the CO_2 in gaseous phase. To avoid the Joule Thomson effect, accompanying this phase change, leading to a sharp cooling effect (negative temperature into the wells), the CO_2 has to be heated at the surface.

This heating need is conditioning the choice for Hewett of a platform (dry wells), supporting heating facilities, therefore leading to higher CAPEX and OPEX than with a normally pressurized reservoir (case of Endurance). Power need for heating the CO_2 @ 6 Mtpa is estimated at 60 Mw by NZT/NEP.

Hewett reservoir is of excellent quality, well-known after 50 years of production, NZT/NEP is estimating its capacity more conservatively to 150 Mt vs 180 Mt by ENI (for the Lower Bunter Reservoir).

Upper Bunter reservoir could be an upside but absence of connection of this reservoir with Little Dotty field has to be closely assessed, as the integrity of the legacy wells tying this reservoir.

The Endurance field was eventually chosen as preferred choice for the project, based on:

Volume - Endurance has approximately three time the effective pore volume of Hewett (~450 Mt vs. 150 Mt probable).

Benchmarking - Benchmarking and operational experience is available for CO_2 storage in saline aquifer reservoirs, giving confidence in Endurance. No such history is available for a depleted field such as Hewett.

Complexity - Endurance does not require heating to mitigate Joule-Thompson cooling across the well choke, enabling operation from a simple NUI or subsea development; Hewett requires 60MW of heating and a more complex platform with power from shore.

Cost - Endurance is only 140km from Teesside, compared to 280km for Hewett. This combined, with the simpler design, results in simpler project execution and a significant lower CAPEX and OPEX than Hewett.

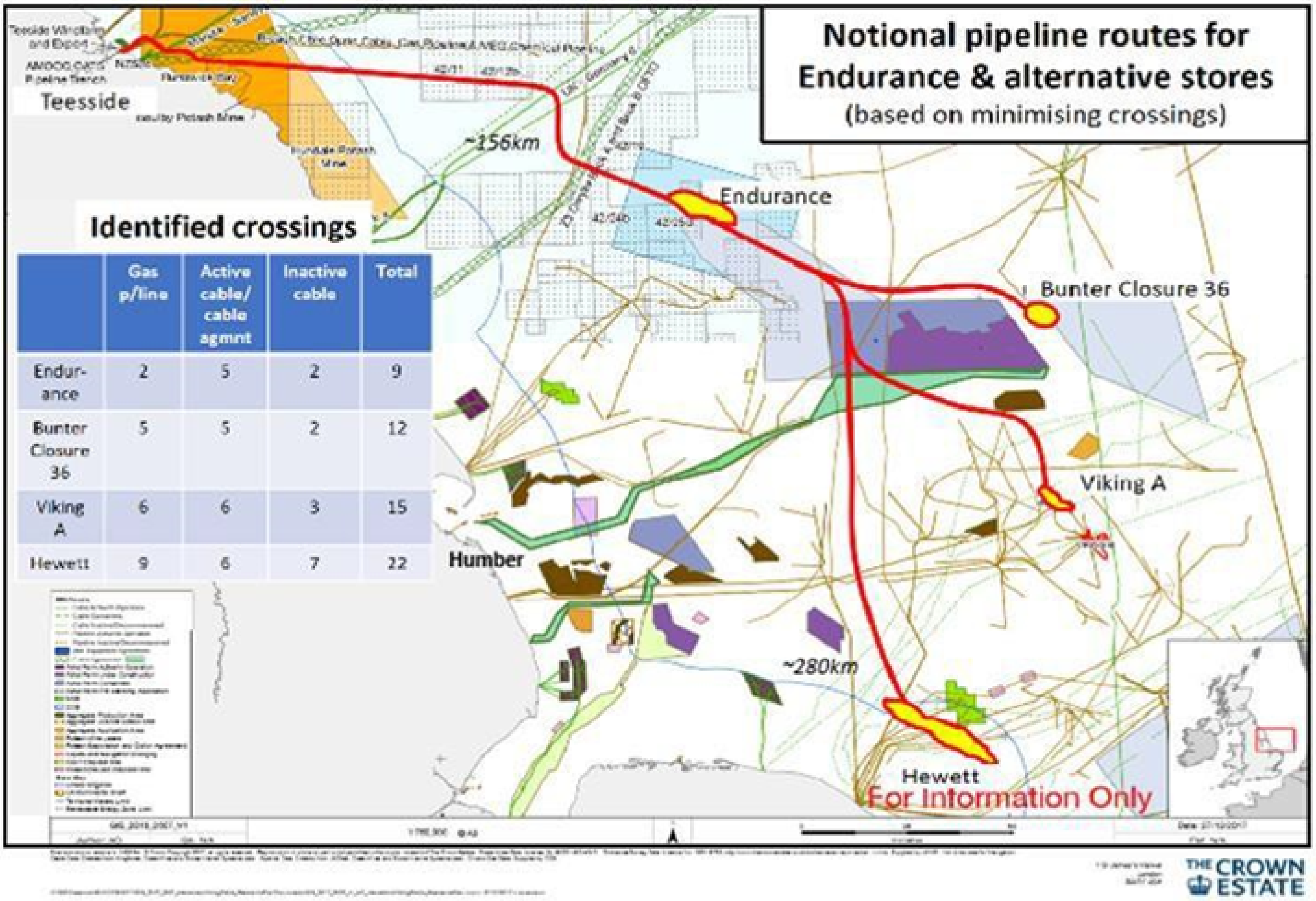


Figure 4 - Endurance pipeline route

This choice should not overshadow the fact that depleted HC fields are a major (and most probably the greatest) component of the future CO2 worldwide storage:

They are well identified and well understood with regards to capacity and integrity

With facilities already in place, some of them could potentially be re-used

There are still technical (and cost) challenges to overcome: JT cooling effect leading to the requirement for CO2 heating depending on the difference between arrival pressure and depletion, but there is a strategic benefit to the UK CCUS sector in advancing knowledge of these types of reservoirs. This includes diversity in store failure modes and enabling progression of additional CO2 store volumes for future expansion, driven by proximity to CO2 source and pricing.

For these reasons, the project team has stopped progressing the subsurface definition of Hewett, and have commissioned a facilities-based study to understand the combinations of reservoir pressure and distance from a CO2 source for which depleted gas reservoirs offer an advantage in being able to store CO2 without significant JT impact (Refer to Annex 0 NS051-PR-TEC-040-00004 - Generic Depleted Reservoir Study)

3.0 Reservoir

The field has a length of approximatively 29 km and lies in a water depth ranging between 20 and 40 m, at about 16 km from the coastline

Hewett is an offshore depleted gas field (120 ft water depth), located in the United Kingdom's Southern North Sea (120' water depth). It is located in Block 48/28, 48/29, 48/30, 52/4a, 52/5a (Figure). It was discovered by well 48/29-1 (Arpet in 1966) and well 52/5-1 (Phillips) and was then developed by a total of 35 wells through 3 production platforms. It came on stream, operated by Philips, in 1968 from the Lower Bunter and in 1973 from the Upper Bunter.

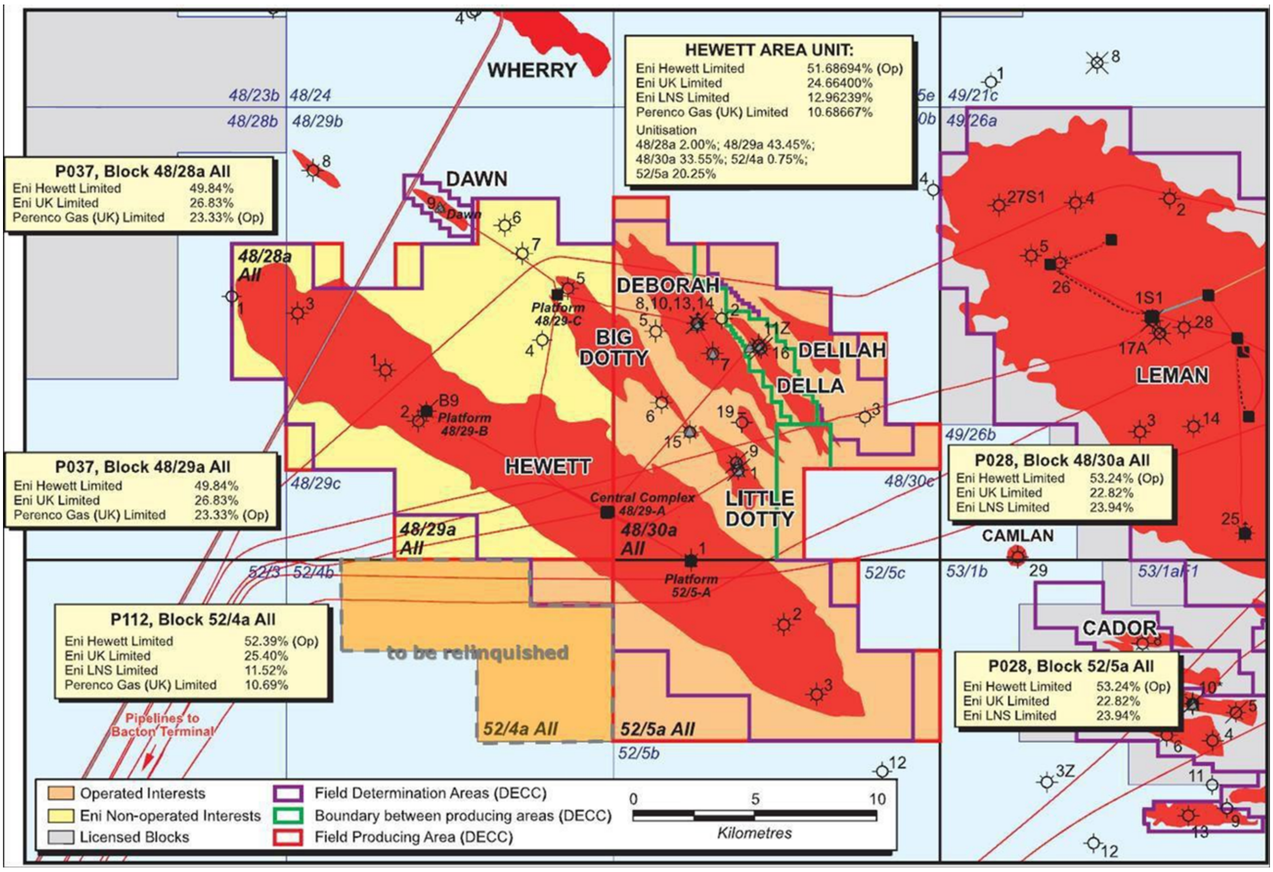


Figure 5 - Hewett gas field

ENI took ownership of the Hewett installation and infrastructure in 2008. Cumulative production is 3490 Bscf at CoA (2019) for an estimated Gif of 3.88 Tcf with the following break out:

Reservoir	Lithology	Start-up	OGIP (Tcf)	Current RF [%]	Current Pressure [psia]
Upper Bunter	Sandstone	1973	1,37	90	126
Lower Bunter	Sandstone	1968	2,17	99	36
Zechstein	Carbonate	1986	0,34	45	500

The two main reservoirs are the Lower Triassic Upper Bunter and Lower Bunter Sandstones, overlaid by a thick and continuous sequence of shale, inside a NW-SE elongated dome structure bounded by major sealing faults.

Lower (also known as Hewett Sandstones) and Upper Bunter Formations consist of good quality sandstones deposited in a deltaic fluvial environment while Zechstein Formation has carbonate origins. Lower and Upper Bunter sands are of excellent quality: mean porosity of 21% and average permeability 1300 mD + in both Fm, with 750 ft of seal over the Lower Bunter and 1400 ft over the Upper Bunter.

A minor accumulation is located into Zechstein Formation (Permian).

ENI has completed an integrated Reservoir Study which is shown in Annex 0 NS051-RE-STU-434-00001 - Integrated Reservoir Study Report with Preliminary Screening CO_2. Following this study, together with Geochemical and Geomechanical preliminary assessments, the suitable characteristics of the field as a CO_2 storage site, are confirmed. Field capacity has been evaluated in 180 Mt for Lower Bunter level while Upper Bunter could be considered as an upside level with a capacity estimated in about 100 Mt.

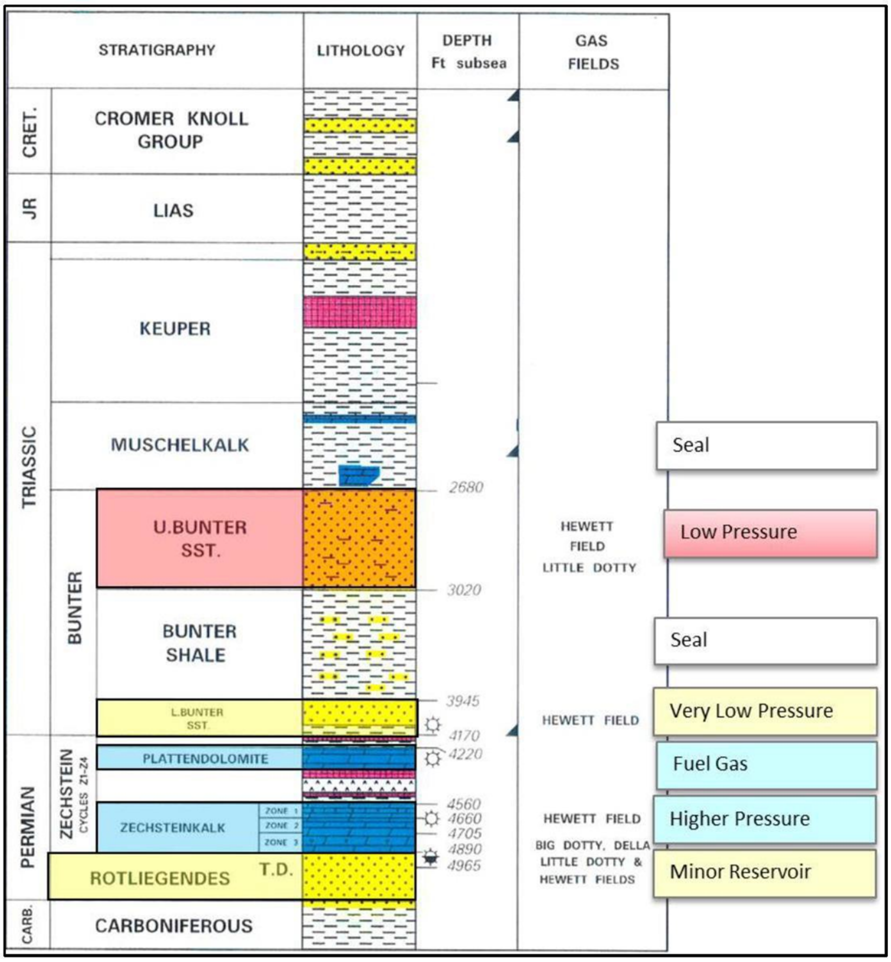


Figure 6 - Integrated reservoir study

The NZT/NEP project drew the following conclusions from this study:

- Hewett reservoir is of excellent quality, well-calibrated after 50 years of production, with excellent permeability and probable lateral excellent connectivity.
- NZT/NEP is discarding the Upper Bunter reservoir, that could be an upside, but absence of connection of this reservoir with Little Dotty field has not been assessed, as the integrity of the legacy wells tying this reservoir.
- NZT/NEP is estimating more conservatively the Lower Bunter capacity to 150 Mt vs 180 Mt by ENI.

4.0 Facilities

In the preliminary phases of the project to convert Hewett field into a CO2 sequestration site, different options have been considered and they included also the possibilities to utilize the existing wells.

In order to process and inject gas into the Hewett Reservoir a four-leg unmanned platform, four wells single completion type and one slot spare are considered.

Reusing or side-tracking the existing wells has also been considered in the first instance but has been rejected as it showed elevated risk mainly related to well integrity issues but also to directional plan limitation.

The current well integrity status has been verified and found in poor condition both for casing condition and for cement reliability in respect of newest CO2 reservoir fluid.

The following ENI studies are included in the attachments (0):

HEWETT PLATFORM TOPSIDE FACILITIES FLOW ASSURANCE_STRUCTURES STUDY_REV.01BIS

HEWETT GAS FIELD CONVERSION INTO CCS - DC FEASIBILITY STUDY

COAPESA-P-1-P-28046 WELL DESIGN

HEWETT GAS FIELD CONVERSION INTO CCS - DC FEASIBILITY STUDY

COAPESA-P-1-P-28047 TIME-COST

The NZT/NEP project has elaborated the following study and drawn the following conclusions in term of cost estimate:

The facilities for the Hewett development were estimated to be £490 MM more than the Endurance development. This is mainly due to:

More complex facilities resulting in a 1900 te heavier NUI for Hewett compared to Endurance

The pipeline is 144km longer from Teesside to Hewett compared to Teesside to Endurance with an additional 7 pipeline crossings.

Additional compression power and compression stages (220 barg vs 150 barg) to enable transport of the CO2 over longer distances.

The key differences in the facilities between Endurance and NUI are described below:

The Endurance NUI is a much simpler injection facility with a ca 2425 te topside weight.

It has a much simpler functionality compared to the heating demand required to inject into the Hewett store.

On arrival on the NUI at ca 110 barg the CO_2 stream passes through filters to remove any particulates to prevent plugging of the reservoir. From these it is routed to the wells through a common manifold with individual flowline offtakes that include flow metering for reservoir monitoring, a flow/backpressure control valve, MEG injection connection and wash water connection.

Water washing of wells will be undertaken on a periodic basis to mitigate against halite precipitation. Wells will be washed one at a time and the operation will be remotely managed from the onshore Compression Plant.

MEG will be located offshore for hydrate management. Use of this is expected only during well washing to provide a barrier between CO_2 and the wash water in the well bore.

The NUI will import power through a cable routed with the pipeline which will also provide control and monitoring capability. At this stage a robust utilities support has been defined including an instrument air system, crane, nitrogen quads, vent (no flare required) and a Temporary Refuge. As a project given was no fossil fuel power generation offshore no back up diesel generator is provided (UPS batteries only) and the crane is defined as electric driven.

A laydown area requirement to support maintenance activities and well workovers has been included. As the maintenance philosophy will be for 4 visits per year using ‘walk-to-work’ capability only no heli-deck is included.

The functionality of the Hewett platform is more complex resulting in a ca 4422 tonne NUI.

The functionality of the Hewett NUI differs from Endurance due to the nature of the reservoir; being a depleted hydrocarbon reservoir (low pressure) as opposed to an aquifer reservoir (high pressure).

As with Endurance, on arrival on the NUI the CO_2 stream passes through filters to remove any particulates to prevent plugging of the reservoir. From these it is passed through heaters where the stream is heated to approximately 70°C before being routed to the wells through a common manifold with individual flowline offtakes that include flow metering for reservoir monitoring, a flow/backpressure control valve, MEG injection connection.

The Hewett reservoir will not require any pressure management by producing the brine. As such no brine handling or wash water facilities are required.

MEG will be located offshore for hydrate management. It is not expected during normal operation but may be required on failure to maintain injection temperatures.

The support utilities included for Hewett in the concept phase are considered robust with a similar selection as for Endurance. The main difference being the heaters are assumed to be electric (no offshore power generation or waste heat available) and therefore have a peak demand of 20 MW per 2 Mtpa injection rate. The Hewett concept (Concept 1B) has a final injection rate of 6 Mtpa therefore power demand for heating is estimated at 60 MW.

Heating of the CO2 stream is required to prevent below 0°C operation anywhere in the system through to the reservoir to prevent potential freezing and plugging. Figure 8 shows several temperatures versus pressure profiles in the wellbore (flowing at the maximum 1.5 Mtpa) superimposed on the phase envelope of the injection stream.

With arrival pressure upstream of the well choke of 100 barg the lowest CO2 operational temperature will be 4°C, set by the lowest seabed temperature. With no heating the top-hole pressure required is approximately 18 barg. This results in a fluid temperature of -26°C. As the fluid travels down the wellbore it gains in pressure, due to static head, and temperature, due to surrounding inflow.

Any upstream temperature below 60°C would result in the top-hole conditions entering the 2-phase region of the phase envelope and still experience temperatures below 0°C at the interface with the reservoir. A minimum of 65°C is required upstream of the choke to ensure acceptable temperatures. Therefore, Hewett has been sized to provide 70°C to allow for operational margins.

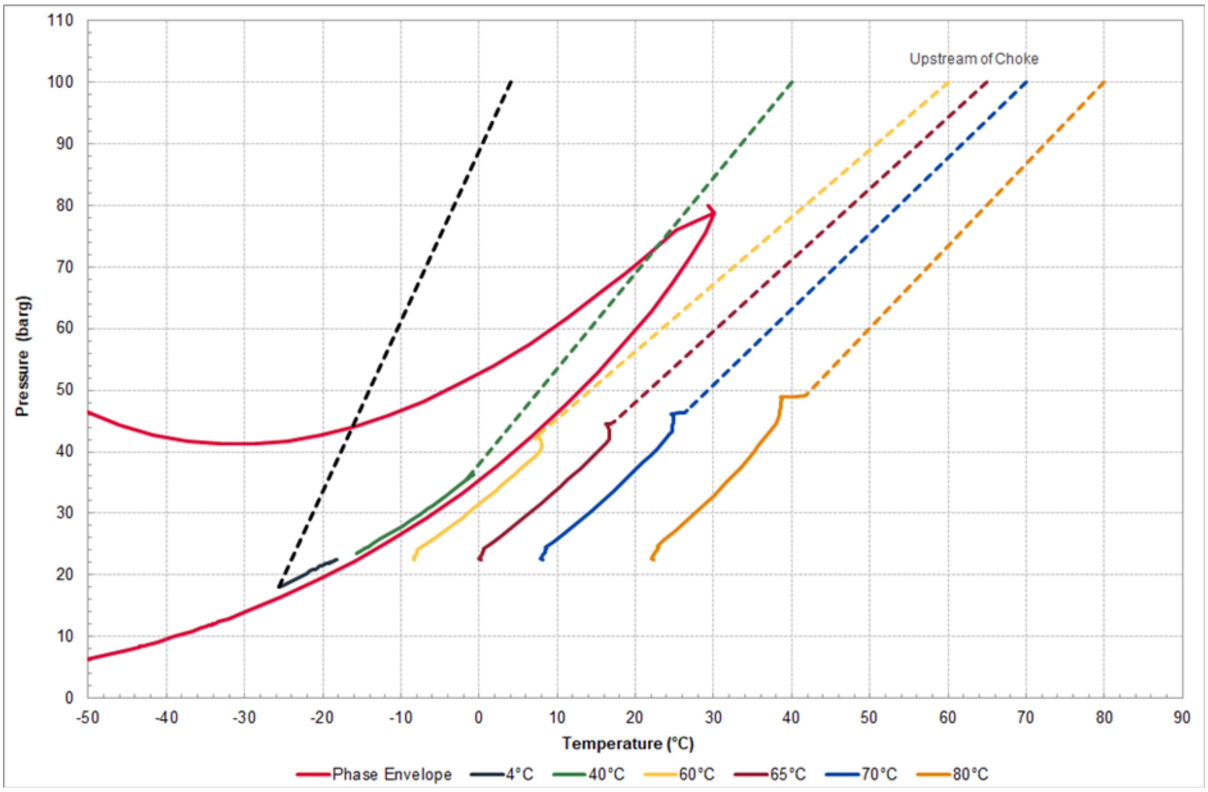


Figure 2 - Wellbore temperatures vs pressure profiles

It was considered not practical to transmit 60 MW of power demand 290 km from the Compression Plant. Therefore, it was assumed this power would be sourced from the closest practical tie-in point. This was determined to be the Salle sub-station (for the Sheringham Shoal windfarm) in East Anglia.

Costs for this option therefore included for a power cable run of 30 km onshore and 30 km offshore with a dedicated shore crossing. At this stage there was no confirmation that the required power demand could be sourced from the Salle sub-station or that the National Grid electrical system has sufficient capacity but was considered feasible and identified as a critical risk for this concept.

Monitoring and control of the NUI would be as per the Endurance concepts, with a cable from the Compression Plant following the pipeline route.

Annex A – Attachments (See attachments tab)

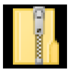
NS051-PR-TEC-040-00004 - Generic Depleted Reservoir Study

NS051-PR-TEC-040-
00004 B01 Generic D

NS051-RE-STU-434-00001 - Integrated Reservoir Study Report with Preliminary Screening CO2

NS051-RE-STU-434-
00001-B01-Hewett-I

NS051-RE-STU-434-00002-B01-Hewett-D&C Feasibility Study



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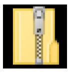
00002-B01-Hewett-D

NS051-RE-STU-434-00003-B01-Flow Assurance Topside Facilities & Structures



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Global Projects Organization

Global Concept Development

Generic Depleted Reservoir Study

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TECHNICAL NOTE

Generic Depleted Reservoir Study

Prepared for: OGCI-CI / BP

Prepared by: Genesis
1 St Paul's Churchyard
London EC4M 8AP
Tel: +44 [0]20 7585 5555
Fax: +44 [0]20 7585 5550
www.genesisoilandgas.com

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GENESIS
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Contents

Figures & Tables

Figures

ABBREVIATIONS

CCS	Carbon Capture & Storage
CO_2	Carbon Dioxide
FEED	Front End Engineering Definition
J-T	Joule Thomson
MTPA	Million Tonnes Per Annum
MW	Megawatt
NUI	Normally Unattended Installation
P/T	Pressure / Temperature
SSI	(Ex) Steel works site

HOLDS LIST

HOLD	SECTION	DESCRIPTION

REVISION HISTORY

REV	SECTION	DESCRIPTION
B1	Throughout	Report updated to incorporate client comments throughout the document.

1.0 INTRODUCTION

1.1 Overview

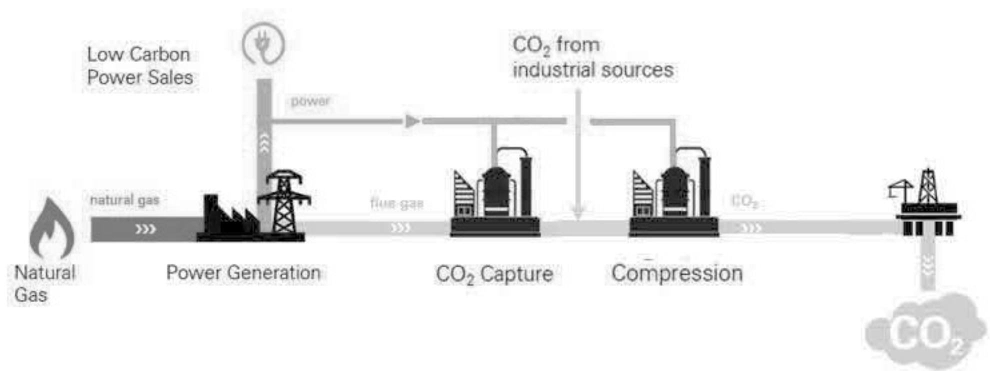
Oil and Gas Climate Initiative Climate Investments (OGCI CI) is proposing a Power and Industrial CCS value chain consisting of a gas-fired combined cycle power station with post-combustion carbon dioxide capture, a gathering system collecting carbon dioxide from the power station and other industrial emitters in the locale, a carbon dioxide compression station, a transportation pipeline and sequestration by injection into an offshore geological formation.

The proposed location of the new compression plant is close to the coast in Redcar in the north east of England on the site of a decommissioned steel works (SSI). The foundation supplier to the CCS system will be a new power station built adjacent to the compression plant (as part of the overall clean power project) and will provide a base load of 2 MTPA of CO_2 for sequestering. The capacity of the compression plant and transport system to the injection wells will be designed to permit expansion up to 10 MTPA to allow for the inclusion of future additional industrial emitters.

The 'upstream' scope of this project covers the power station and CO_2 gathering system. The gathering network will collect carbon dioxide emitted by a range of other industries in Teesside for transfer to the Compression Plant (start of the 'downstream' scope of the project). The Compression Plant, comprising metering, dehydration and compression will then forward the dense phase CO_2 via a dedicated shore crossing and subsea pipeline to an offshore facility (NUI) for sequestration into the Endurance aquifer located approximately 144 km from Redcar.

Figure 1-1 summarises the scope of the overall project.

Figure 1-1 Schematic of the Overall Clean Gas Project



The Endurance reservoir is an aquifer type reservoir, that is, it is at relatively high pressure, with an initial pressure of 140 barg increasing to 200 barg as CO_2 is injected over a period of time. There is a risk that this reservoir may not be able to sequester the long-term volumes envisaged under this project. As an insurance for this risk, a 'Tee' has been included into the subsea pipeline near to the NUI at Endurance to allow for installing additional pipeline to re-route the injection stream to an alternate reservoir. For this project the alternate has been identified as the Hewett reservoir. This is a depleted hydrocarbon reservoir with an initial pressure of approximately 2.5 barg.

1.2 Study Scope

The Clean Gas Pre-FEED project is based on supercritical CO_2 injection into the endurance field. The selection of this field was largely due to its proximity to the source at Teesside as well as a higher initial reservoir pressure. The higher reservoir pressure means that there is less pressure drop that occurs across the choke valves as the CO_2 injection occurs which results in a lower degree of cooling as the gas expands (limits the JT cooling effect). It is recognised however, that if the Clean Gas Project is to be replicated or expanded elsewhere, a suitable aquifer type reservoir may not be readily available. Additionally, if an existing depleted gas reservoir can be used, there are many obvious synergies that can be realised, these include potential re-use of existing pipelines, offshore facilities and possibly even wells. As such this study has been conducted to look at identifying the challenges associated with injecting CO_2 into Hewett.

The early concept work identified one of the major challenges of the Hewett reservoir is overcoming the pressure drop/cooling associated with injecting into a lower pressure reservoir. The facilities required to inject the CO_2 volumes, under the Clean Gas Project, into the depleted Hewett reservoir were quantified as part of the concept phase [Ref. 1] resulting in an estimated 10 MW per 1 MTPA heating duty required at start of field life. This report will study the heating requirements in greater detail with a view to assess heat loads for a generic depleted reservoir.

1.3 Pre-FEED Flow Assurance Analysis

As part of the Clean Gas Pre-FEED flow assurance scope the extent of heating required to inject CO_2 into the Hewett wells was investigated. The analysis determined that for initial temperatures less than 60°C (equivalent to 6 MW/MTPA) the CO_2 remains in the two phase region as it expands into the wellbore [Ref. 3]. This means that 6 MW/MTPA represents a minimum heating load, below which all the energy is consumed by phase change and has minimum impact on the bottom hole temperature.

In order to stay above 0°C after expansion to 2.5 barg in addition to operating the supply pipeline in the dense phase, it was concluded that the temperature upstream of the chokes needs to be greater than 70°C which results in a heating duty of 7.4 MW/MTPA for min arrival temperatures.

2.0 BASIS AND METHODOLOGY

2.1 Pipeline and Reservoir Operating Pressure

Typically CO_2 is transported in the dense phase for sequestration as this reduces the pipeline line size and minimises dynamic pressure losses. The flow assurance performed for the Clean Gas Project is based on a minimum arrival pressure of 100 barg at the injection facility, providing a 20 bar margin above the critical pressure.

This means that when the CO_2 arrives at an injection well associated with a low pressure reservoir, the CO_2 will expand across the choke valve and experience substantial temperature drop in the process. This study will consider reservoir pressures as low as 2.5 barg, which is the value reported for the Hewett field.

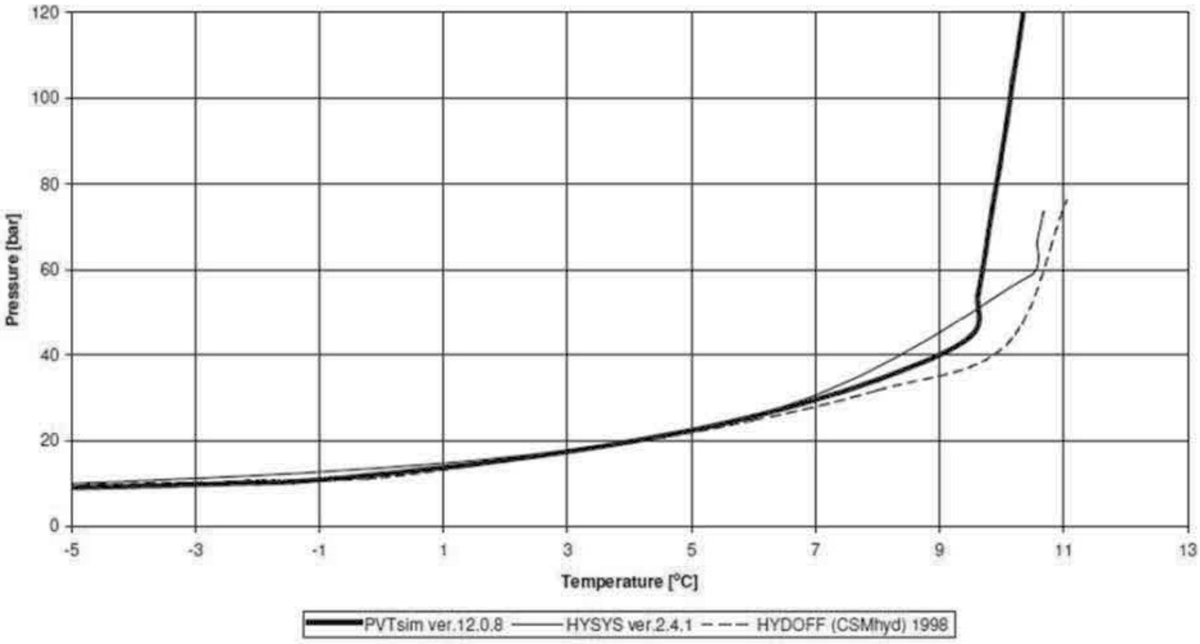
2.2 Temperature Constraints

The concern with low pressure reservoirs (as opposed to aquifers) is the associated J-T cooling of the injection stream resulting in very cold temperatures in the wellbore / annulus and/or reservoir. The concerns of low temperature operation include:

- Risk of water freezing leading to damage to the well and or reservoir.
- Loss of reservoir permeability and injectivity due to plugging from ice and or hydrate formation.
- Need for more exotic and expensive materials to avoid brittle fracture at low temperatures.

In order to avoid these concerns the CO_2 is heated upstream of the choke valves such that when injected into the well/reservoir the temperature does not drop below 0°C . Consideration should also to be given to hydrate formation curve when looking at flowpaths. Figure 3-3 shows the hydrate curve for pure CO_2 in salt free water and can be used as a guide.

Figure 2-1 Hydrate Formation Curve for Pure CO_2 using Different Prediction Methods



2.3 Simulation

HYSYS V10 in conjunction with the GERG 2008 fluid package was used to model the CO_2 stream fluid properties and heating requirements. This is the same simulator and fluid package used for the Pre-FEED H&MB generation.

The assessment in this report is based on the rich composition, refer to the Fluid Characterisation Report [Ref. 2] for details. It should be noted that the difference between the rich and lean case molecular weights is less than 1% so the results differ only to a small degree.

2.4 Assumptions

Assumptions used to quantify heating duty and pressures in this study are:

- No heat inflow from the surroundings is included (including geothermal gradient through the rock on the way to the reservoir). This will inherently result in a more conservative result and higher estimate the heat load required.
- Pressure loss across formation is 20 bar for 1.5 MPTA, based on the results of the Pre-FEED flow assurance work. [Ref. 3]

2.5 Flowrates

The analysis will be building off previous work performed on a 1.5 MPTA flowrate per well, however as heat transfer is not being considered, the heating loads will simply be reported on a per MTPA basis.

3.0 TECHNICAL ASSESSMENT

3.1 Dense Phase Operation

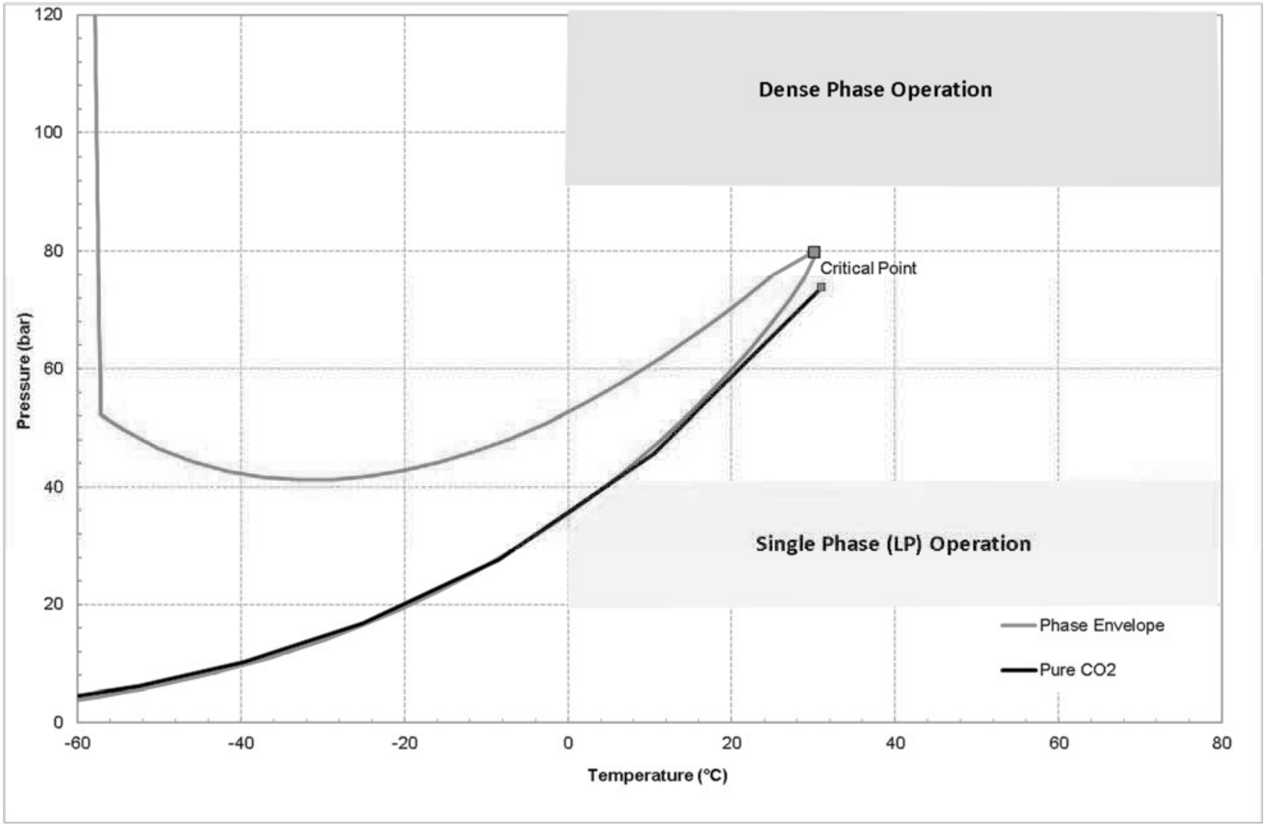
From work completed in the concept phase of this project [Ref. 1] transport of CO_2 for sequestration into a reservoir in the North Sea is expected to be in the dense phase. This offers the advantage of allowing an expanded operating envelope without excessive pipeline diameter and / or offshore booster compression / pumping.

Low pressure, gas phase, operation is possible, but this results in a limited operating window (typically with a maximum arrival pressure of 30 barg and discharge approximately 40 barg) and large diameter pipelines for expected flowrates of CO_2. It may be suitable for specific depleted reservoirs at the start of injection but is likely to be limited by top-hole pressure requirements as the reservoir pressure increases.

Two-phase flow is not considered practical given the requirement for offshore slug / surge management.

Figure 3-1 shows the phase transition line for pure CO_2 and the phase envelope for the 96% (rich) CO_2 composition from the project [Ref. 2].

Figure 3-1 Nominal Pipeline Operating Envelopes



Low pressure operation is restricted to nominally 40 barg to prevent possible two-phase conditions in the pipeline during shutdown or settle out conditions (increased pressure at the injection point and seabed temperatures of 4°C (for the North Sea)).

Dense phase operation will maintain a minimum pressure in the pipeline to prevent conditions that could allow two-phase conditions during a shut down, settle out and cooldown in the pipeline. Typically, a minimum pressure of 90-100 barg would be specified at the injection point to ensure dense phase conditions under all expected operating or shut-in scenarios with margin to account for transient conditions.

3.2 Injection Profile

3.2.1 Injection Flowpath

Figure 3-2 shows the expected arrangement for a typical CO_2 injection well, for a depleted gas reservoir on an offshore facility. Given North Sea conditions the arrival temperature will be a minimum of 4°C (1). The stream is heated (2) and then injected into a well (3). Assuming a low-pressure reservoir, as the stream passes down the well it may cross the phase boundary (4) and then reach bottom hole conditions (5). Finally, the injection stream passes through the near well sand face to reach bulk reservoir pressure (6).

Figure 3-2 Topsides Injection Stream Flowpath Schematic

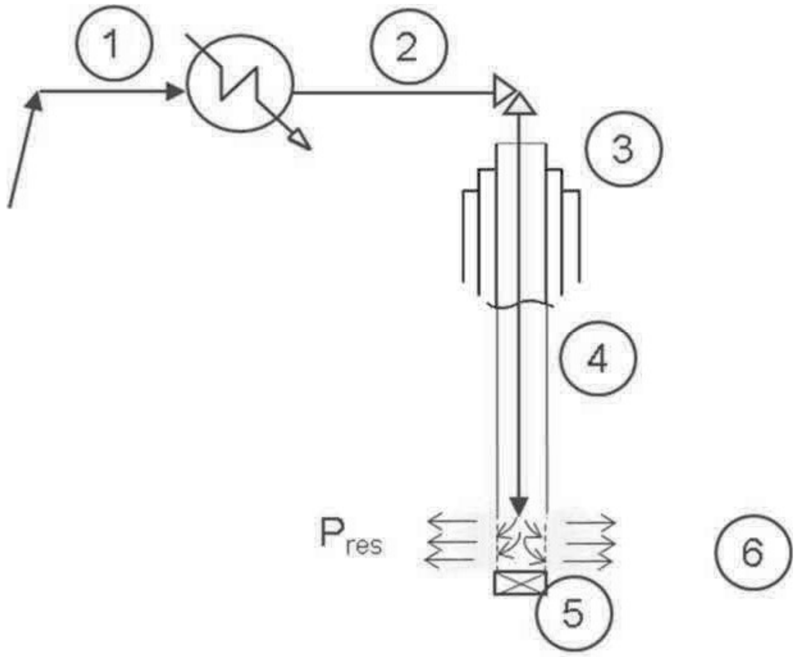


Figure 3-3 shows this injection stream flowpath on a P/T diagram which includes the phase envelope for i) pure CO_2 and ii) 96% CO_2 (rich Ref. 2). Figure 3-3 shows several heating scenario flowpaths assuming an reservoir pressure as per Hewett (2.5 barg).

Arrival conditions upstream of the heater (i.e. onto the offshore platform) is 100 barg (specified to maintain dense phase in the pipeline under all expected scenarios and aligned with the Clean Gas Project specification) and at 4°C, seabed minimum temperature.

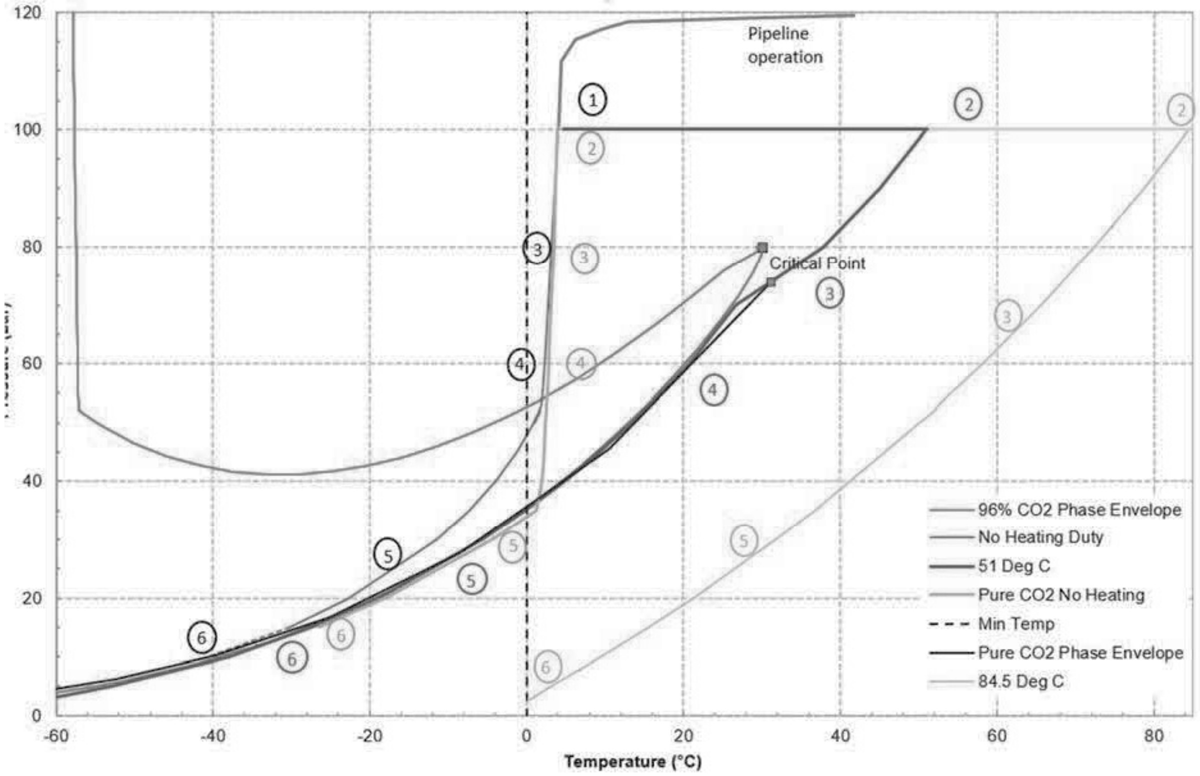
Three heating scenarios are shown:

1) No heating (for 96% CO_2 composition shown in blue and for pure CO_2 show in orange)

2) Heating to 51°C (6 MW per MTPA) (flowpath shown in purple for 96% CO_2 composition)
3) Heating to 84.5°C (8.5 MW per MTPA), which corresponds to the minimum temperature required to stay above 0°C when expanding to reservoir pressure (flowpath shown in green for 96% CO_2 composition).

Unless otherwise stated then the flowpaths below are for 96% CO_2 composition.

Figure 3-3 Injection Flowpath Against Phase Envelope



3.2.2 No Heating Scenarios

With conditions upstream of the well choke at 100 barg and 4°C some pressure loss occurs across the choke valve to the top of the wellbore. As the stream is in dense phase / liquid phase the J-T cooling effect is small such that the stream temperature will be above 0°C. If the pressure in the reservoir is low enough then at some point in the wellbore the fluid will cross the phase boundary. At this point the generation of a vapour phase results in significant evaporative cooling such that only a few bar pressure drop can be tolerated before the 0°C minimum allowed temperature is breached.

For the pure CO_2 and no heat input, to maintain the temperature above 0°C the reservoir would have to be a minimum pressure of approximately 33 barg (where the phase transition is for 0°C). For the 96% CO_2 composition the bubble point (liquid side) of the phase envelope is entered at a higher pressure; 52 barg. At this pressure the stream temperature is approximately 2°C therefore only a further 2 barg pressure drop can be allowed before the minimum temperature limit is breached. Therefore, for this composition a minimum reservoir pressure of 50 barg would be required.

3.2.3 Heating Scenarios

Heating the injection stream to 51°C, equivalent of a heat input of 6 MW per 1 MTPA, allows more pressure drop, hence a lower reservoir pressure, before the minimum temperature is breached. The J-T effect in the wellbore is more pronounced due to the injection stream becoming initially being a vapour phase. In this scenario the stream crosses the phase boundary on the vapour, or dewpoint, side of the phase envelope. Once crossed the fluid follows the phase envelope / phase transition line. A minimum reservoir pressure of approximately 35 barg is required to prevent the minimum temperature limit being breached. This is independent of the composition of the stream.

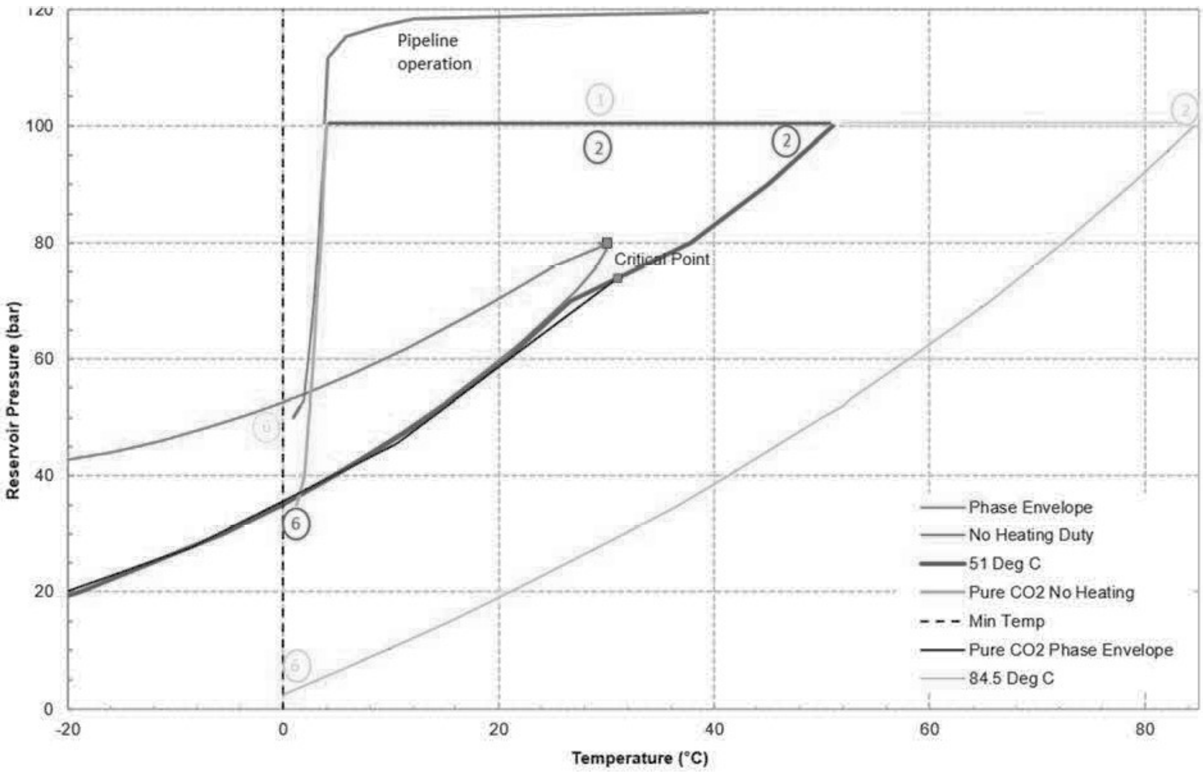
If heated to 84.5°C, equivalent of 8.5 MW per 1 MTPA, the conditions at the top of the wellbore is sufficiently far enough away from the phase envelope that the J-T effect does not result in the phase envelope / phase transition being crossed. In this case the reservoir pressure can be as low as approximately 2.5 barg, matching the Hewett field, before the minimum temperature limit is breached.

Therefore, the addition of 6 MW per MTPA heat input allows the reservoir pressure to be reduced from 50 barg (no heating) to 35 barg. A further 2.5 MW / MTPA allows the reservoir pressure to be reduced to 2.5 barg.

3.3 Reservoir Pressure and Heating Duty

Figure 3-4 also shows the minimum reservoir pressure required to maintain above 0°C operation for the different compositions considered.

Figure 3-4 Minimum Reservoir Pressure



Without any heating the reservoir pressure must be approximately equal to the phase transition pressure at 0°C. With little margin between minimum seabed temperature and freezing point then any pressure lower than this results in liquid formation causing temperature loss. The less pure the CO_2 stream (i.e. the more lighter components in the stream) the higher the pressure required to prevent entering the two-phase region of the phase envelope.

The addition of heating helps reduce the minimum reservoir pressure but there is little benefit in lowering the acceptable reservoir pressure until the temperature of the injection stream is sufficiently high enough to avoid the two-phase region and inject only as gas phase.

The amount of heating required to ensure the injection stream is maintained above 0°C at all conditions through to the bulk reservoir pressure (assuming no heat input from the surroundings) is shown in Figure 3-5. The heating duties in MW/MTPA are shown for pure CO_2, 98% CO_2 and 96% CO_2 (the latter two being the range for the Clean Gas Project composition) [Ref. 2].

Figure 3-5 Reservoir Pressure v Heating Duty

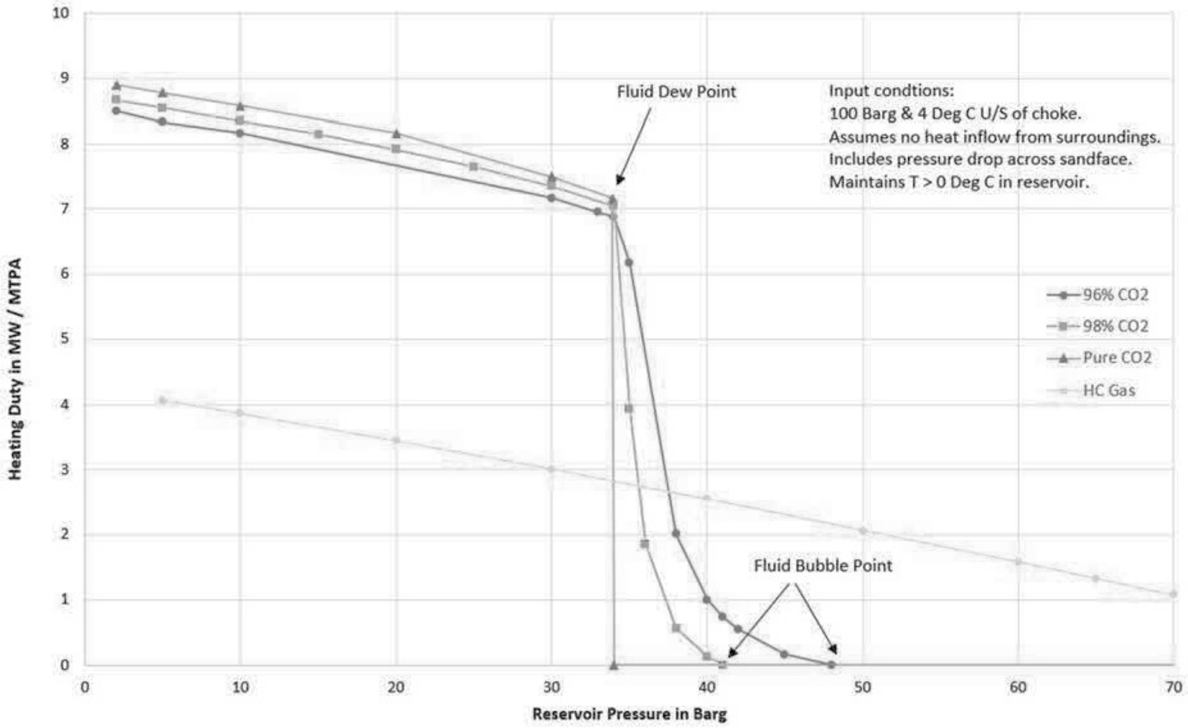


Figure 3-5 shows that for pure CO_2 no heat input is required until the reservoir pressure is below the phase transition pressure of 33 barg. Once this is reached then the bulk of the heating (approximately 7 out of 8.5 MW/MTPA) is required to provide the latent heat required for phase change. At lower reservoir pressures the heating duty increases due to the J-T effect of the gas phase. At 2.5 barg reservoir pressure 8.5 MW/MPTA of heating is required.

The compositions with 98% and 96% CO_2 require the start of heat input at higher reservoir pressures as their phase envelopes are entered. The lower the purity of CO_2 the wider the phase envelope and therefore the higher the pressure at which heat input will be required. For the 98% and 96% CO_2 streams the heat duty increases as the reservoir pressure decreases until approximately matching the pure CO_2 duty at 33 barg (approximately 7 MW). As with the pure CO_2 composition, at lower reservoir pressures the increase in duty is due to the J-T effect of the vapour.

All the data presented above considers the minimum seabed temperature of 4°C. For summer conditions, with a maximum sea bed temperature of 17°C, the heating loads presented are reduced by approximately 2 MW / MTPA.

4.0 CONCLUSION

For transport reasons, CO_2 is commonly delivered to any injection facility at supercritical conditions (pressures greater than 80 barg). This means that if the CO_2 is injected into a low-pressure reservoir, it will be subject to significant expansion cooling. Temperatures below 0°C are not advised due the risk of freezing water in the well annulus, and potentially degrading reservoir injectability due to ice and or hydrate accumulation.

The proposed solution to the issue of CO_2 expansion cooling is to pre-heat the CO_2 upstream of the wellhead. In order to be effective, any pre-heating must be sufficient to avoid the two-phase region of the injection stream during expansion, as the substantial latent heat will ensure that temperatures rapidly drop below zero.

This means that for reservoir pressures below the dewpoint of CO_2 (35-45) barg at ambient conditions the injection gas must be heated to at least 70°C, and even higher as the reservoir pressure approaches 0 barg. The heating duty associated with this is substantial and is the range of 7-9 MW/MTPA for minimum sea bed temperatures (4°C), reducing to 5-7 MW/MTPA for summer conditions (17°C).

These values are approximately double the energy required to compress the CO_2 from 20 barg to 150 barg at the onshore compression facility. If the injection wells could be located adjacent to the compression facility, the heat of compression from the final stage would likely avoid the need for heaters. However, placing compression offshore would not be cost effective and locating injection wells onshore introduces potential safety concerns that have not yet been assessed.

5.0 REFERENCES

Number	Description
Ref. 1	NS051-PM-REP-040-00004 B01, 'Concept Select Report'
Ref. 2	NS051-PR-REP-040-00001 B01, 'CO2 Characterisation Report'
Ref .3	NS051-PL-STU-040-00001 B01, 'Pipeline Sizing, Flow Assurance and Operability Study'

Hewett Integrated Reservoir Study

Applicability:	Net Zero Teesside
Approver:	Project Director
Approval Date:	
Author:	Eni
Checker:	Subsurface Lead
Security Classification:	General
GPO Document Number:	NS051-RE-STU-434-00001 B01
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Third Party Document Number:	00
Third Party Revision	

Revision history

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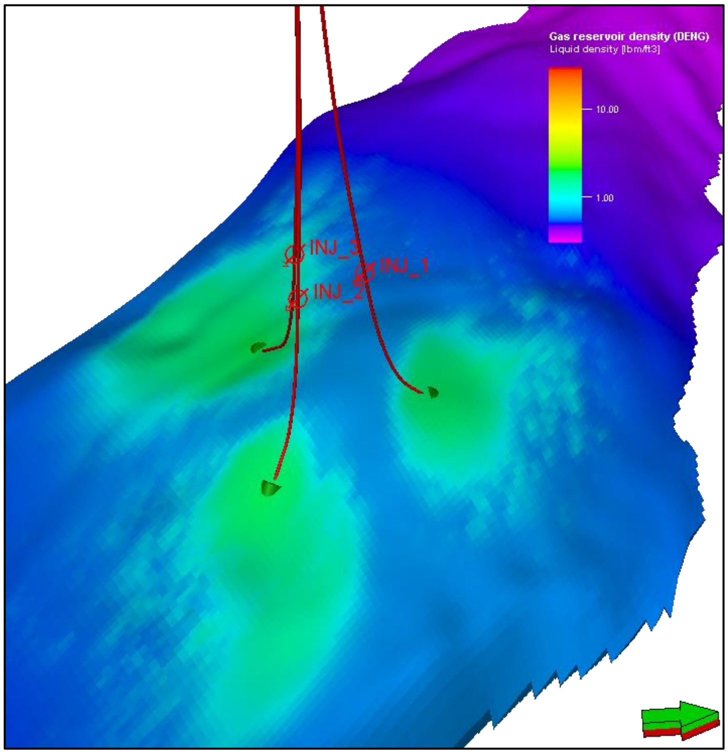
B01	Issued for Use	Eni	Subsurface		P.Director	

UK - Hewett

Hewett CCS
Integrated Reservoir Study

EORG-GEOLAB September 2019



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Carbon Capture and Storage (CCS) Hewett Integrated Reservoir Study

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Hewett has been selected by OGCI-CI as one of the candidates for CCS (Carbon Capture and Storage) of the CO_2 produced by Teesside industrials (East UK coast) in the Clean Gas Project (CGP) framework.

Hewett is an off-shore depleted gas field on production since 1968 (Lower Bunter Sandstone reservoir) and 1973 (Upper Bunter Sandstone reservoir). The field has produced 3.31 Tscf @feb-2019.
Integrated Reservoir Study together with Geochemical and Geomechanical preliminary assessments confirmed the suitable characteristics of the field as a CO_2 storage site.
Field capacity has been evaluated in 180 MMton for Lower Bunter level while Upper Bunter could be considered as an upside level with a capacity estimated in about 100 MMton.

The development scenario foresees the injection of 16500 ton/d (equivalent to 6 MMton/y), by 3 wells for a period of 30 years.

AUTHORS

EORG: Atena R., Biason E., Brignoli M., Depalo S., Facchi G.L.D.
GEOLAB: Geloni C., Ricci S.

Date: September 30th 2019

		M. De Simoni	G. Crema
		P. Cibin	S. Scagliotti
			REIT Il Responsabile Ing. G. Crema
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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

1. EXECUTIVE MANAGEMENT SUMMARY

INTRODUCTION & STUDY OBJECTIVE

Oil&Gas Climate Initiative (OGCI) by its Climate Investment branch with the Clean Gas Project (CGP) is evaluating the suitable reservoir candidates to capture and storage by injecting for 30 years about 6 Mte/y CO_2 emissions produced by the Teesside industrial area.

The aim of this study is to evaluate Hewett field CO_2 storage suitability for Carbon Capture and Storage (CCS) project.

Hewett is a depleted off-shore gas field located in the United Kingdom's Southern North Sea (120 ft water depth).
It was discovered by well 48/29-1 (Arpet in 1966) and well 52/5-1 (Phillips) and was then developed by a total of 35 wells through 3 production platforms (**Errore. L'origine riferimento non è stata trovata.**).

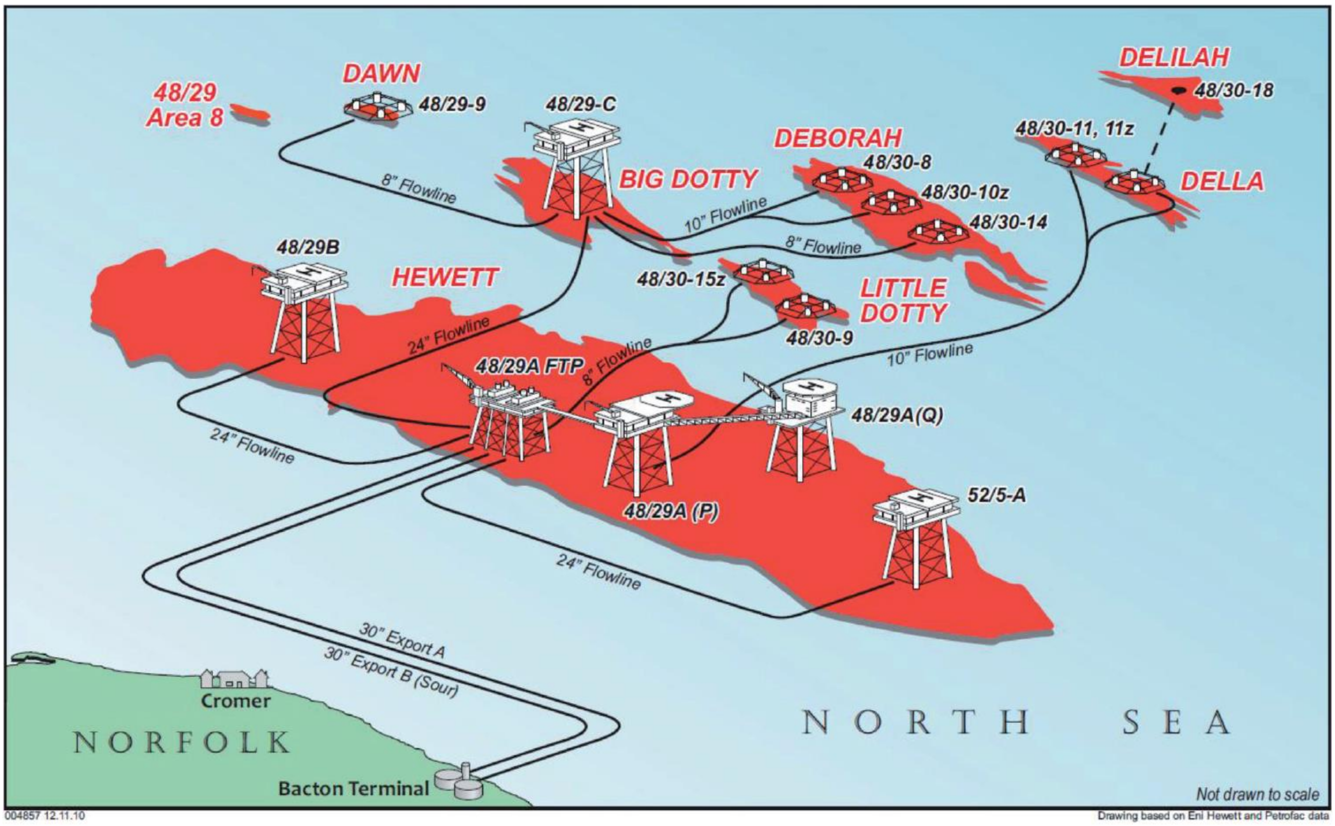

Figure 1-1: Hewett field - Platforms scheme.

CONCLUSIONS AND RECOMMENDATIONS

The Integrated Reservoir Study, including Geomechanical and Geochemical assessments, proved Hewett field as a suitable CO_2 reservoir storage candidate for Carbon Capture and Storage CGP project thanks to:

- storage capacity (280 MMton)
- verified containment thanks to the presence of a thick and continuous seal of the cap rock
- well gas injectivity thanks to its high quality and homogeneous petrophysical sandstones characteristics.
- geochemical favorable conditions (no evidence of solids precipitations)
- fluid dynamic suitable CO_2 injection (depleted gas reservoir)

Hewett main storage reservoir consists of the Lower Bunter sands (mean porosity of 21% and average permeability 1300 mD with 750 ft of seal). A second potential storage candidate is the Upper Bunter reservoir (same excellent properties and 1400 ft of seal).

Geomechanical preliminary assessment ensure that cap rock integrity is not affected by the CO_2 injection process.

Major lateral faults are sealing and isolate Hewett from the surrounding fields while internal faults, where present, do not compromise the containment in the whole area.

The development scenario foresees the injection of 16500 ton/d (equivalent to 6 MMton/y), by 3 wells for a period of 30 years.

To strengthen the geomechanical assessment due to paucity of direct stress measurements on existing wells, a data acquisition plan is highly recommended.

2. GENERAL INFORMATION AND FIELD HISTORY

Hewett is an offshore gas field located in the United Kingdom's Southern North Sea (120' water depth). It is located in Block 48/28, 48/29, 48/30, 52/4a, 52/5a (Figure 2-1).
This field has been discovered by Arpet in 1966 (well 48/29-1) and Phillips (well 52/5-1).
Eni was involved since the beginning of Exploration: in April 1969 an Unitization Agreement was signed (Field areas in Quad 48, 49, 52) and Phillips became the Operator while in 2001 with the LASMO take over, Eni increased the participating interest; after six years, in 2007, Perenco acquired the "Exxon-Mobil" interests and, one year later (2008), Eni UK completed the acquisition of a 51.69% equity interest and the operatorship of the Hewett Unit and the associated Bacton onshore gas processing terminal.

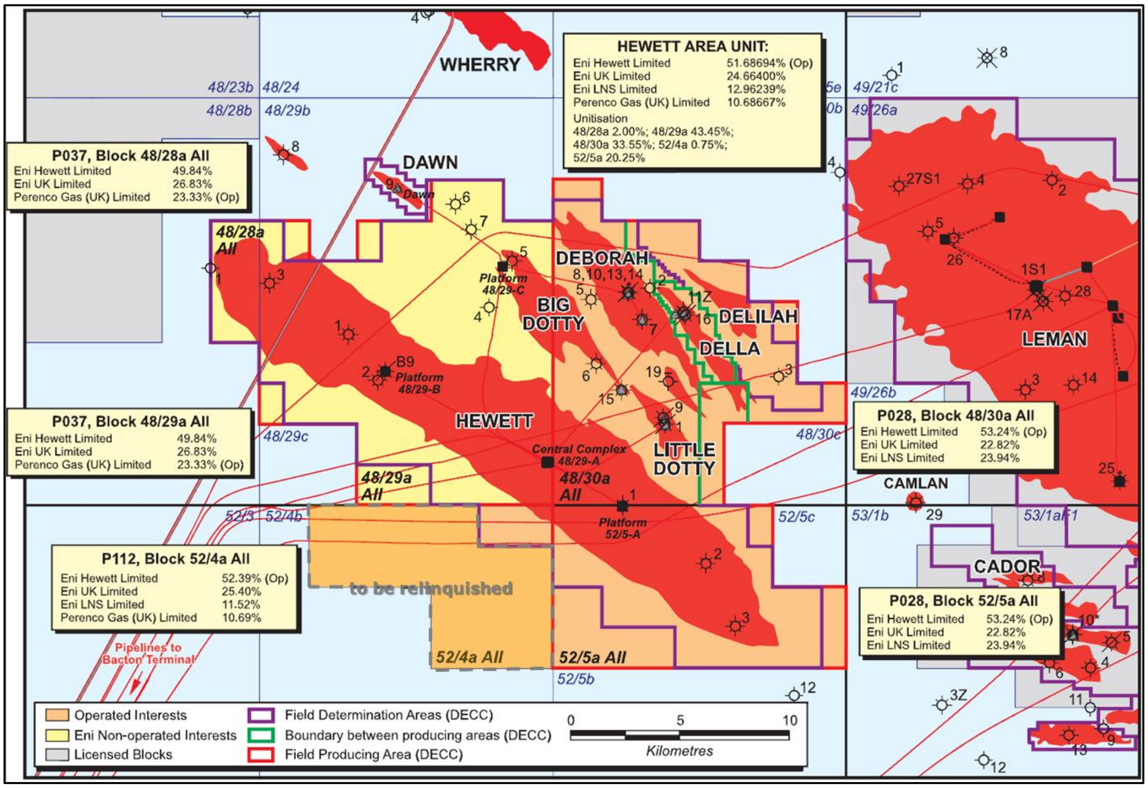

Figure 2-1: Hewett field location

Five others exploratory wells were perforated followed by 35 producers.
The two main reservoirs are the Lower Triassic Upper Bunter and Lower Bunter Sandstones, overlaid by a thick and continuous sequence of shale, inside a NW-SE elongated dome structure bounded by major sealing faults.
A minor accumulation is located into Zechstein Formation (Permian).
Lower (also known as Hewett Sandstones) and Upper Bunter Formations consist of good quality sandstones deposited in a deltaic fluvial environment while Zechstein Formation has carbonatic origins.
Production started in 1968 from the Lower Bunter and in 1973 from the Upper Bunter.
Estimated Original Gas in Place for the two main reservoirs is 3.7 Tcf (dry gas): in particular, Upper Bunter has an estimated HOIP equal to 1.32 Tcf (RF=90%) while Lower Bunter has an HOIP equal to 2.38 Tcf (RF=99%).

3. DATA GATHERING

A **3D seismic survey** (Survey PH943F0003) was acquired in 1994/1995 by PGS for Phillips Petroleum and was publicly available since 2000. It is a quality seismic up to 75 Hz and shows good tie with wells.
Since reservoir static and dynamic models were already in use and demonstrated to be a robust tool for reservoir management during the production life of the field, sesmic derived tops and faults used in the model were considered still valid (an example in Figure 3-1); therefore no seismic data review was performed.

Structural tops used in the model are:

- Triassic Sequence
- Upper Bunter Sandstones
- Zechstein

Stratigraphic tops encountered by wells ensured calibration and definition of structural tops that were not pickable from seismic (e.g.: Lower Bunter).

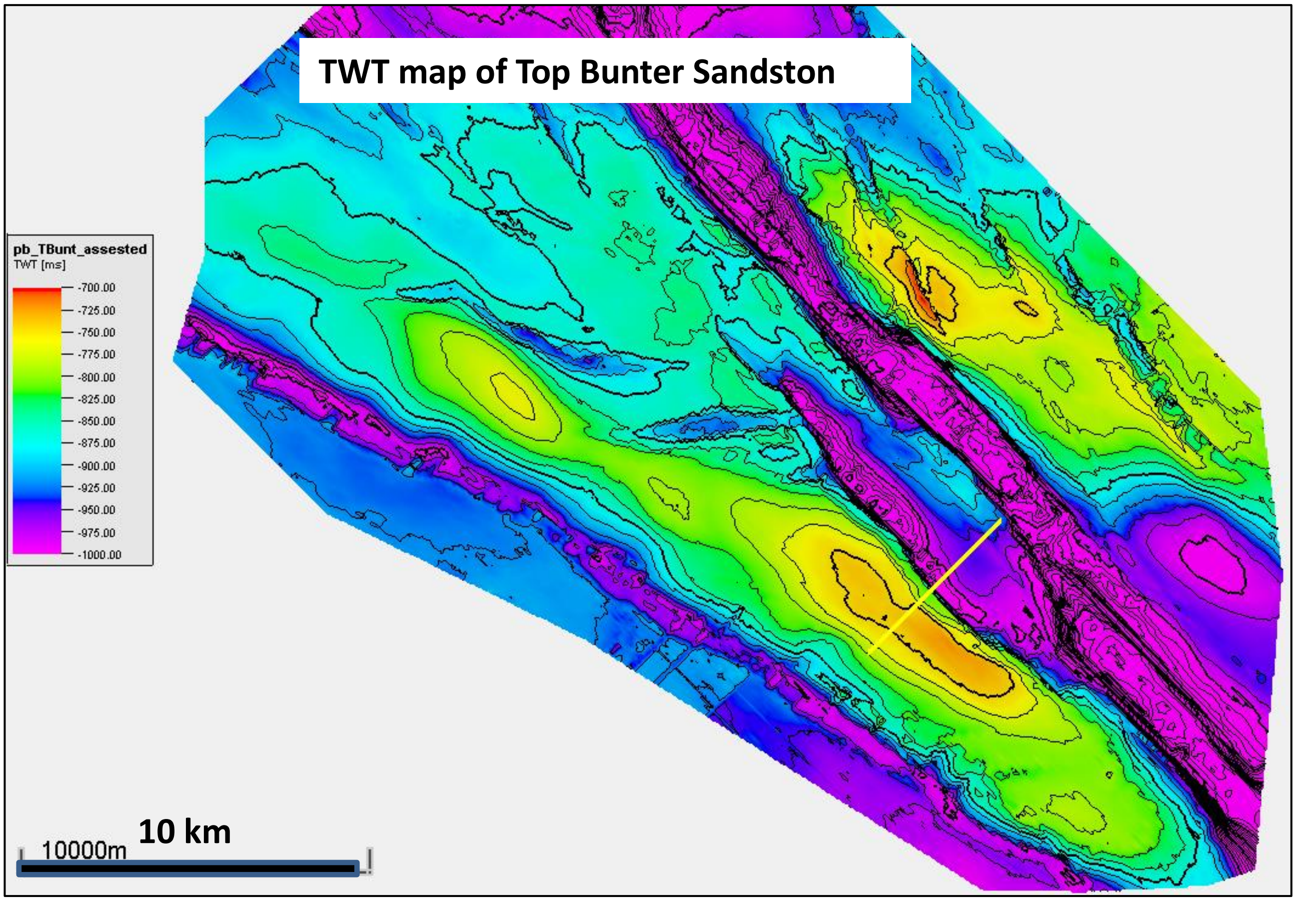

Figure 3-1: Seismic derived strctural top - Upper Bunter.

A complete **well log data set** was available for reservoir characterization, including CPIs for 22 wells.

In particular, log data available are (Figure 3-2):

- Caliper
- GR
- NPHI-RHOB
- Sonic
- Resistivity
- Porosity
- Shale Volume
- Water Saturation

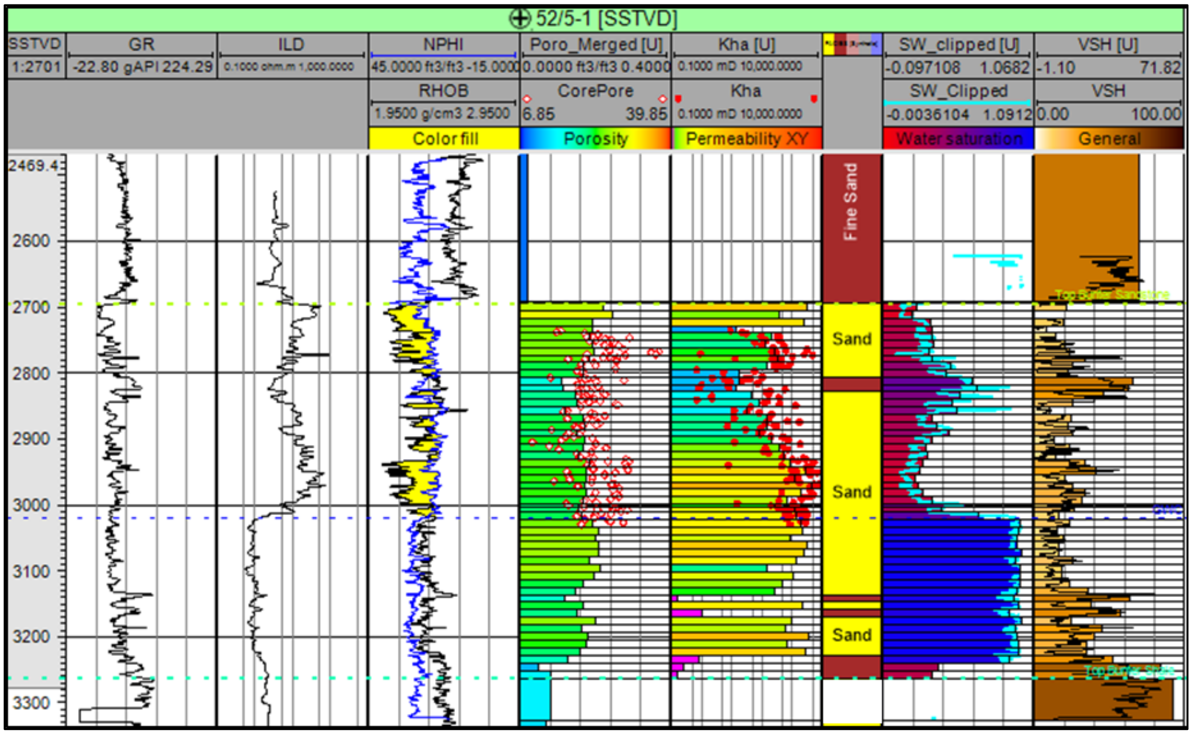

Figure 3-2: Available log dataset

Core data (core porosity and core permeability from RCA) are available for the following wells:

- 48/29a-A1
- 48/29-1
- 48/29-2
- 48/29-3
- 52/5-1
- 52/5-3
- 48/29-5
- 48/30-9

Examples of cores are shown in the following Figure 3-3 and Figure 3-4.

Figure 3-3: Well 48/29-A1, core 1, depth 2964 – 2970 ft (Upper Bunter interval).

Figure 3-4: Well 48/29-A1, core 8, depth 4249 – 4255 ft (Lower Bunter interval).

Available **Reservoir engineering Data** are fluids samples (recombined separator sample) from wells 48/29-A1 and 52/5a-A4. The water salinity and water composition have been retrieved from literature and previous reports.
Production data derive from OFM and previous operator's database.

4. GEOLOGICAL SETTING

The geological evolution of the Hewett area was characterized by several paleoenvironment.
The stratigraphic sequence is shown in Figure 4-1 and here below described.
In particular, in the Late Carboniferous coastal plain deposits developed to the northern part of the London–Brabant Massif (southwest of the Hewett Field): these sediments were deposited during a period of continuous conditions creating very thick coal-bearing sequences called the Rotliegendes Group. These sediments contain the source rock that generated the hydrocarbons found in all reservoirs in the Hewett area.
During the Permian period these Carboniferous rocks were uplifted and eroded.
Such conditions were brought to an abrupt end when the Rotliegendes basin was flooded by the Zechstein Sea: Zechstein base is well marked by the Kupferschiefer shale and this shale is overlain by four carbonate-evaporite sedimentary cycles of marine transgression followed by a regression.
The Rotliegendes and Zechsteinkalk formations are sealed by the overlying and adjacent Zechstein evaporites.
In the Triassic, the Bacton Group was deposited: it is made up of the Bunter Shale Formation and Bunter Sandstone Formation (Upper Bunter). The Bacton Group is a clastic succession deposited in a non-marine environment settled when the Permian Zechstein Sea withdrew.
Starting from the bottom, the Bunter Shale represents the base of the succession in the basin and embeds the Lower Bunter Sandstone (also known as the Hewett Sandstone): a clastic alluvial fan deposit described as a fine to coarse, well sorted quartzose sandstone with scattered pebbles and thin conglomerates with angular clasts of metamorphic rocks. It is a complex of fluvial, distal floodplain and playa lake clastic deposits with minor evaporates prograding eastwards and north eastwards into the Southern North Sea basin from the London-Brabant Platform.
The Lower Bunter formation is characterized by very fine sandstone at the top becoming medium sized and coarse at the base (it can contain anhydritic cement): its average thickness is 25m (85-90ft).

Upper Bunter Sandstones deposited over this succession and the top is defined by a sharp downward change from mudstones with dolomite and evaporate interbeds to a thick sandstone dominated sequence: this boundary is an interpreted angular unconformity at which beds within the formation are truncated and where overstep by the overlying Dowsing Dolomite Formation occurs. The environment of deposition is interpreted as an alluvial fan succession dissected by fluvial braided channels in a semi-arid climate: it was supposed that the distal deposits at the margins were probably formed by a series of coalescing alluvial fans intersected by braided rivers whereas the more proximal central deposits were lain down by sheet floods.

From Hewett wells correlations it is possible to observe the increasing thickness of the sandstone from the north of the field at 48/29-1 where the thickness is 270ft to the south of the field at 52/5-3 where the thickness reaches 700ft.

The Bacton Group extends from Hartlepool, NE England till the Central North Sea province, and it is continuous with that of the Eskdale and Sherwood Sandstone Groups onshore to the southwest. Bunter Shale Formation is made up by an anhydritic floodplain mudstone with interbedded siltstone and claystone with dolomite and sand stringers at the top (average thickness is 650ft).

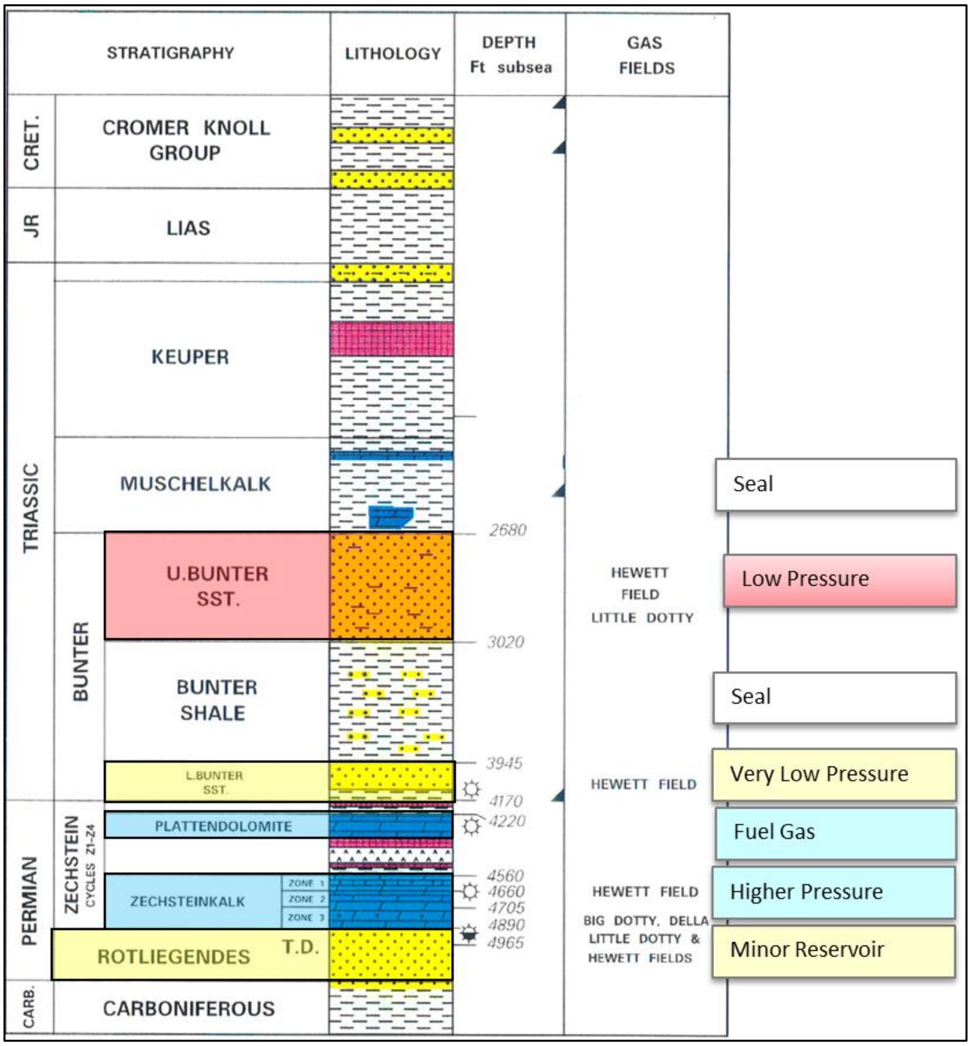

Figure 4-1: Hewett Stratigraphic Sequence

5. RESERVOIR MODELLING & SIMULATION

5.1. GEOLOGICAL ARCHITECTURE

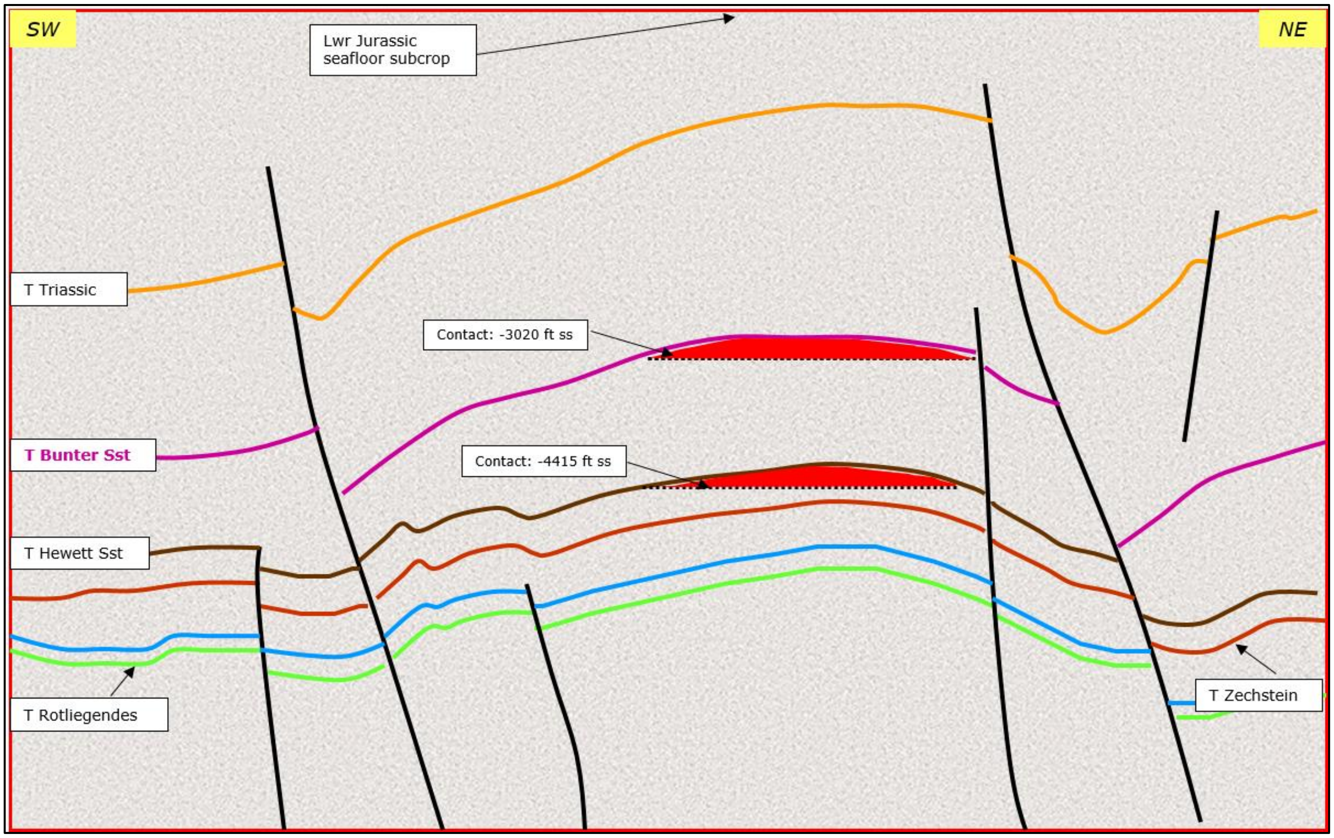

Figure5-1: Structural setting of Hewett Field

For the purpose of this study, the attention was focused on the two main reservoirs, Upper and Lower Bunter. They belong to the Bacton Group (Triassic), consisting in a clastic succession deposited in a fluvial environment.

In particular, Lower Bunter Formation is a clastic alluvial fan deposit very continuous and homogeneous all along the field with an average thickness of 90 ft.

This formation is overlaid by the Bunter Shale Formation, claystone interbedded with sandstone locally grading to siltstone (average thickness: 750 ft).

The Upper Bunter Formation (average thickness: 550 ft) is characterized by an angular unconformity at its top and its paleoenvironment can be related to a series of coalescing alluvial fans intersected by braided rivers whereas the more proximal central deposits were lain down by sheet floods.

The Upper Bunter seal is an Upper Triassic succession characterized by an alternation of shale and anhydrites with an average thickness of 1400 ft.

The high number of wells drilled lead to a good control and clear definition of the strucure, which consists of a fault bounded NW-SE trending anticline (Figure5-1).

5.2. PETROPHYSICAL CHARACTERIZATION

The petrophysical characterization has been carried out using both Log and core data: porosity from Log and core porosity data has been merged together in order to increase data population and to make the following interpretations more robust.
As results, the following characteristics for Upper Bunter (UB) and Lower Bunter (UB) have been found through CPI analysis (**Errore. L'origine riferimento non è stata trovata.**):

	NTG [-]	PORO [-]	PERM [mD]	SWi [-]	Vsh [-]
UB	0.80	0.20	1330	0.17	0.21
LB	0.90	0.21	1615	0.10	0.1
*full field mean values					

Table 5-1 Petrophysical parameters.

Due to the occurrence of high quality petrophysical characteristics in both reservoirs, Upper Bunter can be considered as an additional potential storage site.

5.3. FLUID CONTACTS & COMPARTMENTS

Fluid contacts could be clearly detected from log analysis (Figure 5-2). Also from seismic data GWC has clear seismic expression (i.e. at Well 52/51)
In particular, the following contacts have been interpreted:

- Upper Bunter: GWC at 3020 ft
- Lower Bunter: GDT at 4415 ft (from well 52/5-3)

No compartmentalization has been recognized even if some faults are present: Hewett is characterized by two main border sealing fault and by minor strike-slip faults inside the field that do not act as barriers to flow, as demonstrated by dynamic data (Figure 5-3).

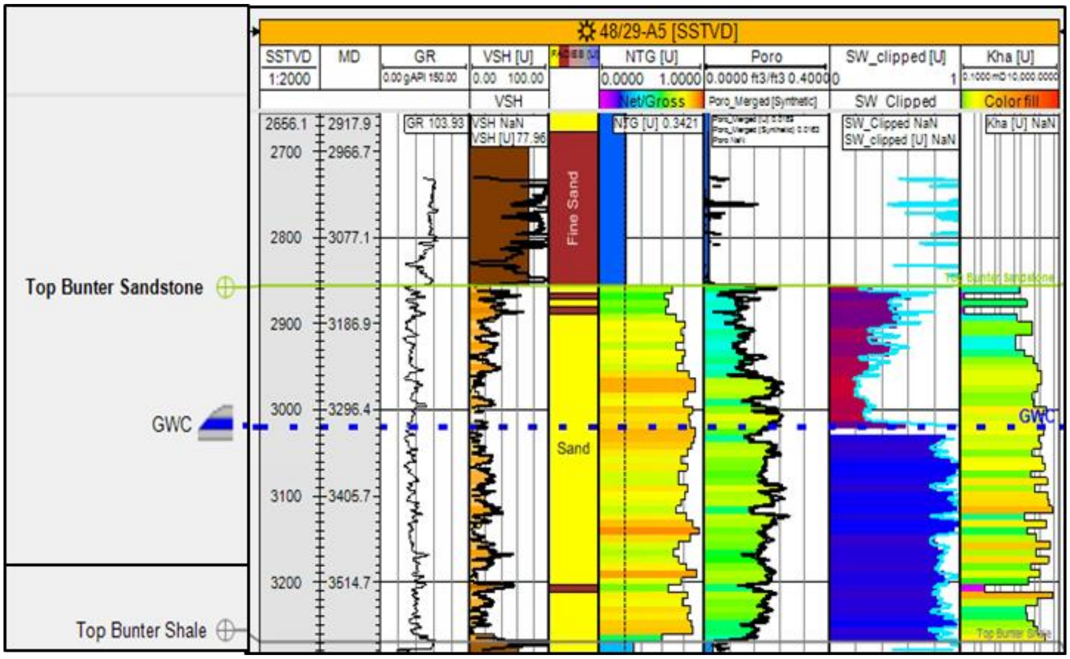

Figure 5-2: GWC definition in Upper Bunter

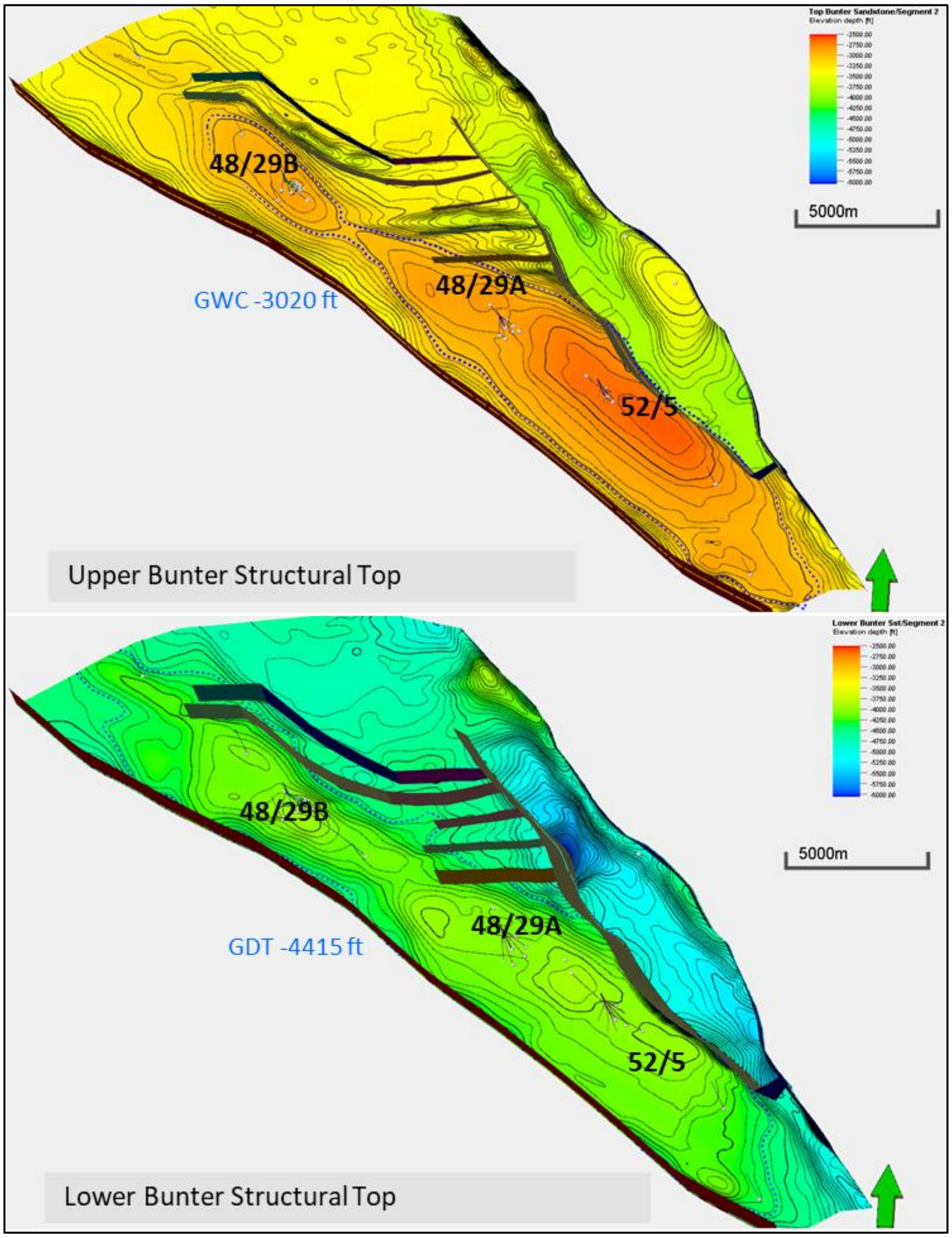

Figure 5-3: Structural Tops Of Upper and Lower Bunter

A more complex situation is present at the fault that separates Hewett from Little Dotty (Figure 5-4): it is a NW-SE trending, scissors-like fault with high thrown towards the South that could create partial communication between these two fields but only in the Upper Bunter and through the acquifer on its NW side.

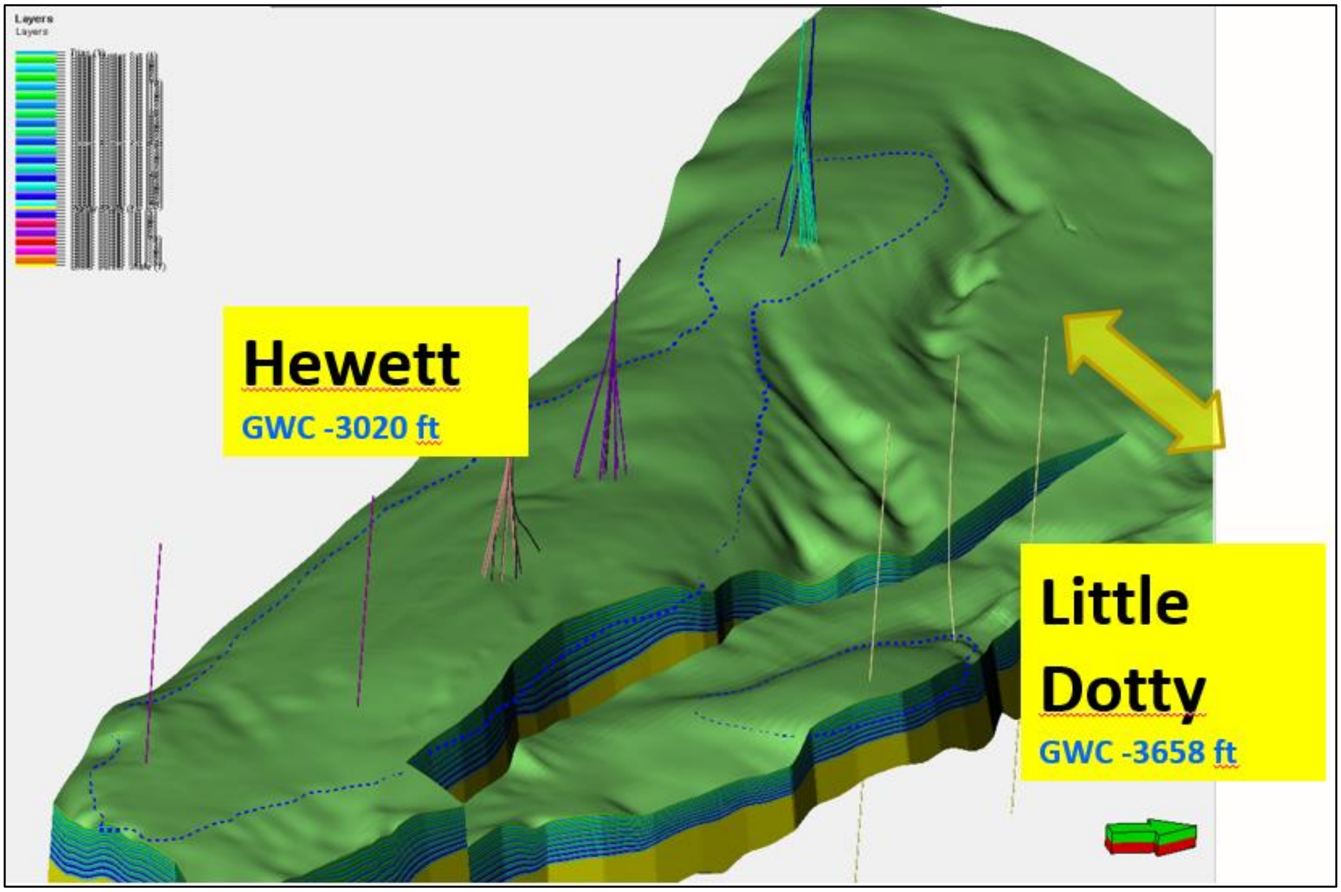

Figure 5-4: Stuctural separation between Hewett and Little Dotty field

5.4. 3D GEOLOGICAL MODELING

A traditional geological modeling workflow has been adopted using Petrel software to obtain a 3D static model as a base for volumetric calculation, History Match and CO_2 injection scenarios.
The workflow steps are shown in figure Figure 5-5.

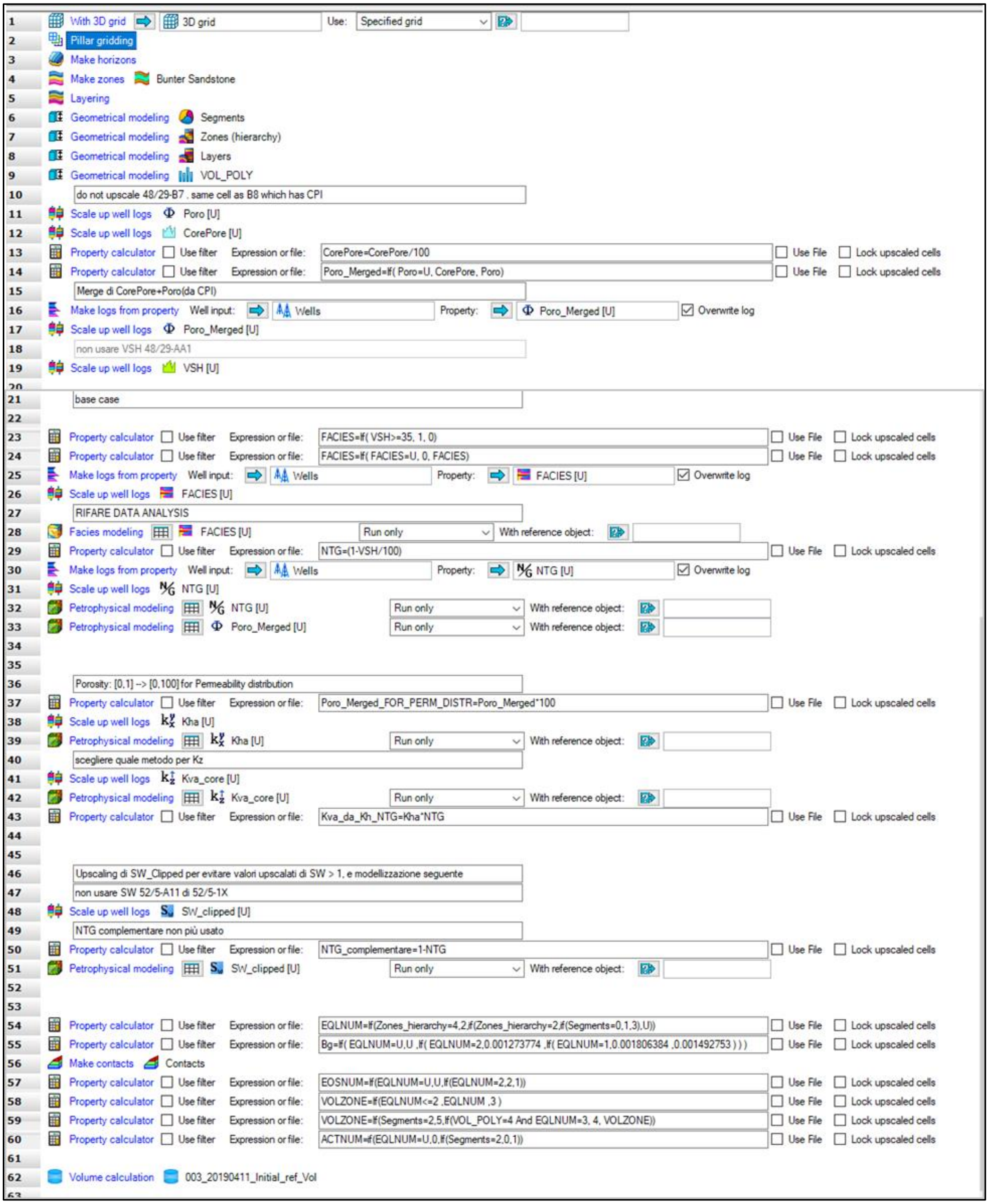

Figure 5-5: Adopted modelling workflow

Fault modeling was performed with a simplistic approach: faults surrounding and crossing Hewett field were created as vertical planes. Due to the small amount of control points across the central faults, they were assumed not to have a significant thrown, but were constructed to account for any possible dynamic flow interference. External faults define the limit of the generated 3Dgrid (Figure 5-6).

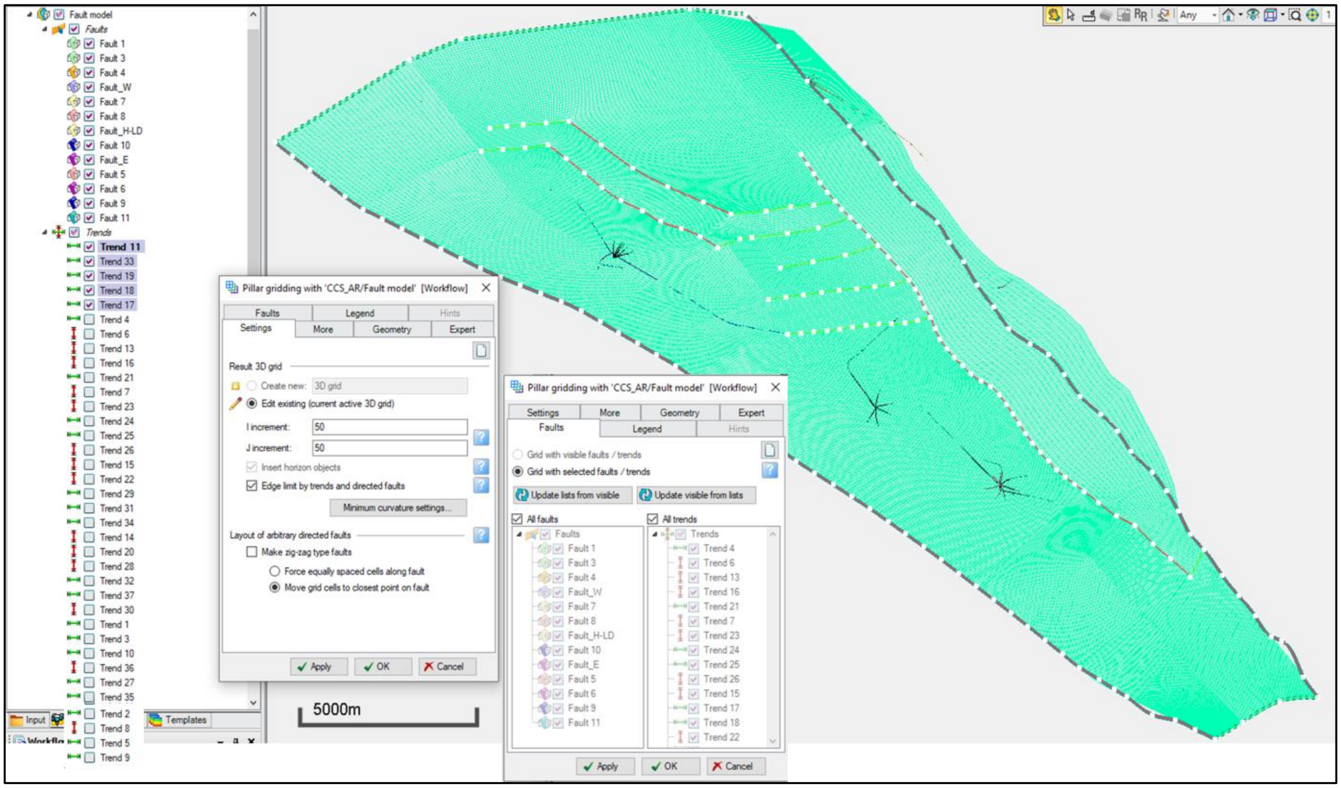

Figure 5-6: 3D grid creation

The 3D grid consists of 5238380 cells with 50x50x10ft dimension and was created using existing faults and additional trend directions, in order to obtain the most orthogonal gridding possible to facilitate the dynamic simulation.

Make Horizon process (based on "conformable" option) has been performed starting from the seismic derived structural tops to obtain the main element of Hewett field:

- Triassic seal sequence
- Upper Bunter
- Top Bunter Shale
- Lower Bunter
- Lower Bunter Shale

The **layering** process (based on "proportional" option) has been performed on Upper and Lower Bunter creating 5 ft thick layers in order to catch the vertical heterogeneity in each reservoir: Upper Bunter, 500 ft thick, has been divided into 50 layers, while Lower Bunter, 90 ft thick, into 18 layers.

Facies definition was first performed in order to distribute the other properties according to the facies occurrence.
Two facies were identified and distributed inside Lower and Upper Bunter; in particular, they were defined with a Vsh=35% cut-off, discriminating sand and fine sand facies.

Facies distribution was performed through Data Analysis with Vertical Proportion Curves (VPC) and histogram statistics.

To account for possible heterogeneity in the areas not controlled by wells, two cases have been defined: a base case where facies percentage at field scale strictly reflects well data statistics and a downside case where coarse sands percentage at field scale is lower (it has been defined with a Vsh=25 cutoff), but set to obtain the minimum GOIP needed to justify the field produced gas volume (Figure 5-7).

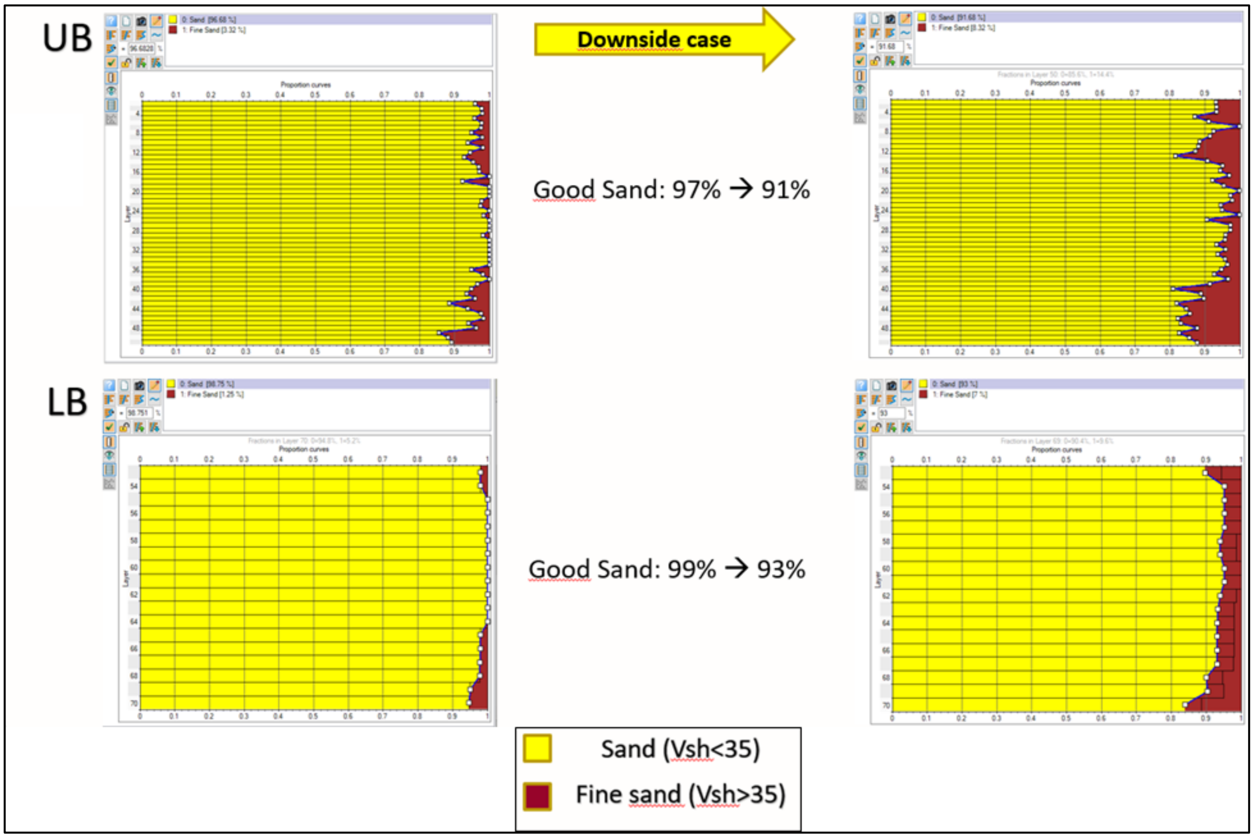

Figure 5-7: NTG distribution – Upper Bunter

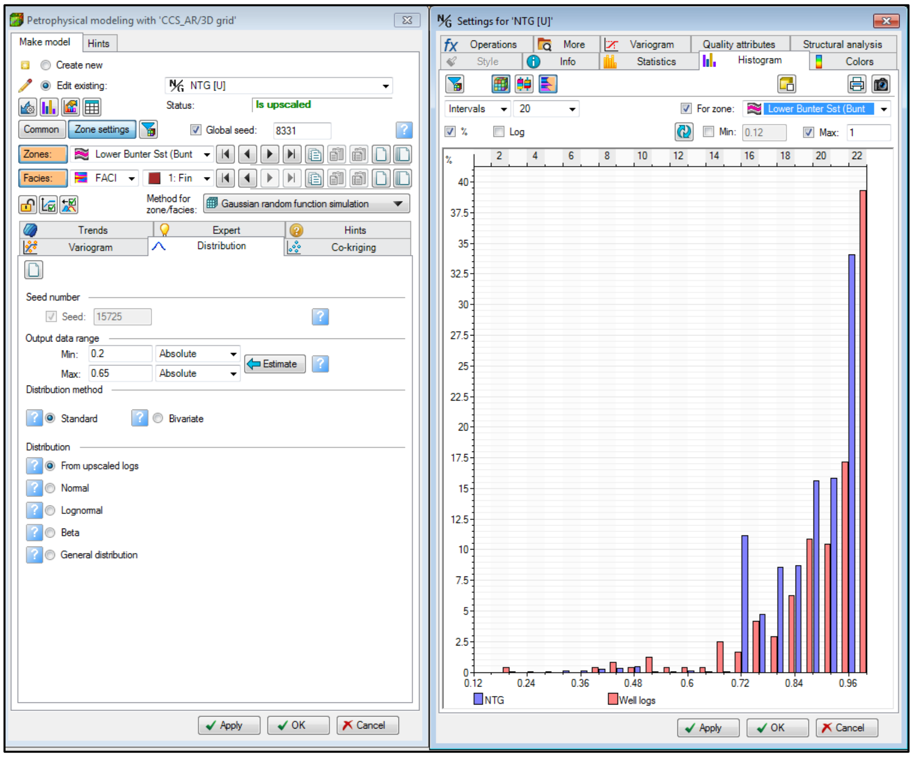

Figure 5-8: NTG distribution – Lower Bunter

The 3D Grid has finally been populated with the following properties:

- Facies
- NTG
- Porosity
- Water Saturation

Properties distribution has been performed based on statistical evaluation of the property values for each facies (an example onFigure 5-8).

Statistics, settings and results are shown in the following figures (from Figure 5-9, to Figure 5-11).

Results shows very good correspondence among well logs and upscaled cells both for Upper and Lower Bunter.

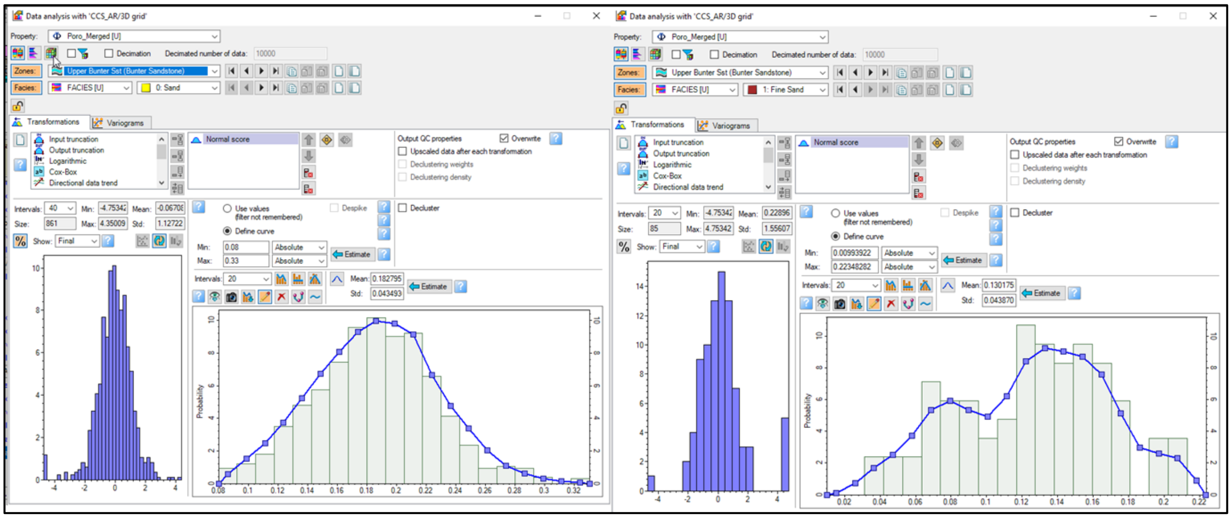

Figure 5-9: Statistical distribution analysis: porosity in Upper Bunter.

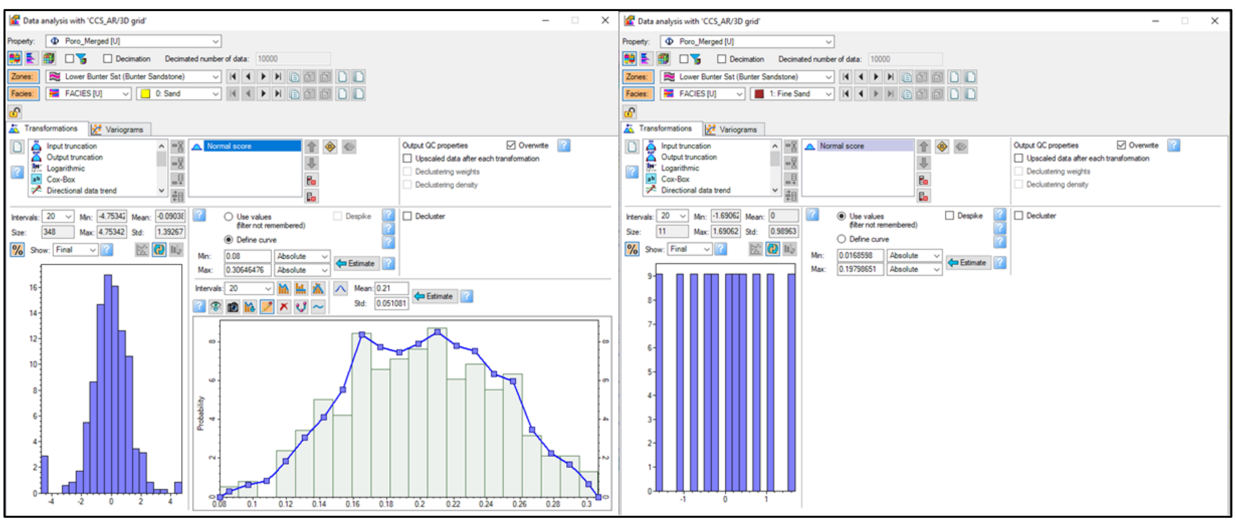

Figure 5-10: Statistical distribution analysis: porosity in Lower Bunter.

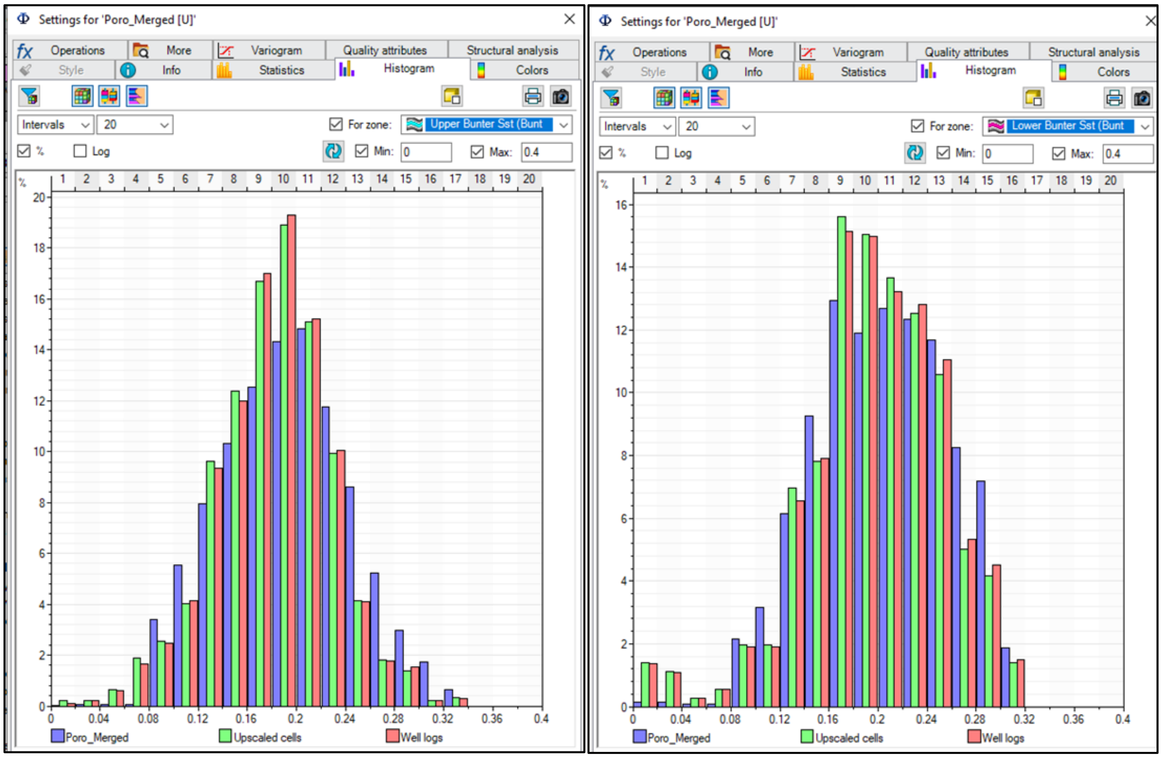

Figure 5-11: Porosity distribution results in Upper and Lower Bunter

5.5. PRODUCTION DATA ANALYSIS

The production and pressure data for the two reservoirs are available in different formats with different peculiarities each: in the following sections the analysis and the quality check of the data is reported.

5.5.1. LOWER BUNTER (25 WELLS)

Lower Bunter data comes from an OFM database updated by Eni UK on monthly basis. The available data span from the first gas (1969) to the last available month (February 2019).
The dataset comprises the Gas production both at field level and at well level: however, a few criticalities have arisen during the QC of the available data.

- Before January 1995: the well 48/29-A2 accounts for the total field production, monthly. The field is under ConocoPhillips operatorship

- 1995 – 2002: the well 48/29-A2 accounts for the total field production, daily. ConocoPhillips still in charge of the operation
- 2002-2010: Total field production allocated on well basis, daily. Tullow operatorship
- 2010 onwards: Total field production allocated on well basis, daily. Eni operatorship

The different allocations are shown in Figure 5-12 and Figure 5-13: the total cumulative production at February 2019 is **$2.1 \cdot 10^{12}$ scf**.

Due to different operatorship and various allocation method, the Lower Bunter observed production have been kept unaltered and no re-allocation has been performed to avoid any human artifact that would lead to a less robust model.

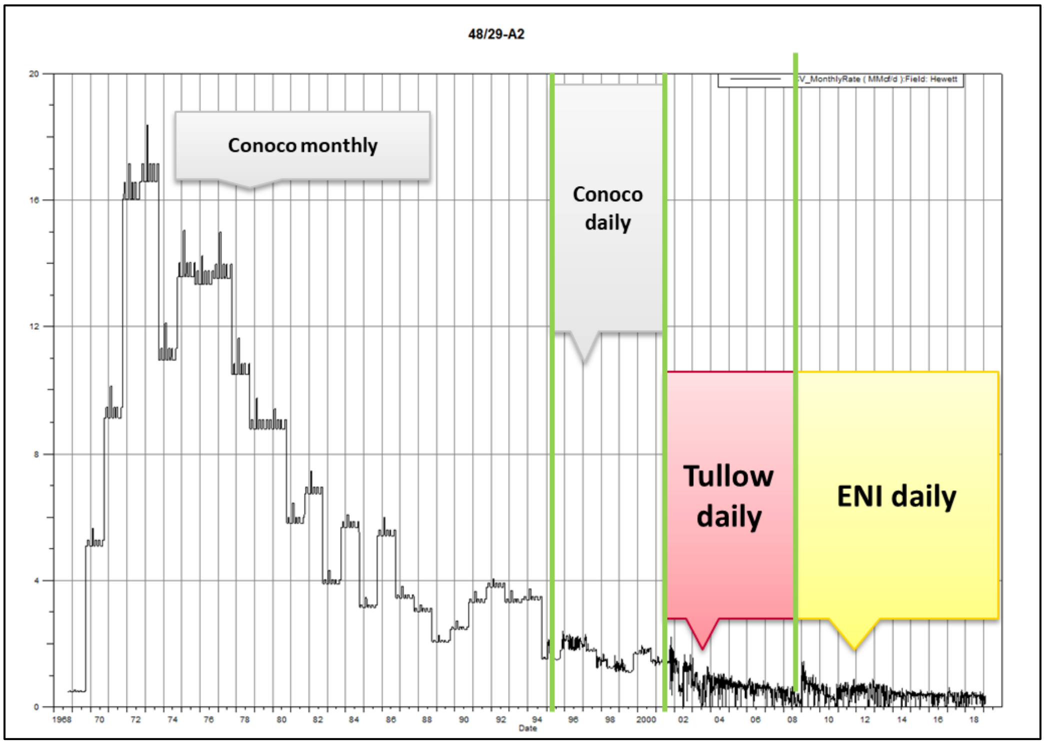

Figure 5-12: Lower Bunter: 48/29-A2 allocated production

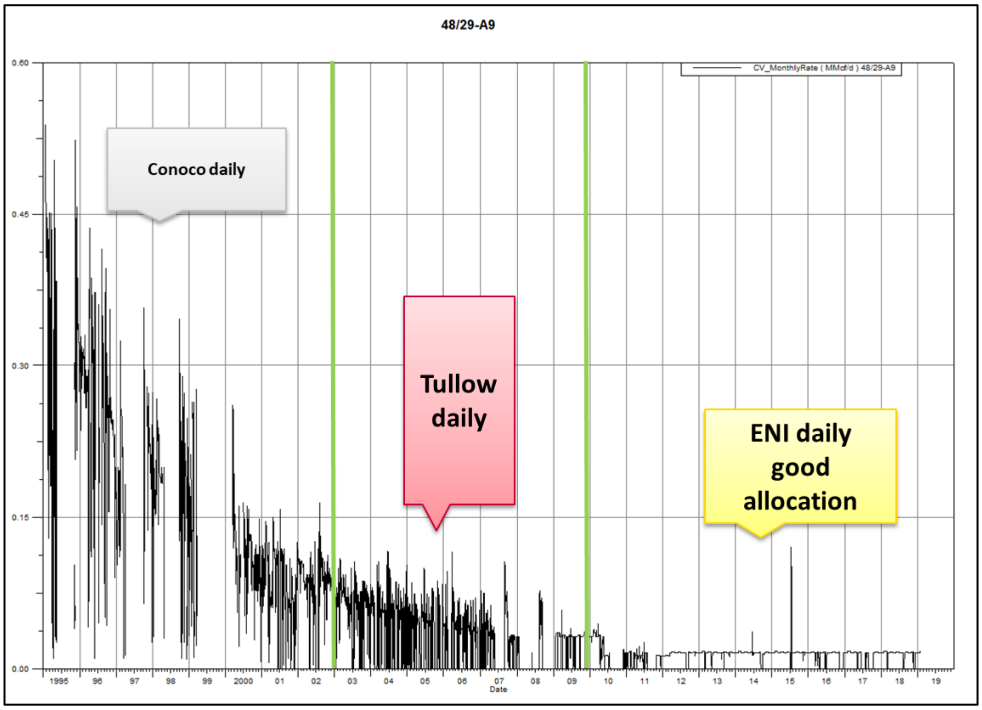

Figure 5-13: 48/29-A9: allocated production

Pressure data comes from three different sources: Conoco Phillips Report (1998), Tullow Report (2002) and the Eni UK database.
Conoco Phillips pressure are Shut-In Bottom Hole Pressures (**SIBHP** from now on), which come comprehensive of gas gradients and depth references, are illustrated in Figure *5-14*.
Conoco Phillips dataset comprises of the following data :

- 48/29-A platform: June 1968 – June 1994
- 48/29-B platform: November 1972 – September 1993
- 52/5 platform: June 1967 – May 1972

HEWETT LOWER BUNTER PRESSURE DATA
ALPHA PLATFORM

note: gas gradients were calculated from each survey's data

DATE	Pressure (psia)	Gas Grad (psi/ft)	Pressure @ 4200' ss Datum	Well/Field details & Gauge depth	TIC Report / Comments
02-Jun-68				Upper Bunter DST Report	WE.48/29-A1.6(16)
09-Jun-68				Upper Bunter DST Report	WE.48/29-A1.6(23)
07-Aug-70				Isochronal Test (flow rate data available)	WE.48/29-A1.6(20)
	1735			Lubricator pressure measured with survey gauge	
	1914	0.0470	1932	3882' RKB	
06-Jul-71				Well Test for Horner Build-up (Well was SI for 156 hrs)	WE.48/29-A1.6(18)
	1656			Lubricator pressure measured with survey gauge	
	1836	0.0455	1850	3952' RKB, Temp = 123 Deg F	
04-Sep-72				Well SI for 43.62 hours, the other wells were flowing	WE.48/29-A1.6(22)
	1497			Lubricator pressure measured with survey gauge	The 48/29-A platform flowed
	1643	0.0375	1657	3881' RKB, Temp = 122 Deg F	183-184 mmscfd during the
				Qcum from 06:00 15th Aug to 21:03 2nd Sep was 746 mmscf	A1 SI period.
				Flow Rate data for the individual wells is in file: 'WE.48/29-A1.6(21)	
15-Oct-73				Isochronal Test (flow rate data available)	WE.48/29-A1.6(17)
	1347			Lubricator pressure measured with survey gauge	12 hr Build-up
	1474	0.0332	1489	3809' RKB, Temp = 122 Deg F	
24-Aug-74				Isochronal Test (flow rate data available)	WE.48/29-A1.6(8)
	1270			Lubricator pressure measured with survey gauge	1 hr Build-up
	1394	0.0316	1405	3930 ft, Temp = 122 Deg F	
24-Nov-74			1400		Red. of Res. Rpt. 12/77
19-Jun-76			1155	Platform SI on 24 May 76 Pressure calculted from WHP data	Redetermination of Res. Report, Dec 1977
15-Dec-76			1085	Pressure calculted from WHP data	Red. of Res. Rpt, 12/77
15-Jun-77			1002	Pressure calculted from WHP data	Red. of Res. Rpt, 12/77
15-Oct-77			974	Pressure calculted from WHP data	Red. of Res. Rpt, 12/77
09-Nov-82	497		546	W/H Shut-in Pressure before Reperforating Not sure if this is a stabilized pressure point.	Well Potential Data Sheet
22-Jan-83	487		535	W/H Shut-in Pressure after Reperforating Not sure if this is a stabilized pressure point.	Well Potential Data Sheet
May-86			349	BHP survey Field SI for 5 Days. Unsure of measurement well	APR 12/91 Table 4.2.2.2
10-Jun-86				Isochronal Test (flow rate data available) do not know how long well was SI for.	WE.48/29-A1.6(2)
	308			Lubricator pressure measured with survey gauge	
	336	0.0070	337	4068 ft MD RKB , Temp = 127 Deg F	
02-May-87				Well SI for several hours minimum	WE.48/29-A1.6(29)
	276			Lubricator pressure measured with survey gauge	WE.48/29-A1.6(14) copy
	305	0.0062	305	4213' RKB, Temp = 124 Deg F	
Jul-87			307	BHP survey Field SI for 60 Days. Unsure of measurement well	APR 12/91 Table 4.2.2.2
17-Apr-88				Static TDT survey. Well SI prior to test.	WE.48/29-A1.6(13)
	232			Lubricator pressure measured with survey gauge	
	250	0.0043	250	4213' RKB, Temp = 117 Deg F	
Jun-90			225	BHP survey Field SI for 4 Days. Unsure of measurement well	APR 12/91 Table 4.2.2.2
Aug-91			195	BHP survey Field SI for 30 Days.	APR 12/91 Section 4.2.3 pg14
29-Aug-91				Rotliegendes Sandstone	WE.48/29-A1.6(27)
12-Sep-93	146			Lubricator pressure measured with survey gauge	WE.48/29-A1.6(25)
	160	0.0033	161	4206' RKB, Temp = 127 Deg F	
27-Jun-94				Well SI for several hours minimum	WE.48/29-A1.6(26)
	125			Lubricator pressure measured with survey gauge	
	136	0.0026	136	4213' RKB, Temp = 127 Deg F	

HEWETT LOWER BUNTER PRESSURE DATA
BRAVO PLATFORM

note: gas gradients were calculated from each survey's data

DATE	Pressure (psia)	Gas Grad (psi/ft)	Pressure @ 4200' ss Datum	Well/Field details & Gauge depth	TIC Report / Comments
01-Nov-72	1520			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(4)
	1670	0.0384	1687	3808' RKB, Temp = 124 Deg F	5 hr Build-up
15-Mar-73				There is an initial flow with a 3hr shut-in peirod followed by four 2 hour flows with 20 minute shut-ins.	WE.48/29-B1.6(17)
	1620	0.0384	1632	@ 3943 feet TVD, Temp = 125 Deg F	End of 3 hr SI
	1619			@ 3943 feet TVD, Temp = 125 Deg F	End of 1st 20 min SI
	1619			@ 3943 feet TVD, Temp = 125 Deg F	End of 2nd 20 min SI
	1619			@ 3943 feet TVD, Temp = 125 Deg F	End of 3rd 20 min SI
	1621		1633	@ 3943 feet TVD, Temp = 125 Deg F	2 hour SI
				Wellhead data of above report	WE.48/29-B1.6(16)
			1627	Baker Report THP to BHP (w/flow data of isochronal test)	WE.48/29-B1.6(26)
08-Apr-73	1447			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(15)
	1592	0.0384	1605	@ 3912 feet TVD, Temp = 123 Deg F	
				Interference test but no info about Alpha Platform.	
12-Nov-73	1333			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(14)
	1464.6	0.0334	1477	@ 3891 feet TVD, Temp = 123 Deg F	2 hr Build-up
15-Nov-73				File Coded Wrong-- Well 48/29-B2, do not know if test is on Lower or Upper Bunter. It is probably Lower as Gauge depth is 4212 ft. 4 Point Isochronal Test performed.	WE.48/29-B1.6(11)
23-Aug-74	1264			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(3)
	1389	0.0317	1400	@ 3920 feet TVD, Temp = 122 Deg F	1 hr Build-up
17-Jul-75	1137			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(30)
	1245	0.0277	1255	@ 3898 feet TVD	I think the well was SI for 5 hours prior to survey.
15-Dec-76			1085	Pressure calculted from WHP data	Red. of Res. Rpt, 12/77
15-Oct-77			969	Pressure calculted from WHP data	Red. of Res. Rpt, 12/77
02-Oct-79				At this time Upper Bunter gas production was possible through a sliding sleeve. For this test, the Lower Bunter was shut in in this well since 6 June 1979. The other Lower Bunter producers were shut in early September.	WE.48/29-B1.6(5)
	700			Lubricator pressure (17' RKB) measured with Deadweight tester	
	693			Lubricator pressure (17' RKB) measured with survey gauge	
	761	0.0170	766	3920.75' RKB = 3920.56 ' TVD RKB, Temp = 124 Deg F	
				(Not sure if the pressures are psia or psig)	
02-Apr-82	480			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(32)
	510	0.0130	527	@ 2941 feet TVD, Temp = 111 Deg F	data in psia
30-Aug-84	446			Well 48/29-B4. Gauge at 4582 ft from Main Deck! (Deviated Well)	WE.48/29-B4.6(2)
08-Jun-86				Probably Lower Bunter. Gauge at 3920 ft	WE.48/29-B1.6(7)
	312			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(18) copy
	341	0.0069	343	3920.75' RKB, Temp = 124 Deg F	
				Performed Isochronal Test	
Jul-91			195	BHP survey Field SI for 30 Days.	APR 12/91 Section 4.2.3 pg14
04-May-92	169.0	0.0048	170.7	3898 ft RKB. Commencement of Build-up.	WE.48/29-B1.6(35)
01-Jun-92	175.2		176.9	Well SI	6 month survey
01-Jul-92	176.5		178.2	Well SI	
01-Aug-92	177.2		178.9	Well SI	
01-Sep-92	177.8		179.5	Well SI	
01-Oct-92	178.2		180.0	Well SI	
01-Nov-92	178.7		180.4	Pressure just prior to opening well for 4 days of flowing	WE.48/29-B1.6(36)
29-Sep-93	149			Lubricator pressure measured with survey gauge	WE.48/29-B1.6(34)
	162	0.0031	165	3523' RKB Temp = 123 Deg F	data in psia

Figure 5-14: Lower Bunter Pressure, Conoco Phillips Report

A limited difference (less than 15 psia – 1 bar) in the initial pressure points may be noticed, which can be imputed to the initial pressure wave propagation limited to the near wellbore region and the initial drainage: it is worth mentioning that the trends for the two main platforms (48/29-a and 48/29-B) tend to coincide after 1976 with almost the same value.
This behavior is indicative of two important reservoir characteristics:

- There is no significant compartimentalization of the reservoir
- The flow becomes boundary dominated after 1976

The aforementioned findings have been used to drive the reservoir simulation to deliver a validated model for the injection phase

Tullow data are comprehensive of Shut in WellHead Pressures (**SIWHP** from now on) together with shut-in times. Those pressures were extrapolated at the datum depth by using an average gradient. Figure *5-15* reports the available data, that confirms the consideration made by analyzing the Conoco Phillips ones

LOWER BUNTER PRESSURE DATA

DATE	SHUT-IN (Hr.Min)	SURF PRESS (psia)	CALC BHP (psia)	Z	BHP/Z (psia)	CUM PROD (Bscf)
			1,986	0.850	2,336	0
7/69	0.05	1,790	1,985	0.850	2,335	1
8/69	0.05	1,788	1,983	0.850	2,333	3
9/69	0.05	1,782	1,976	0.850	2,324	6
10/69	0.05	1,787	1,982	0.850	2,331	9
11/69	0.05	1,779	1,973	0.850	2,321	13
12/69	0.05	1,777	1,970	0.850	2,318	19
1/70	0.05	1,773	1,965	0.850	2,312	26
2/70	0.05	1,770	1,963	0.851	2,306	32
4/70	0.05	1,753	1,943	0.851	2,283	45
5/70	0.05	1,747	1,937	0.851	2,276	49
6/70	0.05	1,746	1,936	0.851	2,275	52
7/70	0.05	1,743	1,932	0.851	2,270	56
8/70	0.05	1,712	1,898	0.852	2,227	59
9/70	0.05	1,739	1,928	0.851	2,265	63
10/70	0.05	1,734	1,922	0.851	2,259	70
11/70	0.05	1,726	1,913	0.852	2,246	79
12/70	0.05	1,715	1,901	0.852	2,231	89
1/71	0.05	1,705	1,890	0.852	2,218	100
2/71	0.05	1,693	1,876	0.853	2,200	111
3/71	0.05	1,684	1,867	0.853	2,188	122
4/71	0.05	1,673	1,854	0.853	2,174	132
5/71	0.05	1,670	1,850	0.853	2,169	140
6/71	0.05	1,663	1,843	0.853	2,160	148
7/71	0.05	1,659	1,839	0.854	2,153	153
8/71	0.05	1,655	1,834	0.854	2,147	160
9/71	0.05	1,649	1,827	0.854	2,139	167
10/71	0.05	1,642	1,820	0.854	2,131	179
11/71	0.05	1,626	1,802	0.855	2,107	194
12/71	0.05	1,615	1,789	0.855	2,093	211
1/72	0.05	1,591	1,762	0.856	2,059	231
2/72	0.05	1,578	1,748	0.857	2,040	249
3/72	0.05	1,563	1,731	0.857	2,020	266
4/72	0.05	1,551	1,717	0.858	2,002	281
5/72	0.05	1,535	1,699	0.858	1,981	297
6/72	0.05	1,525	1,688	0.859	1,966	313
7/72	0.05	1,510	1,672	0.859	1,947	323
8/72	0.05	1,494	1,654	0.860	1,923	339
9/72	0.05	1,492	1,652	0.860	1,921	349
10/72	0.05	1,489	1,648	0.860	1,916	361
11/72	0.05	1,470	1,627	0.861	1,890	378
12/72	0.05	1,454	1,610	0.862	1,867	396
1/73	0.05	1,442	1,596	0.863	1,850	415
2/73	0.05	1,426	1,577	0.863	1,828	434
3/73	0.05	1,409	1,559	0.864	1,804	452
4/73	0.05	1,391	1,538	0.865	1,778	470
5/73	0.05	1,379	1,526	0.866	1,762	489
8/73	0.05	1,372	1,518	0.866	1,752	525
9/73	0.05	1,358	1,502	0.867	1,732	536
10/73	0.05	1,349	1,492	0.868	1,719	550
11/73	0.05	1,337	1,478	0.868	1,703	562
12/73	0.05	1,327	1,467	0.869	1,688	574
1/74	0.05	1,317	1,456	0.870	1,673	587
8/74	0.05	1,269	1,403	0.873	1,607	652
9/74	0.05	1,265	1,398	0.873	1,601	660
10/74	0.05	1,250	1,381	0.874	1,580	677
11/74	0.05	1,237	1,367	0.875	1,562	692
12/74	0.05	1,222	1,350	0.876	1,541	707
1/75	0.05	1,211	1,337	0.876	1,527	723
2/75	0.05	1,197	1,322	0.877	1,507	738
3/75	0.05	1,182	1,305	0.878	1,486	755
4/75	0.05	1,172	1,294	0.879	1,472	766
5/75	0.05	1,167	1,288	0.880	1,464	776
6/75	0.05	1,157	1,278	0.880	1,452	789
7/75	0.05	1,148	1,267	0.881	1,438	799
8/75	0.05	1,155	1,275	0.880	1,449	806
9/75	0.05	1,144	1,262	0.881	1,433	814
10/75	0.05	1,137	1,255	0.882	1,422	825
11/75	0.05	1,121	1,237	0.883	1,401	840
12/75	0.05	1,099	1,213	0.885	1,370	857
1/76	0.05	1,086	1,198	0.886	1,353	876
2/76	0.05	1,062	1,171	0.888	1,318	896
3/76	0.05	1,040	1,146	0.889	1,289	918
4/76	0.05	1,033	1,139	0.890	1,279	932
5/76	0.05	1,026	1,131	0.890	1,270	943
7/76	0.05	1,024	1,129	0.891	1,267	952
8/76	0.05	1,022	1,127	0.891	1,265	957
9/76	0.05	1,018	1,122	0.891	1,259	965
10/76	0.05	1,005	1,108	0.892	1,242	976
11/76	0.05	988	1,088	0.894	1,217	994
12/76	0.05	967	1,066	0.895	1,191	1,015
1/77	0.05	948	1,044	0.897	1,164	1,035
2/77	0.05	933	1,028	0.898	1,145	1,051
3/77	0.05	921	1,014	0.899	1,128	1,069
4/77	0.05	907	999	0.901	1,109	1,084
5/77	0.05	901	992	0.901	1,101	1,093
10/77	0.05	885	974	0.903	1,079	1,125
11/77	0.05	875	963	0.904	1,065	1,137
2/78	0.05	828	911	0.908	1,003	1,180
3/78	0.05	817	898	0.909	988	1,194
4/78	0.05	808	889	0.910	977	1,205
5/78	0.05	802	882	0.910	969	1,213
8/78	0.05	794	873	0.911	959	1,234
9/78	0.05	784	863	0.912	946	1,237
10/78	0.05	786	864	0.912	947	1,243
11/78	0.05	773	850	0.913	931	1,252
12/78	0.05	763	839	0.914	918	1,265
1/79	0.05	745	819	0.916	894	1,280
2/79	0.05	728	800	0.918	871	1,295
3/79	0.05	713	784	0.919	853	1,309
4/79	0.05	707	777	0.920	844	1,320
5/79	0.05	699	768	0.920	835	1,328
6/79	0.05	702	771	0.920	838	1,330
10/79	0.05	705	775	0.920	842	1,343
11/79	0.05	684	751	0.922	815	1,355
12/79	0.05	677	744	0.923	806	1,367
1/80	0.05	652	716	0.925	774	1,384
2/80	0.05	647	710	0.926	767	1,395
3/80	0.05	640	703	0.926	759	1,408
4/80	0.05	626	688	0.928	741	1,415
5/80	0.05	622	683	0.928	736	1,420
6/80	0.05	622	683	0.928	736	1,428
12/80	0.05	580	636	0.933	682	1,460
7/81	0.05	573	628	0.934	672	1,495
10/81	0.05	558	612	0.935	654	1,511
3/82	0.05	471	516	0.945	546	1,563
12/82	0.05	473	518	0.944	549	1,588
2/83	0.05	459	503	0.946	532	1,596
5/83	0.05	442	484	0.948	511	1,615
9/83	0.05	450	493	0.947	521	1,622
1/84	0.05	429	470	0.949	495	1,646
3/84	0.05	405	443	0.952	466	1,667
4/84	0.05	386	423	0.954	443	1,675
7/84	0.05	408	447	0.952	469	1,680
8/84	0.05	403	441	0.952	463	1,684
1/85	0.05	379	415	0.955	434	1,702
8/85	0.05	371	406	0.956	425	1,718
5/86	120.05	319	349	0.962	363	1,773
6/86	0.05	318	348	0.962	362	1,774
7/86	0.05	316	346	0.962	360	1,775
11/86	0.05	300	328	0.964	340	1,791
1/87	0.05	286	313	0.966	324	1,803
2/87	0.05	280	306	0.966	317	1,809
4/87	0.05	272	297	0.967	308	1,817
5/87	1080.00	280	306	0.966	317	1,817
6/87	1440.00	281	307	0.966	318	1,817
7/87	1920.00	281	307	0.966	318	1,818
1/88	0.05	255	279	0.969	288	1,836
6/88	0.05	246	269	0.970	276	1,854
6/90	96.00	206	225	0.975	231	1,895
9/92	2328.00	165	181	0.981	185	1,944
8/93	3408.00	*	161	0.982	164	1,962
8/94	2400.00	129	144	0.985	146	1,980
8/95	4872.00	127	139	0.984	141	1,987
8/96	1680.00	112	122	0.987	123	1,997
8/97	4872.00	103	112	0.988	113	2,011
10/98	4400.00	94	102	0.989	103	2,020
10/99	4056.00	84	92	0.990	93	2,029
7/00	1824.00	75	82	0.991	82	2,039
1/7/01	504.00	57	62	0.993	62	2,044
1/7/02	384.00	55	60	0.994	60	2,049

Figure 5-15: Lower Bunter: Tullow Report data (2002)

Eni UK databases comprises of SIWHP (Figure *5-16*). Given the lack of completeness of well data (completion schematics, intervention history etc.) those pressure have been used as a soft to evaluate the match quality without performing any THP match.
Neither water influx nor watering out has been observed during the exploitation of the Lower Bunter reservoir: given the very high recovery factor (above 99%) and the pressure evolution during time, with low (less than 3 bar) but stable pressure lead to the fact that no water is movable within this system, which behaves as a closed, isolated tank.

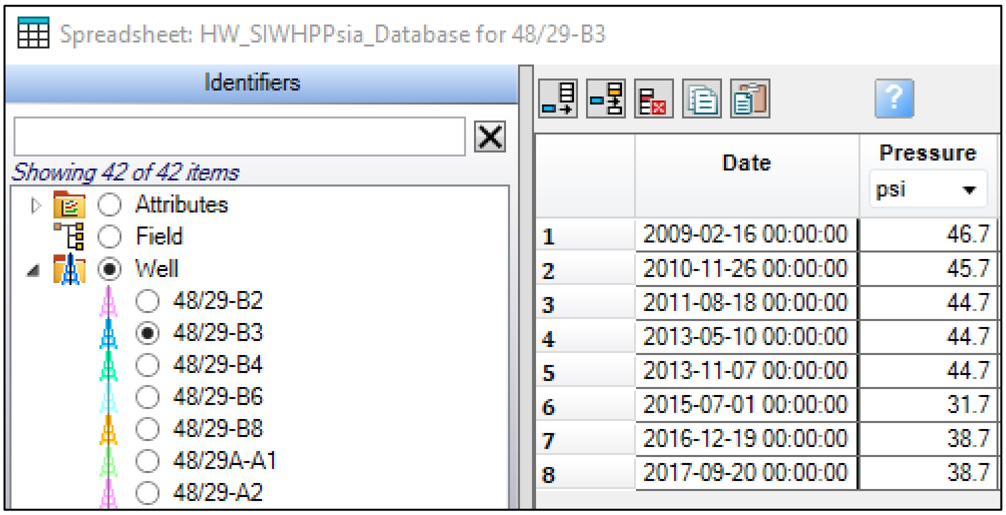

Figure 5-16: Lower bunter Pressure (sample), Eni UK SIWHP Database

5.5.2. UPPER BUNTER (10 Wells)

The Upper Bunter production data comes in the form of an excel database with the Gas production grand total only: the total cumulative production is **1.218 10^{12} scf** (Figure *5-17*). No information about the well allocation is available: henceforth the main assumption driving the allocation has been the petrophysical uniformity and the volumetric distribution of hydrocarbons within the Upper Bunter Unit (Figure *5-18*). the total cumulative production at February 2019 is 1.218 1012 scf

A	B	C	D	E	F	G
Date	Gas Cumulative [10^9 scf]	Field Average Daily Rate [10^3 scf/d]	Monthly Well Count	Well Average Daily Rate [10^3 scf/d]	Well Average Monthly cumulative [10^3 scf]	Field Average Monthly cumulative [10^3 scf]
01/09/2001	1217.1	14016.1	10.0	1401.6	42048.21918	420482.1918
01/10/2001	1217.2	3370.1	10.0	337.0	10447.33333	104473.3333
01/11/2001	1217.2	2781.5	10.0	278.1	8344.416667	83444.16667
01/12/2001	1217.4	3634.5	10.0	363.5	11267	112670
01/01/2002	1217.5	3149.0	10.0	314.9	9762	97620
01/02/2002	1217.5	3238.2	10.0	323.8	9067	90670
01/03/2002	1217.6	3075.2	10.0	307.5	9533	95330
01/04/2002	1217.6	69.7	10.0	7.0	209	2090
01/05/2002	1217.6	0.0	10.0	0.0	0	0
01/06/2002	1217.6	0.0	10.0	0.0	0	0
01/07/2002	1217.6	0.0	10.0	0.0	0	0
01/08/2002	1217.6	0.0	10.0	0.0	0	0
01/09/2002	1217.6	178.3	10.0	17.8	535	5350
01/10/2002	1217.7	1898.1	10.0	189.8	5884	58840
01/11/2002	1217.8	1567.0	10.0	156.7	4701	47010
01/12/2002	1217.8	0.0	10.0	0.0	0	0
01/01/2003	1217.8	0.0	10.0	0.0	0	0
01/02/2003	1217.8	0.0	10.0	0.0	0	0

Figure 5-17: Upper Bunter production data

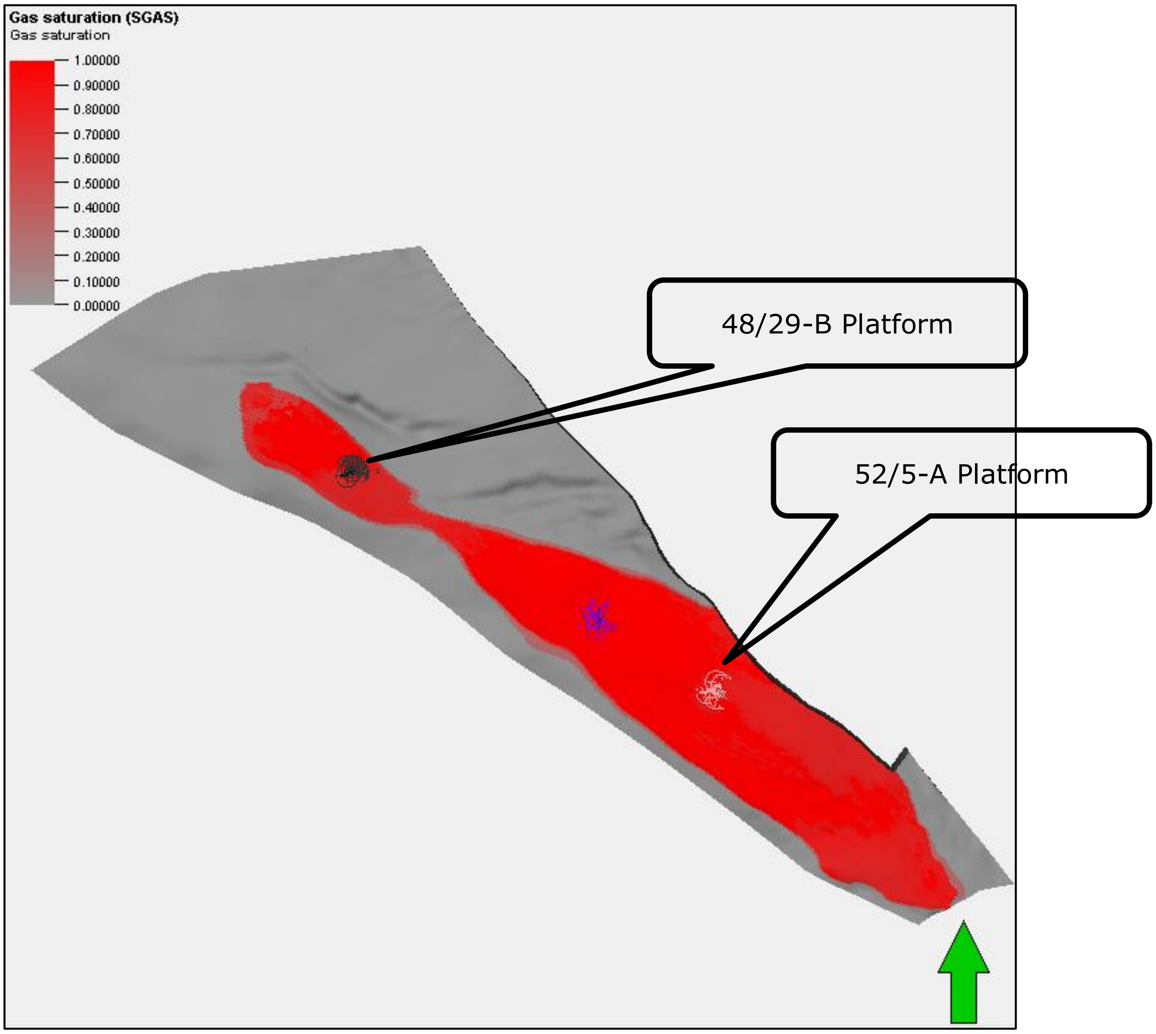

Figure 5-18: Upper Bunter Gas Saturation distribution

The initial assumption for re-allocating the grand total was to follow the petrophysical uniformity of the reservoir unit: high quality sands, little variation in the petrophysical properties at core and log scale across the sampling points led to an equal repartition among the wells, timed on the individual well start-up date (retrieved from end of well reports anorperforation reports). The whole 52/5-A platform is dedicated to the production from the Upper Bunter unit, with later exploitation coming from two 48/29-B: B1 and B6

This assumption has been later modified accounting for the hydrocarbon distribution depicted in Figure *5-18*: given the local asymmetry of the structure the contribution of the 48/29-B has been reduced and proportionally redistributed on the 52/5A wells: Figure 5-19 shows the production data for a 52/5-A well and for a 48/29-B well.

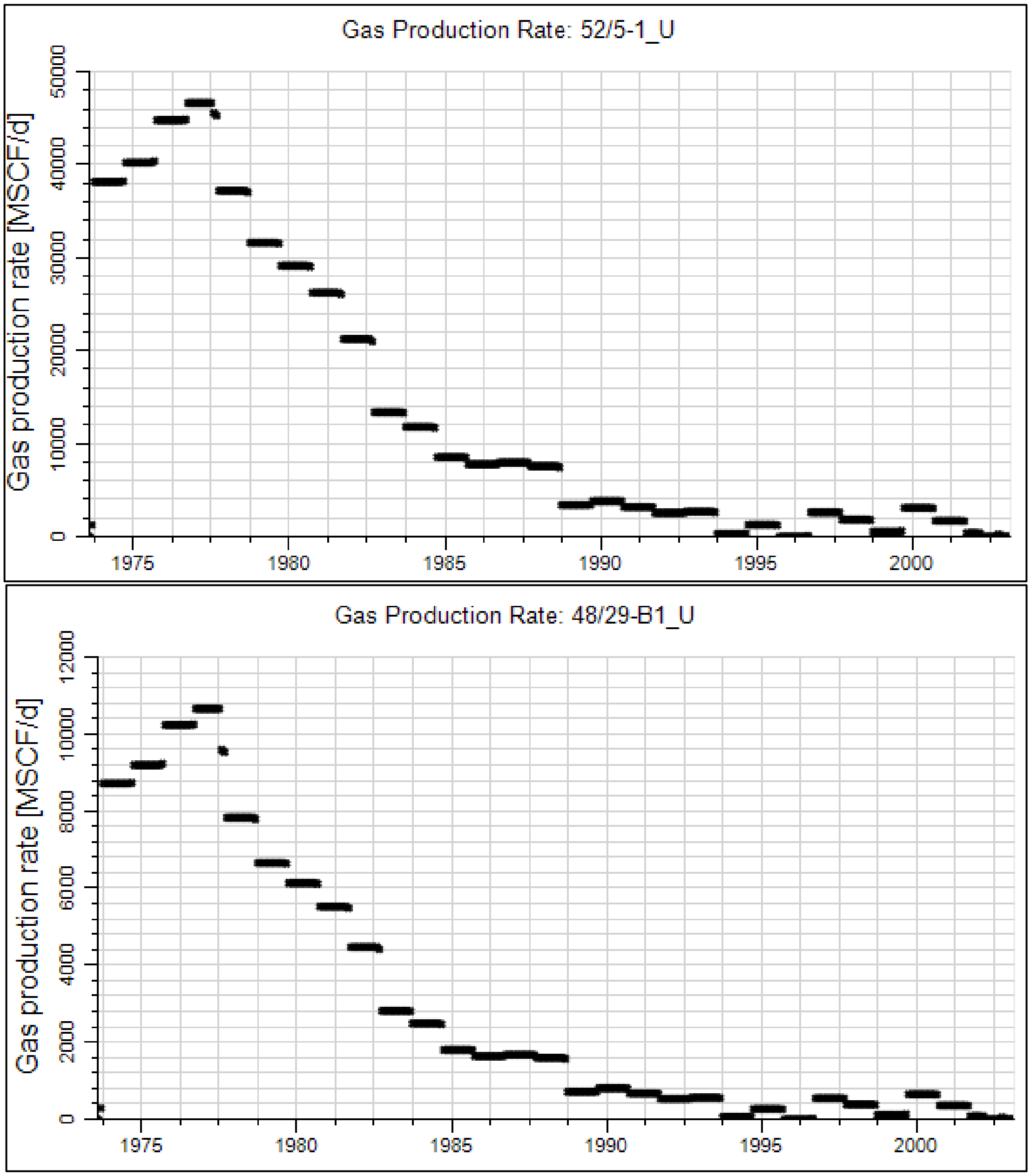

Figure 5-19: Upper Bunter well production: 52/5 well (top); 48/29-B well (bottom)

5.5.3. RECOMMENDED SIMULATION APPROACH

For the purposes of the CCS study, the evaluation of the storage capacity and the correct evaluation of the CO2 plume propagation dynamics the most viable option is the 3D compositional simulation. This methodology allows to perform the most reliable evaluation of the complex thermodynamic phenomena occurring during the injection of a stream with specified composition into a depleted gas reservoir, allowing to keep track of density evolution during time and opening the possibility to additional specialist studies that rely on compositional models.

5.6. THERMODYNAMIC STUDY & CO2 CHARACTERIZATION

To assess a correct modeling of the CO2 storage process into a depleted gas reservoir, the fluid characterization is crucial.
Initial condition of the two reservoir are different both in terms of initial temperature and initial reservoir pressure as Table 5-2 shows.

Formation	Initial P (bara)	Initial T (°C)
Upper Bunter	137	52.2
Lower Bunter	94	42

Table 5-2 Initial Reservoir Condition.

Given the long production history of the field (almost 50 years) the selection of the most representative fluids for the PVT characterization has been made accordingly to:

- Sampling date
- Sampling well
- Sample type (bottom hole/separator)

For the Hewett reservoir two fluids samples are available for the thermodynamic characterization:

- Fluid samples from well 48/29-A1 (separator sample, recombined), representative for the Lower Bunter unit (LB_sample from this point onwards)
- Fluid samples from well 52/5a-A4 (separator sample) w/o experimental data, representative for the Upper Bunter Unit (UB_sample from this point onwards)

Figure *5-20* and Figure 5-21 shows the experimental data available: whilst LB_sample possesses a CCE experiment performed close to the reservoir temperature (129°F) used for validating the thermodynamic model, UB_sample comes only with separator test data: henceforth the validity assessment of the UB_sample PVT model has been performed with the separator data only.

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Page 3 of 4
File RFL 6827
Well No. 1, Arpet "A" Platform

Pressure-Volume Relations of Reservoir Fluid at 129° F.
(Constant Composition Expansion)

Pressure PSIG	Relative Volume	Deviation Factor Z
5000	0.4775	0.994
4500	0.5076	0.952
4000	0.5471	0.912
3500	0.6016	0.878
3000	0.6821	0.854
2500	0.8039	0.840
2100	0.9530	0.837
2040	0.9809	0.837
2003 Reservoir Pressure	1.0000	0.838
1950	1.0273	0.838
1877	1.0690	0.840
1752	1.1472	0.842
1453	1.3990	0.853
1083	1.9094	0.871
878	2.3835	0.884
732	2.8644	0.889
603	3.5149	0.902
492	4.3268	0.911

Core Laboratories, Inc.
Reservoir Fluid Analysis

P. L. Moses HS
P. L. Moses
Manager

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Well No. 1, Arpet "A" Platform

Hydrocarbon Analyses of Separator Products and Calculated Well Stream

Component	Separator Liquid Mol Per Cent	Separator Gas Mol Per Cent	Separator Gas GPM	Well Stream Mol Per Cent	Well Stream GPM
Carbon Dioxide	Nil	Trace		Trace	
Nitrogen	0.61	2.31		2.31	
Methane	31.01	92.15		92.07	
Ethane	4.54	3.67		3.67	
Propane	2.64	0.88	0.242	0.88	0.242
iso-Butane	0.85	0.16	0.052	0.16	0.052
n-Butane	1.63	0.23	0.072	0.23	0.072
iso-Pentane	1.12	0.10	0.036	0.10	0.036
n-Pentane	1.19	0.08	0.029	0.08	0.029
Hexanes	2.91	0.08	0.033	0.08	0.033
Heptanes plus	53.50	0.34	0.154	0.42	0.199
	100.00	100.00	0.618	100.00	0.668

Properties of Heptanes plus

	Separator Liquid	Separator Gas	Well Stream
API gravity @ 60° F.	55.5		
Specific gravity @ 60/60° F.	0.7565		0.728
Molecular weight	138	103	109

Calculated separator gas gravity (air = 1.000) = 0.611
Calculated gross heating value for separator gas = 1061 BTU
per cubic foot of dry gas @ 14.696 psia and 60° F.

Primary separator gas collected @ 1270 psig and 96 °F.
Primary separator liquid collected @ 1270 psig and 96 °F.

Primary separator gas/separator liquid ratio 726220 SCF/Bbl @ 96° F.
Primary separator liquid/stock tank liquid ratio ______ Bbls @ 60° F./Bbl
Primary separator gas/well stream ratio 998.58 MSCF/MMSCF
Stock tank liquid/well stream ratio ______ Bbls/MMSCF

Figure 5-20: LB experimental data and composition

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Page 2 of 3
File RFLA 840083
Well 52/5-A4 Upper Bunter

HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS AND CALCULATED WELL STREAM

Component	Separator Liquid Mol Percent	Separator Gas Mol Percent	Separator Gas GPM	Well Stream Mol Percent
Hydrogen Sulphide	N/D	N/D		N/D
Carbon Dioxide	0.01	0.07		0.07
Nitrogen	0.11	9.18		9.18
Methane	6.41	81.68		81.68
Ethane	3.34	5.70		5.70
Propane	5.92	2.77	0.760	2.77
iso-Butane	1.37	0.26	0.085	0.26
n-Butane	1.29	0.16	0.050	0.16
iso-Pentane	0.33	0.02	0.007	0.02
n-Pentane	0.22	0.01	0.004	0.01
Hexanes	2.20	0.06	0.025	0.06
Heptanes plus	78.80	0.09	0.041	0.09
	100.00	100.00	0.972	100.00

Properties of Heptanes plus

	Separator Liquid	Separator Gas	Well Stream
API gravity @ 60°F.	42.5		
Specific gravity @ 60/60°F.	0.8126		0.705
Molecular weight	143	103 (assumed)	105

Calculated separator gas gravity (air=1.000) = 0.658
Calculated gross heating value for separator gas = 1018 BTU
per cubic foot of dry gas @ 14.696 psia and 60°F.

Primary separator gas collected @ 337 psig and 104 °F.
Primary separator liquid collected @ 337 psig and 104 °F.

Primary separator gas/separator liquid ratio 16882 MSCF/Bbl @ 104°F.

Figure 5-21: UB composition data

5.6.1. LOWER BUNTER

Peng-Robinson 78 equation with Temperature dependancies has been selected for the proper modelization of the fluids by PVTSim 3.3.
One may notice the proximity of the phase envelope to the separator test point, as well as the limited distance between the Cricondermtemp and the Reservoir temperature: due to the total absence of condensate production throughout the reservoir life, monitoring this parameter is crucial to provide the correct fluid description and limiting the two-phase regime at reservoir condition.

The initial phase envelope is close to the separator tests condition: to match the condensate presence, the separator point are used for the numerical validation of the EOS model via tuning of the following C7+ fraction properties:

- Molecular Weight
- Critical Temperature
- Critical Pressure
- Acentric Factor

Figure 5-22 show the tuning results.

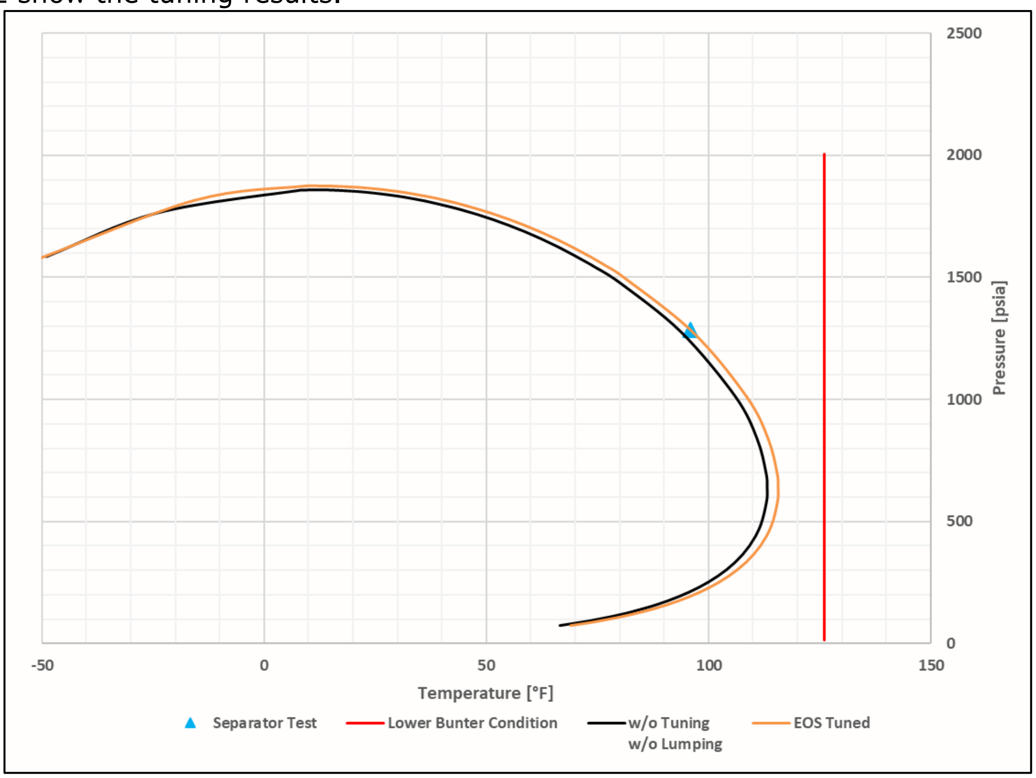

Figure 5-22: Lower Bunter Tuned EOS model (orange line)

Performing the separator test at the dedicated condition gave good results in terms of composition of separator fluids as well as GLR.

The original model comes out with 11 components: to reduce the computational cost of each simulation the initial set has been reduced to 7 components, providing a suitable description of the examined fluid. The main lumping criteria is the molecular similarity (same vibrational dynamics) Table 5-1Table 5-3 shows the lumping scheme for the Lower Bunter Fluid, with the tuned phase envelope of the 7-component equation pictured in Figure 5-23

Fluid Component	Lumping Group
CO_2	CO2
N_2	PS1
C1	PS1
C2	PS2
C3	PS2
iC4	PS2
nC4	PS2
nC5	PS3
iC5	PS3
C6	PS3
C7+	PS4

Table 5-3: Lumping Scheme

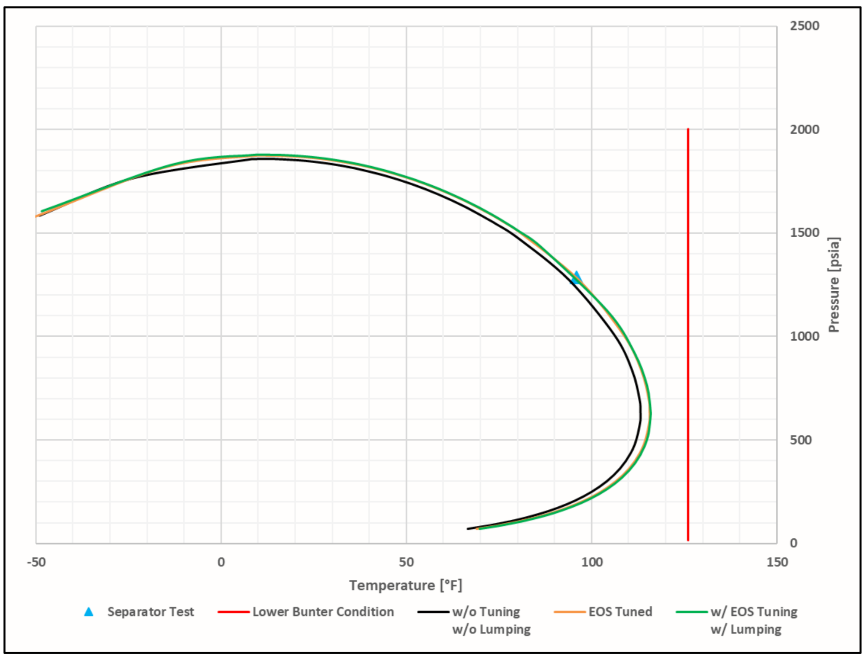

Figure 5-23 Lower Bunter models: 11 components (black line) vs 7 component tuned (green line)

At this stage to simulate the CCE performed on the Lower Bunter reservoir fluid a series of flash calculation to atmospheric pressure can reconstruct the Relative Volume, Gas Compressiblity and Gas Formation volume factor table versus pressure: the accordance between the simulated and experimental data is good, with a contained relative difference (ca. 3%) to the experimental data. Figure 5-24 shows the aforementioned comparison.

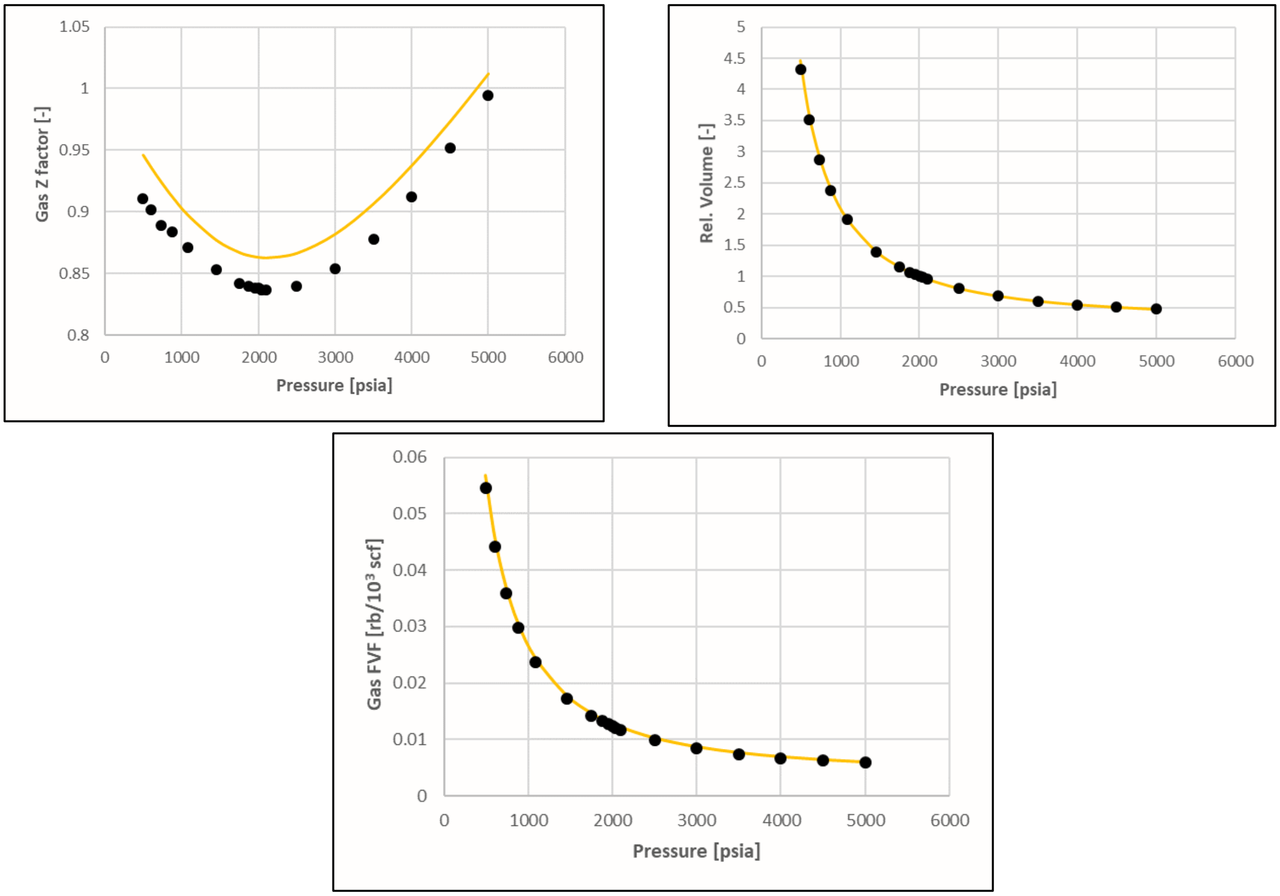

Figure 5-24: Comparison between Lower Bunter experimental (black dots) and simulated (orange line) data

5.6.2. UPPER BUNTER

The Upper Bunter (UB) fluid characteristics comes out from the fluid sample taken from well 52/5-A4. Fluid composition and separator condition are available, toghether with the separator test condition and the separator GLR
The same EOS (PR78-T) has been chosen for the Upper Bunter fluid.
Starting from the original one, composition has changed to tune the EOS model for the Upper Bunter reservoir, accounting for heavier compounds which can cause condensation: given the very Low CGR, any small oscillation into the C7+ subcomponents abundance turns into a dramatic variation of the CGR estimate.

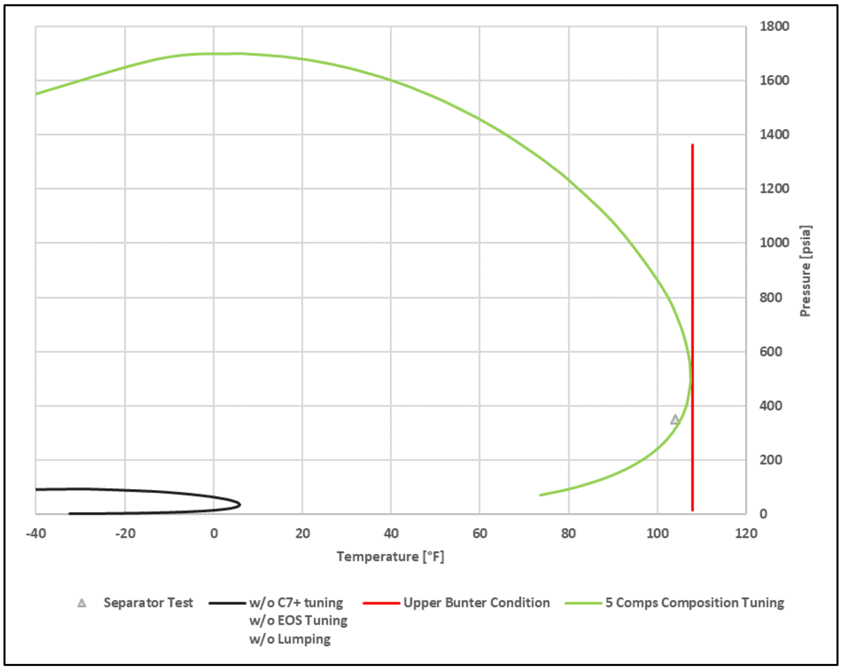

Figure 5-25: Upper bunter Lumped and Tuned EOS model

The lumping scheme is the same mentioned in section 5.6.1 with the adoption of the same criteria: Figure 5-25 shows the results of the tuned EOS model: at this stage the relative difference between the Separator GLR and the calculated one is less than 25%

5.6.3. WATER PROPERTIES

For the Hewett area neither water samples nor separator water are available: Salinity in terms of NaCl equivalent [2] is available for the two reservoir, with the respective ranges reported in Table 5-4:

Formation	Salinity range (kppm)
Upper Bunter	70 – 90
Lower Bunter	120-140

Table 5-4: Water Properties

5.6.4. CO2 CHARACTERIZATION FOR RESERVOIR MODELING

The project foresees a constant injection of $6 \cdot 10^6$ t/y of CO2, however no detailed spefication of the stream composition are available at this stage. Henceforth the injection stream will be composed by 100% CO2.
Thermodynamic properties of CO2 are well modeled in literature (Figure 5-26): for reservoir modeling purposes the same EOS of the two reservoir applies.

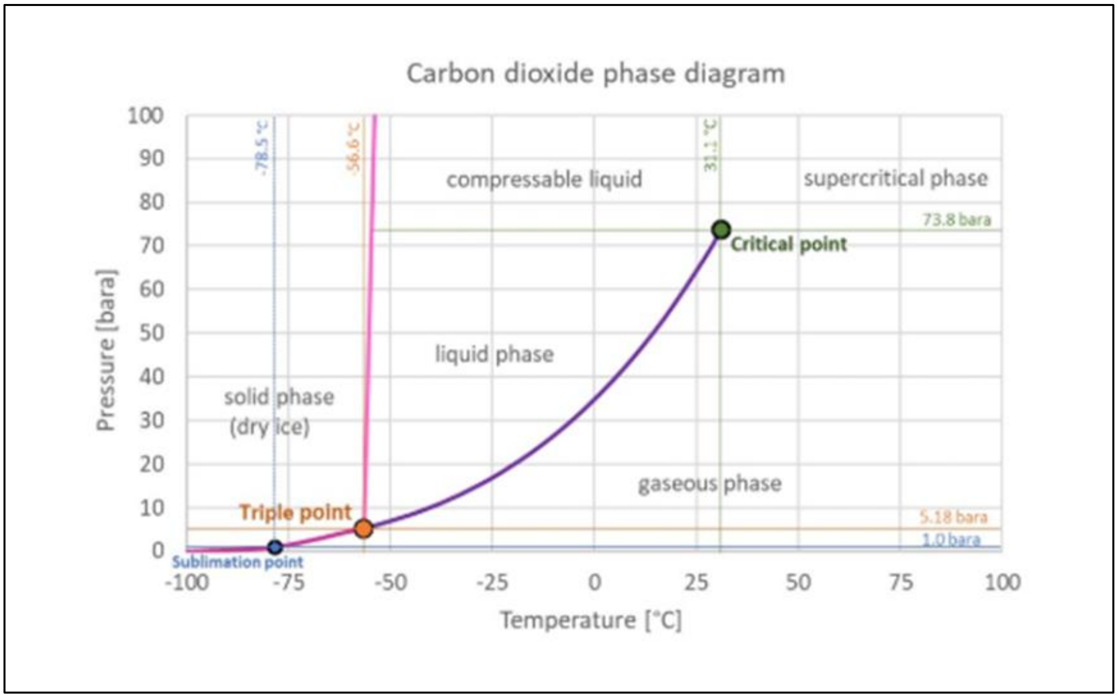

Figure 5-26: CO2 Envelope

5.6.5. SATURATION AND ROCK FUNCTIONS

No SCAL data are available for the Hewett reservoir units, henceforth the search from analogous formation has been a necessity to model the fluid flow within the porous medium. The initial saturation function tables come from an analogue reservoir located in the Liverpool Bay area, which shows similar reservoir characteristics (comparable φ- and k- ranges)

The relative permeability curves are depicted in the plots below (Figure *5-27*) in which both drainage and imbibiion curves are depicted. One may note that, being the Hewett sandstones gas-bearing, only the upper portion of the Krg(Sg) curves (i.e. Sg=1) is explored during the reservoir life

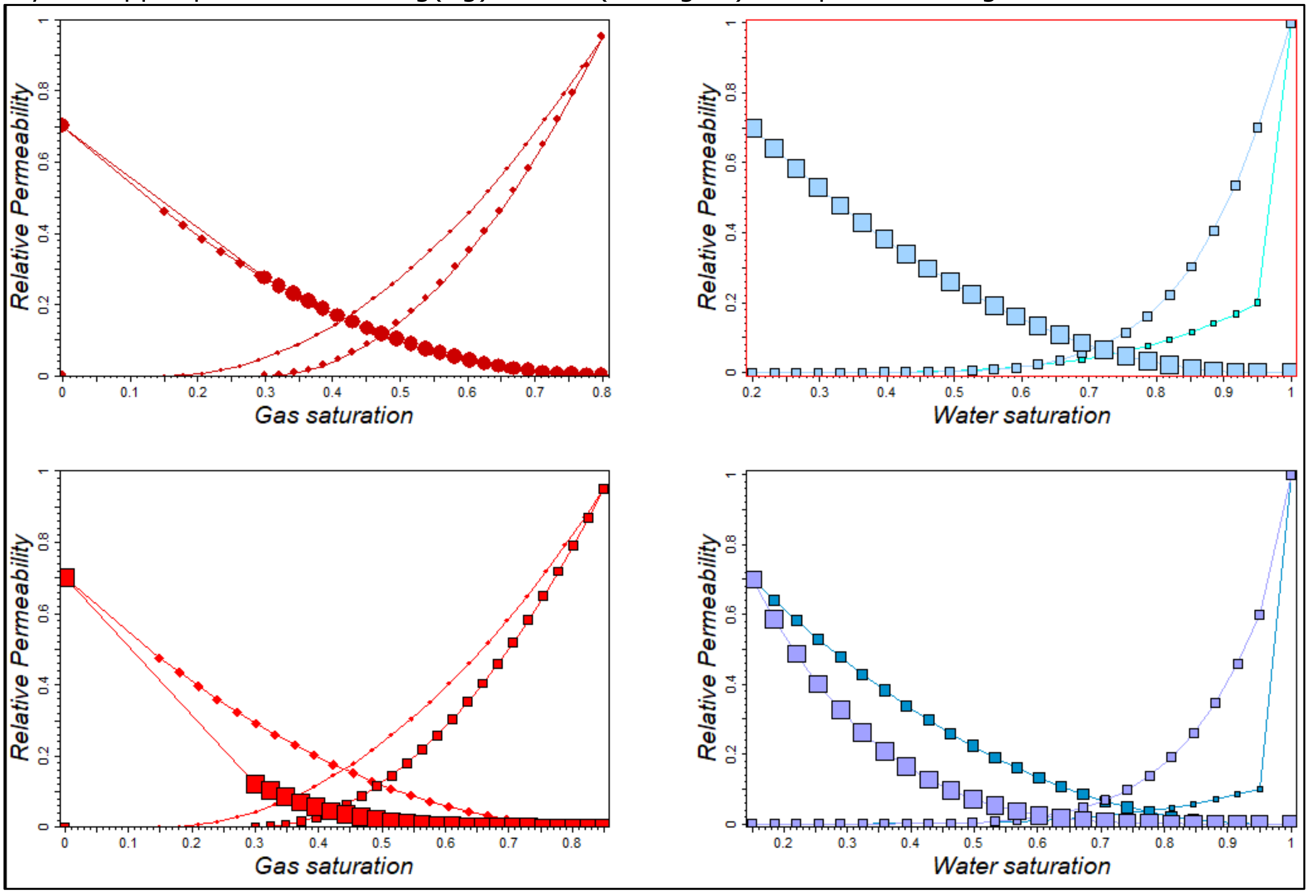

Figure 5-27: Saturation Function: Upper Bunter drainage and imbibition (top left: gas, top right water); Lower Bunter drainage and imbibition (bottom left: gas, bottom right: water)

Imbibition curves are introduced to mimick the future back-displacement of water in case of injection within a reservoir that bears mobile water, thus allowing the simulation of gas trapping phenomena.
Given the absence of oil rims at reservoir condition and the negligible interaction within gas and water, capillary pressure curves are set to 0 for every saturation
No experimental data are available for the rock compressibility: the default value set by intersect (i.e $2.2 \cdot 10^{6}$ psi^{-1}) is used

6. INITIALIZATION AND VOLUMETRIC CONSISTENCY

Following the contact identification described in section 6.2, two distinct equilibration region have been defined, with the intial condition set depicted in Table 6-1. No acquifers have been introduced in the numerical model.

Hewett Level	Datum Pressure (psia)	Datum Depth (ft TVDSS)	Gas Water Contact (ft TVDSS)	Temperature (°F)
Upper Bunter	1985	4200	4415	126
Lower Bunter	1362	2900	3020	108

Table 6-1: Initial condition

All the wells are perforated within the reservoir section, either in the Upper Bunter or the Lower Bunter: no commingle production has been reported during the field exploitation, as per the Well report and well intervention history: no details are available for the completion diagram, henceforth no VLP computation have been performed. Each of the well run in RESV (**Res**ervoir **V**olume) to ensure that the reservoir pore volume is adequate enough to sustain the production given the PVT properties descripted in section 5.5.
The grid model, composed by almost $5{\cdot}10^6$ cells (as described in section 6.1) was initialized without upscaling using Intersect (IX) as reservoir simulator. Consistency checks have been performed to ensure static equilibrium of the fluid system: the reservoir fluid stays stable after 30 years of simulation without any production, with $\Delta p(t) \approx 0 \,\forall t$. Static volumes were calculated per region assuming the distributed water saturation, NTG and Porosity as per the modelling process described in Section 5.4
The results of the initialization, in terms of static vs. dynamic model comparison, is highlighted in Table 6-2: Hewett volumes: static vs. dynamicTable 6-2.ERRORE. L'ORIGINE RIFERIMENTO NON È STATA TROVATA.

Hewett Level	Initial Static volume (10^9 scf)	Initial Dynamic volume (10^9 scf))	Delta to static (%)
Upper Bunter	1320	1253	-5%
Lower Bunter	2380	2301	-1%

Table 6-2: Hewett volumes: static vs. dynamic

One may note a difference among the static and the initialized dynamic models which might be imputed to structural modelling: all the control points of the whole grid are located among the major axis of the reservoir (namely NE-SW), providing little control on the lateral behaviour of the horizons. Henceforth an introduction of pore volume multipliers has to be foreseen to properly evaluate the dynamic behaviour of the reservoir fluid.

6.1. MODEL VALIDATION (History Match)

The history matching phase objectives have been:

- Honor the gas production rate
- Match the available pressure points
- Reproduce the mentioned produced water

As per the description in the previous sessions, and given the reservoir volumes produced up to February 2019 highlighted in Section 5.5 the history matching has been performed by adjusting primarly the pore volume multipliers to take into account the lack of lateral control of the structure Given the lack of a detailed well equipment description, all the wells have been described as a volumetric point source without performing any THP calculation.

In addition, due to the absence of a clearly identified Gas Water Contact in the Lower Bunter reservoir, all the cells falling below the GDT have been deactivated.

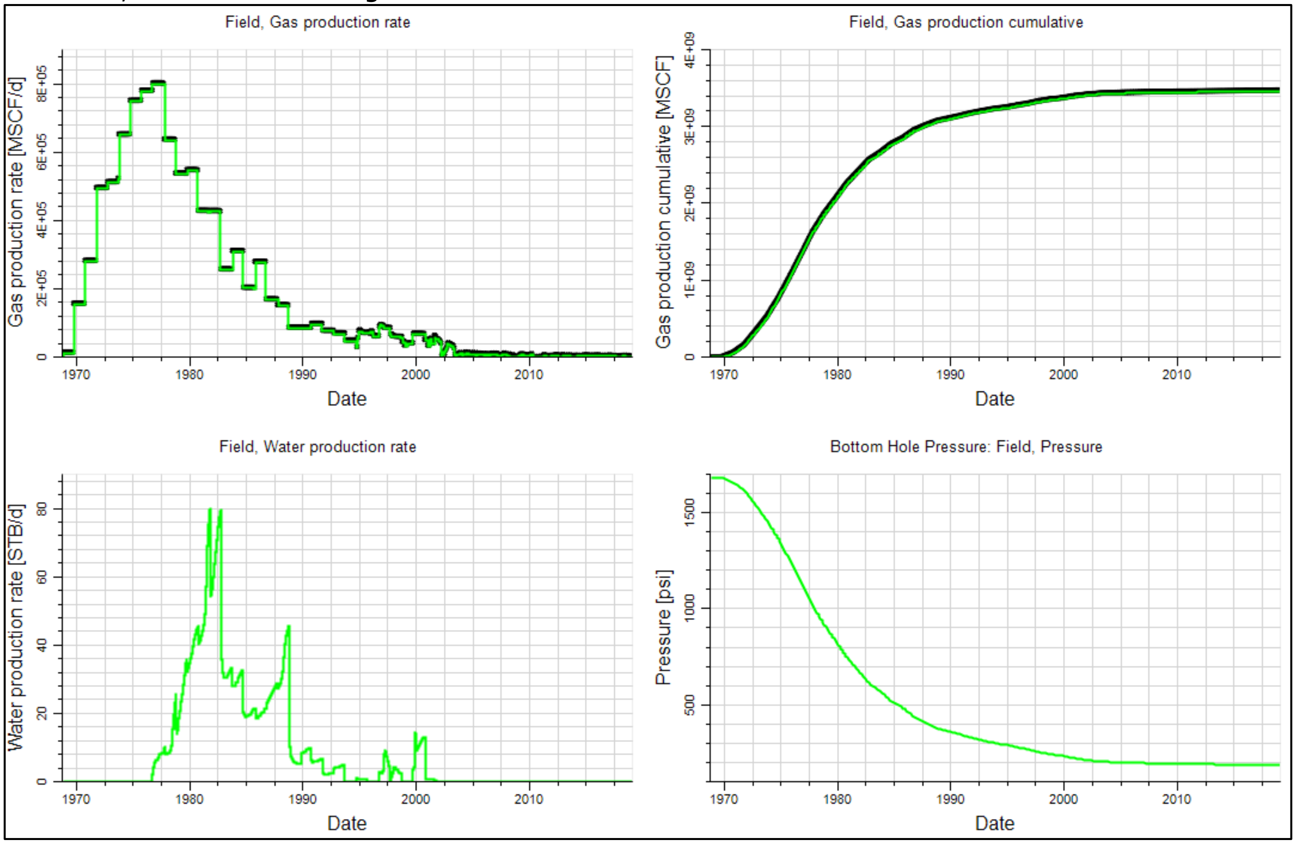

Figure 6-1: Hewett Field History matched model

Figure 6-1 shows the history match results at field level: gas production rates are honoured for each of the well involved in the field exploitation. The elapsed time for the simulation is approximately 1.5 hours with 256 processors

Figure 6-2Errore. L'origine riferimento non è stata trovata. to Figure 6-4 show the match of the available SIBHP data: the overall match quality is good, with a satisfactory reproduction of initial pressure and the main depletion experienced during the field exploitation.

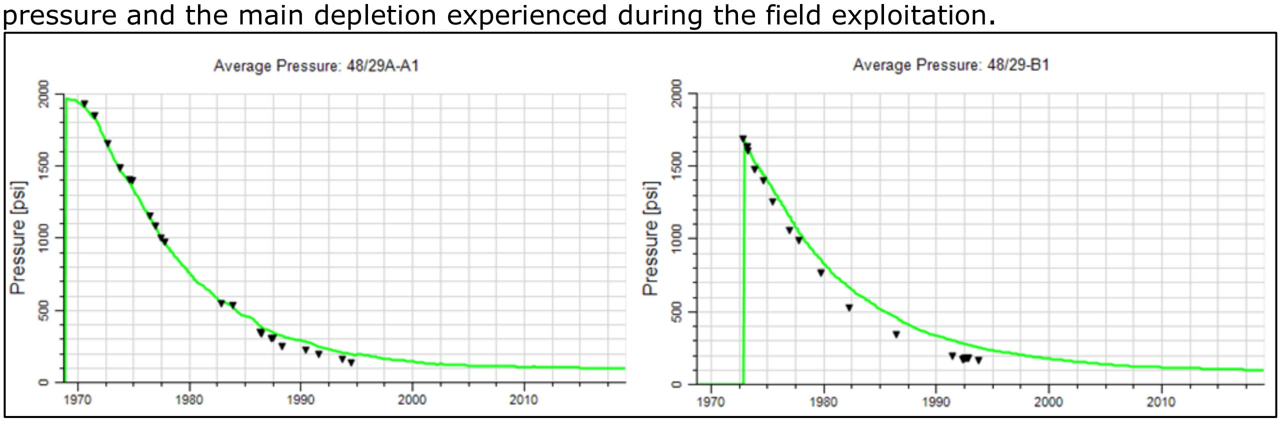

Figure 6-2: Lower Bunter wells: 48/29-a1 (left); 48/29-b1 (right)

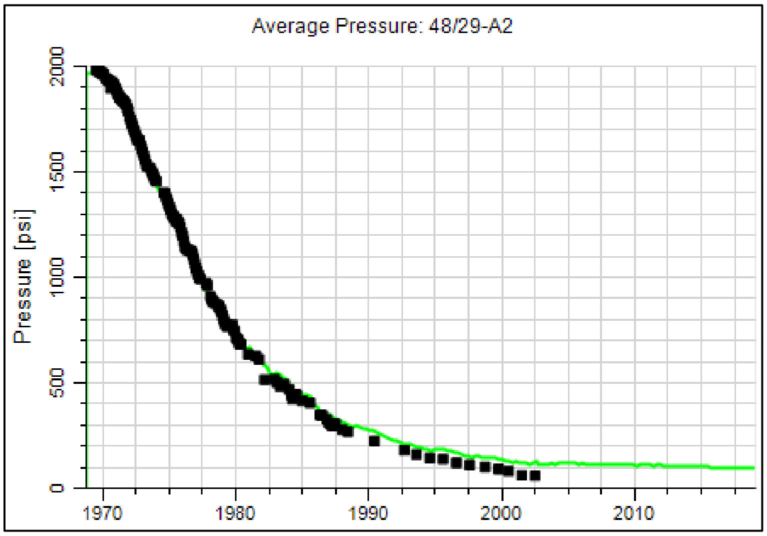

Figure 6-3: Lower Bunter 48/29-a2, pressures

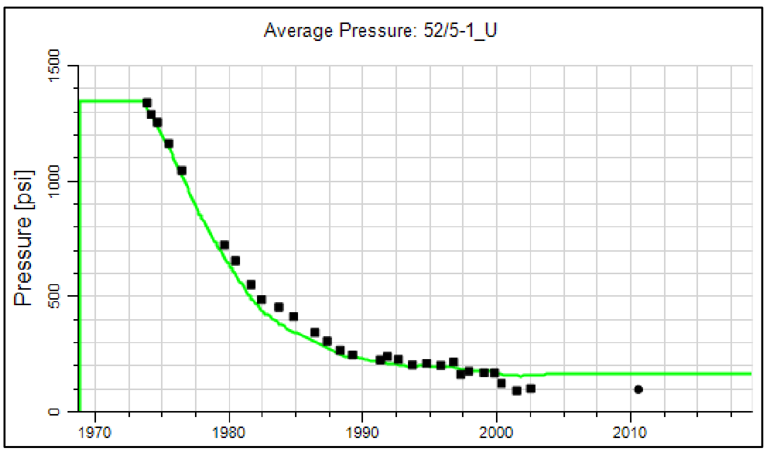

Figure 6-4: Upper Bunter 52/5-1: rates (left); pressures (right)

The shut-in wellhead pressures, available from 2010 onwards, have been used as a soft trend for validating the pressure match as mentioned in the previous section.

The average reservoir pressure at the end of the history match henceforth are:

- **346 psia** for the Upper Bunter Reservoir
- **115 psia** for the Lower Bunter Reservoir

Table 6-3 shows the Initial Static and the HM volumes, with the associated variation

Hewett Upper Bunter [10^{12} scf]			**Hewett Lower Bunter [10^{12} scf]**			**Grand Total [10^{12} scf]**		
Static	*HM*	***Δ [%]***	*Static*	*HM*	***Δ [%]***	*Static*	*HM*	***Δ [%]***
1.32	1.37	**4%**	2.38	2.17	**-7%**	3.65	3.54	**-3%**

Table 6-3: History Matched volumes

Whe following figure (Figure *6-5*) shows gas density distribution inside UB and LB reservoir.

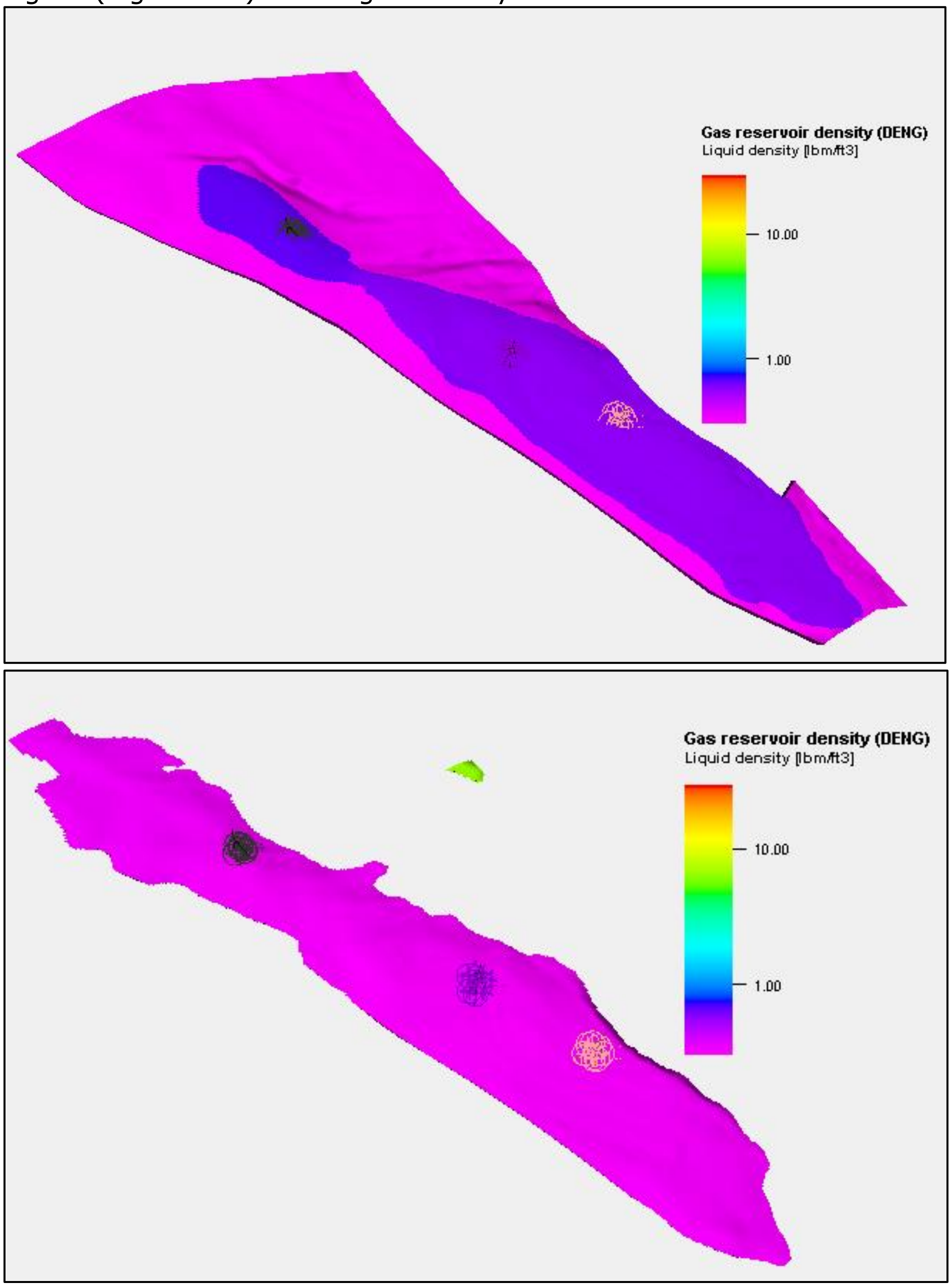

Figure 6-5: Gas densities: Upper Bunter (top), Lower Bunter (bottom)

6.2. DEVELOPMENT SCENARIOS

The development scenarios for the purposes of the CCS study stick to the following workflow:

- Preliminary Capacity estimate
- Assessment of the existing well status
- Definition of the injection strategy
- Well Modeling
- 3D simulation

For the specific case of the Hewett field only the forecast injection rate is defined, with an expected tonnage equal to 6 10^6 metric tonnes per year (**MTPA** from now on) corresponding to ca. $9 \cdot 10^6$ sm^3/d. The preliminary capacity estimate led to the following results:

- 120 10^6 t for the Upper Bunter Unit
- 206 10^6 t for the Lower Bunter Unit

With those figures, which represent the maximum theoretical capacity, the definition of the injection points and strategy has been carried out taking into account:

- Existing/legacy well status
- Reservoir quality
- Fault proximity

Hewett field exploitation started in the early 1970s, henceforth the average age of the wells is around 50y, rendering them not viable for Carbon Dioxide injection especially for corrosion-related issues. Also Sidetracked wells are not practical because of the status of the parent holes (cased or not), no more accessible. Further details are available in the drilling section of the CCS reservoir study.

The situation of the existing/legacy wells led to the definition of a new injection point considering all the factors defined above. Focusing on the reservoir part, good quality sandstones with lateral continuity guarantees sufficient pore space to accommodate the injected fluid. Mid-high permeability, combined with the thickness, can provide high injectivity allowing a smooth increase in pressure with limited pressure drop across the perforations.

Hewett field complies with all the requirements listed above (figures of merit are described in Section 5.4): the most adequate location for CO_2 delivery is the central area of the field, almost midway between the 52/5-A and 48/29A platforms. The injectors are closer to the central culmination, allowing CO2 dispersion, which in turns allows the exploitation of the reservoir as a whole.

As Figure 6-6 and Figure 6-7 depict, the location of the platform would allow also a future injection in the Upper Bunter unit, being closer to the top of the South-western culmination

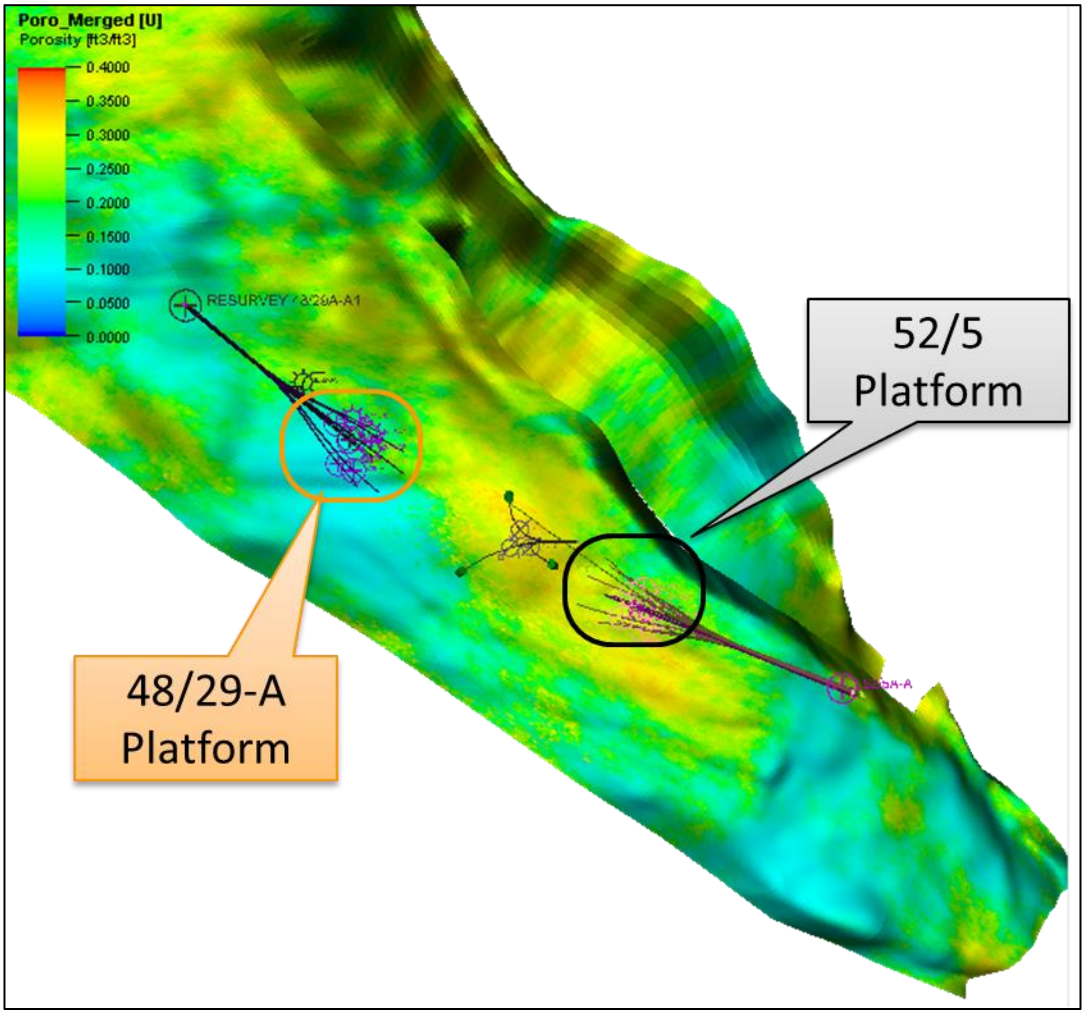

Figure 6-6: Top Upper Bunter injector platform location

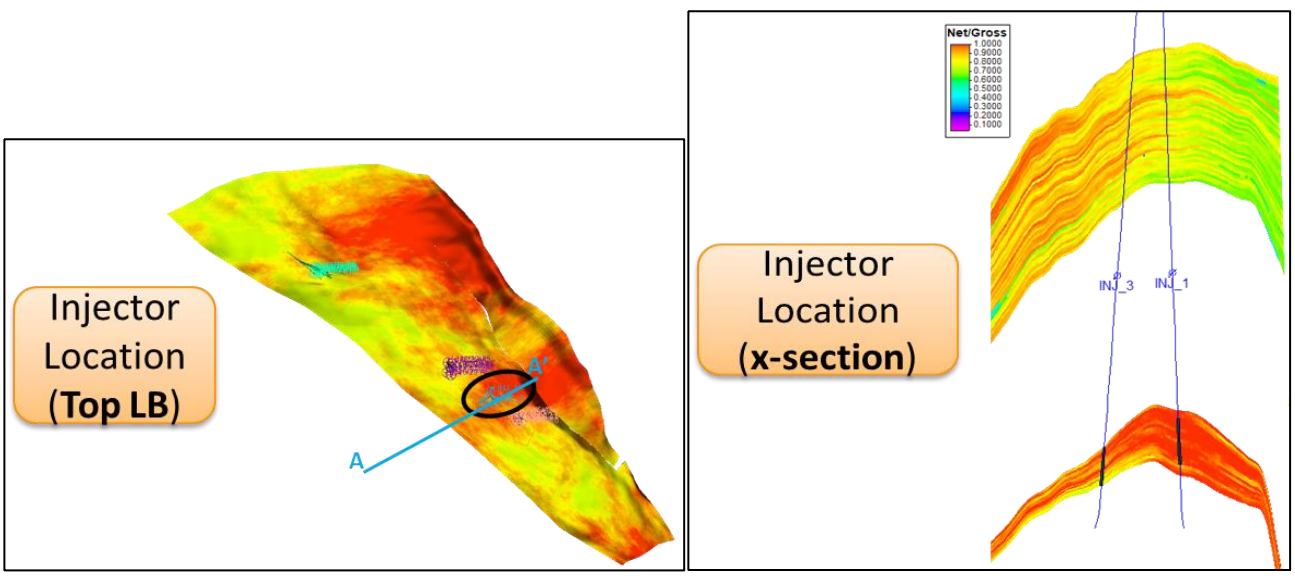

Figure 6-7: NTG and Injector Location. Top view (left); Side view (right)

The well trajectory definition come from a neighbouring field (gas bearing sandstone, depleted): a deviated well with an average inclination of 50° to increase the contact area between the CO2 source and the reservoir (given the thickness of the formation, almost uniform around 100 ft).
Given the well trajectories, the model set-up in PROSPER required the injection fluid specifics and temperature. The modelling of the Vertical Lift Performance curve (**VLP**s from now on) has developed with the subsequent assumption:

- Single completion well ($3\frac{1}{2}$ in to $9\frac{5}{8}$ in)
- Injection temperature: 40 °C or 10°C

The calculation of the VLPs have been performend accounting for

- Reservoir Temperature (52.2 °C)
- Injection Temperature (10 °C, 40 °C)
- Injection rate range: 0 – $4{\cdot}10^6$ sm^3/d
- THP range: 5 – 200 bar
- Perforation depths
- Fracturing pressure (estimated): 105 bar

The VLP and the Bottom hole temperature (**BHT** from now on) for the 40 °C scenario are illustrated in Figure 6-8: the exploitable regimes fall all below the fracturing pressure, and no freezing of the injected fluid is predicted at bottom hole during the field re-pressurisation.

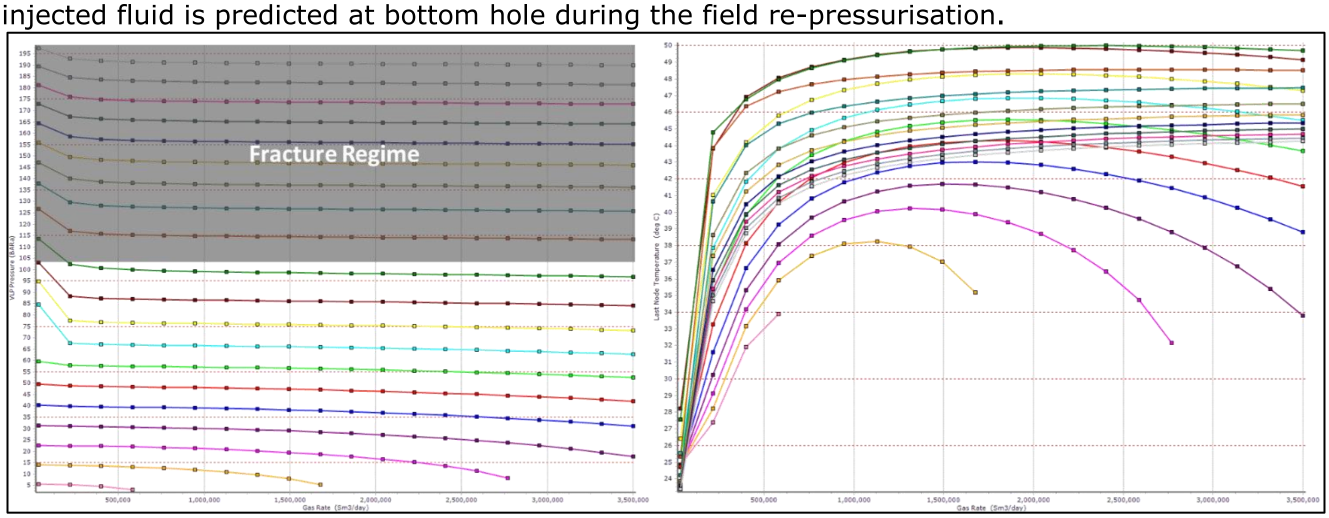

Figure 6-8: 40° injection VLP. BHP (left), BHT (right)

For the 10° C Tubing Head Temperature (**THT** from now on), a few more considerations take place:

- **Bottom hole freezing**: BHT may lower far below 0°C because of gas expansion, causing either formation water freezing or Hydrate formation. This limits the injection rate
- **Unstable flow**: close to the CO2 vaporization line , i.e. $p_{vap}(T = 10\,°C) \approx 46\,bara$, slug/bubble flow may arise, posing another cap on the injection rate
- **Two-phase flow**: presence of two phase flow within the tubing string. This caps the maximum THP

All the above consideration, depicted in Figure *6-9* poses the necessity to find a smaller completion diameter to guarantee the absence of phase transition/freezing in any point across the well.
The single phase is ensured via a recompletion option: to keep the bottom hole condition (pressure, injection) different combination of tubing were tested to

- Being able to inject the maximum rate in gas phase (i.e. 3.0 10^6 sm^3/d)

- maintain the working point (i.e. 46 bar at bottom hole)
- Being able to inject the maximum rate in liquid phase

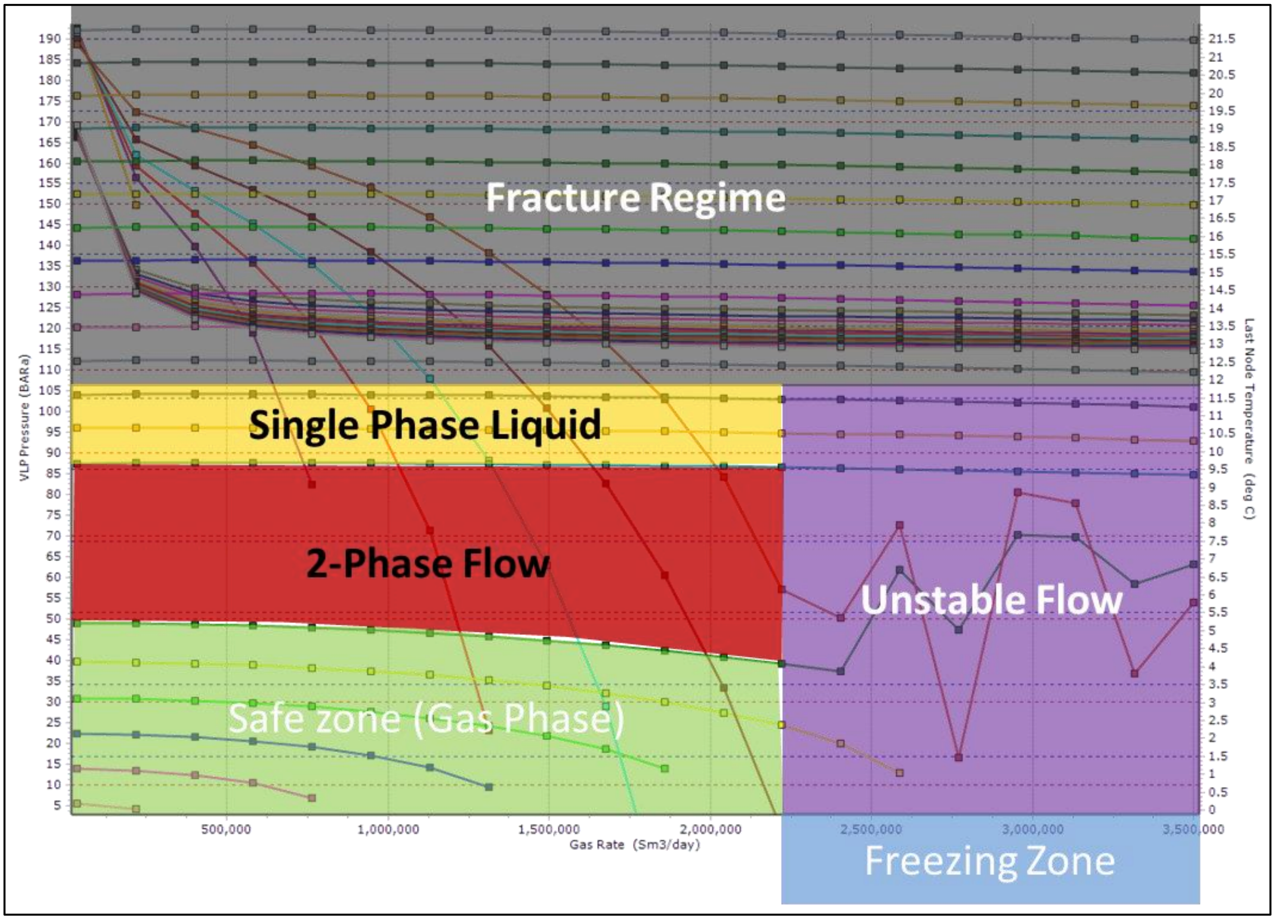

Figure 6-9: Low T scenario: regions

Figure *6-10* shows the combination of completion selected according to the workflow listed above: the yellow bold cross represents the working condition for the injector wells.

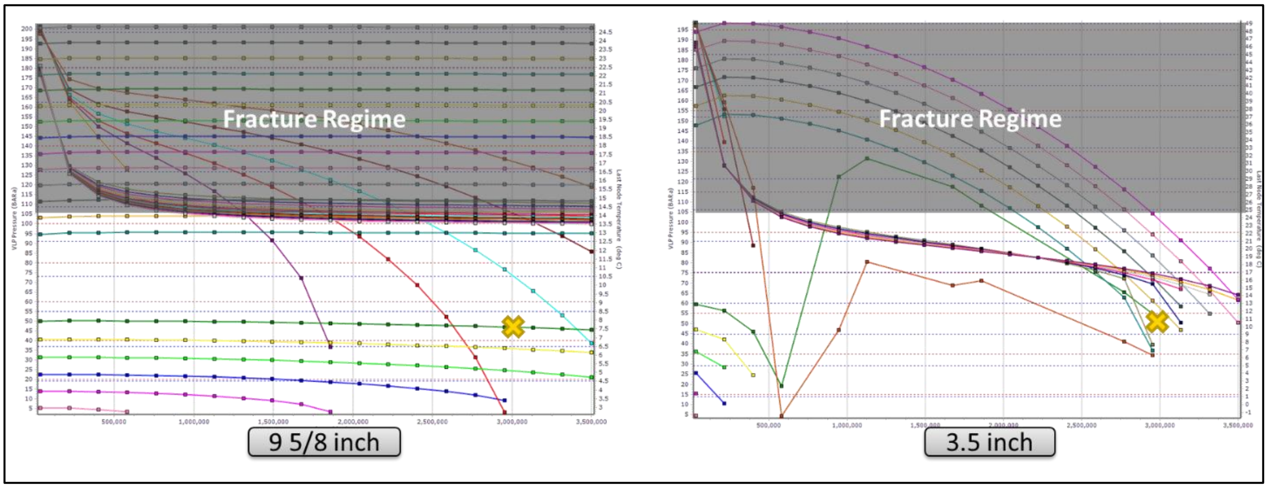

Figure 6-10: Low T scenario: recompletion

To favour the re-pressurization of the reservoir and avoid excessive pressure drop at perforation level, thus counteracting the *Joule-Thompson* effect, the injection strategy foresees an initial ramp-up to target rate in 5 years, followed by a 25 y steady state injection. Moreover this step rate program might be feasible for monitoring purposes. Figure 6-11 shows the implementation in IX syntax with a graph of the constraint.

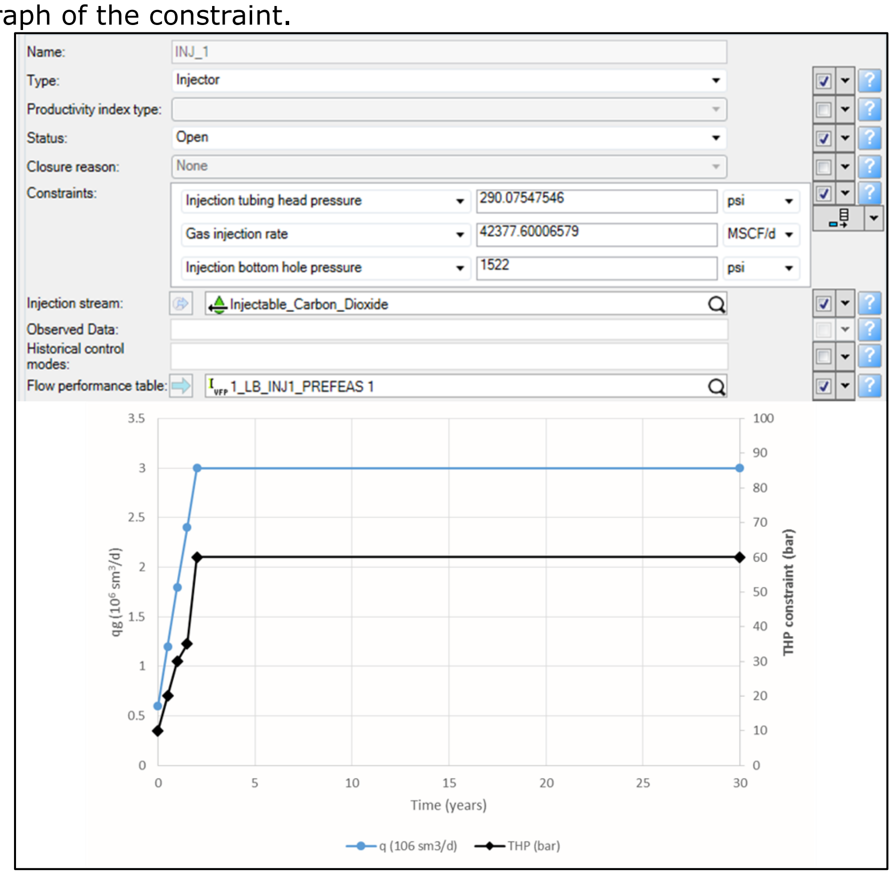

Figure 6-11: Rate constraint

The results of the injection scenario, as shown in Figure *6-12*, shows that for a 30 y injection period the Lower Bunter reservoir is capable to accommodate $180 \cdot 10^6$ t of CO_2 within the given set of boundary conditions.

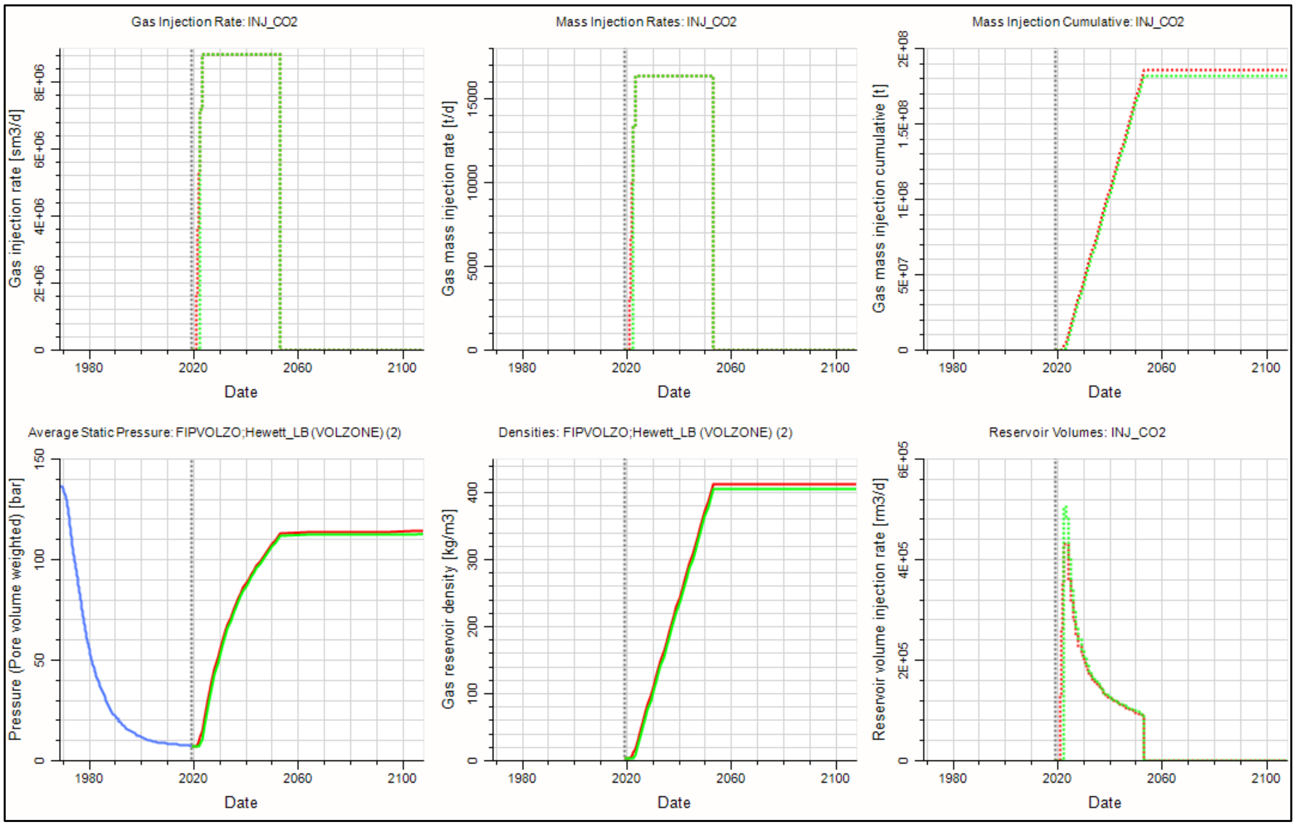

Figure 6-12: Lower Bunter injection scenario: history match (fluo green); 40° C injection (red line); 10° injection (blue line).

Given the fast dynamics occurring at the beginning of the injection, the simulation time for the whole run (injection + stabilization) is approximately 11 hours with 256 processors.
After the simulation the analysis of the well performances (Figure *6-13*) has shown that

- The wells are able to inject up to $3 \cdot 10^6$ sm^3/d without any major issues
- Each well can store one third of the total cumulative
- The reservoir reaches an average pressure of 110 bara in 30 y, lower than the initial one
- The gas density increases up to 400 kg/m3, due to CO_2 transition from dense gas to supercritical phase
- THP trend smooths out during time

Moreover, the difference between the flowing BHP (**WBHP**) and the average static pressure calculated in IX (namely **WBPC_3**) is less than 1 bar, as Figure *6-14* show. This limits the severity of the cooling across the perforation length, the most critical point during the whole injection phase

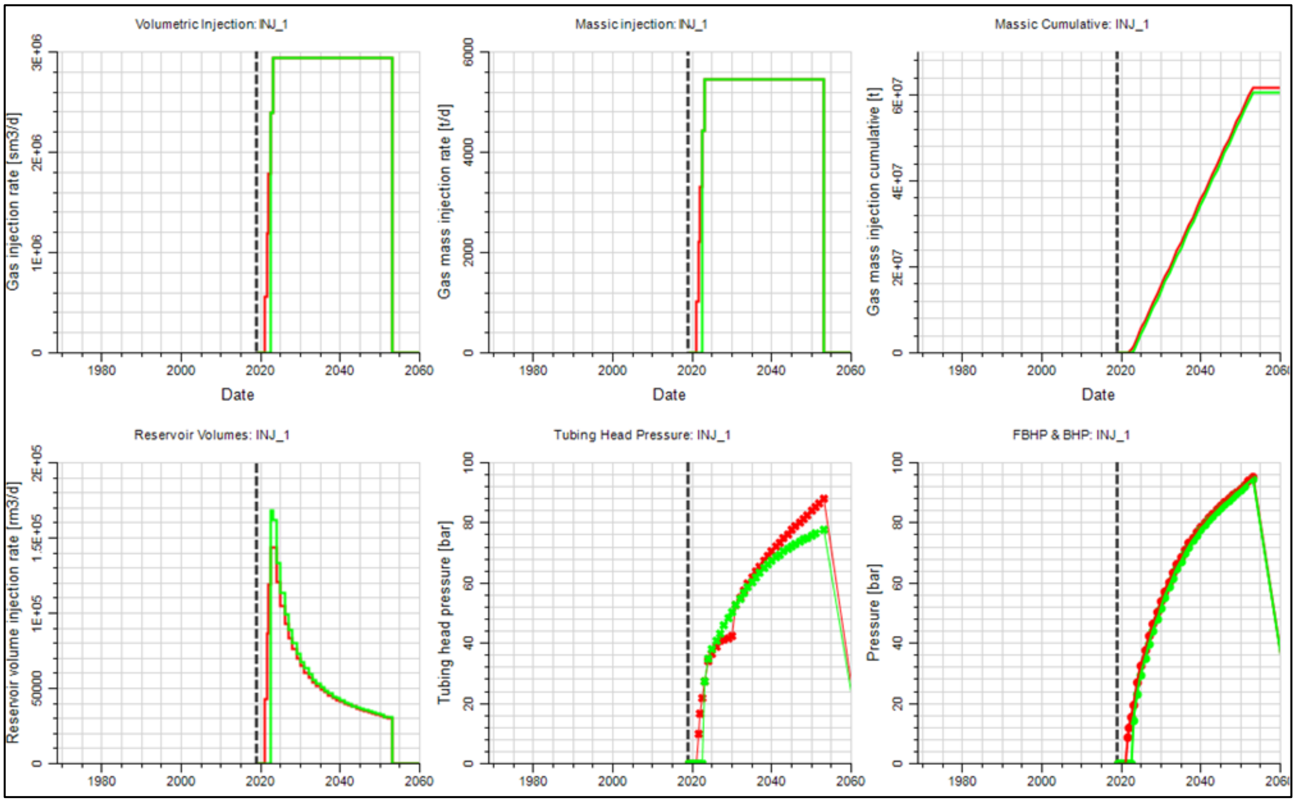

Figure 6-13: INJ_1 profiles

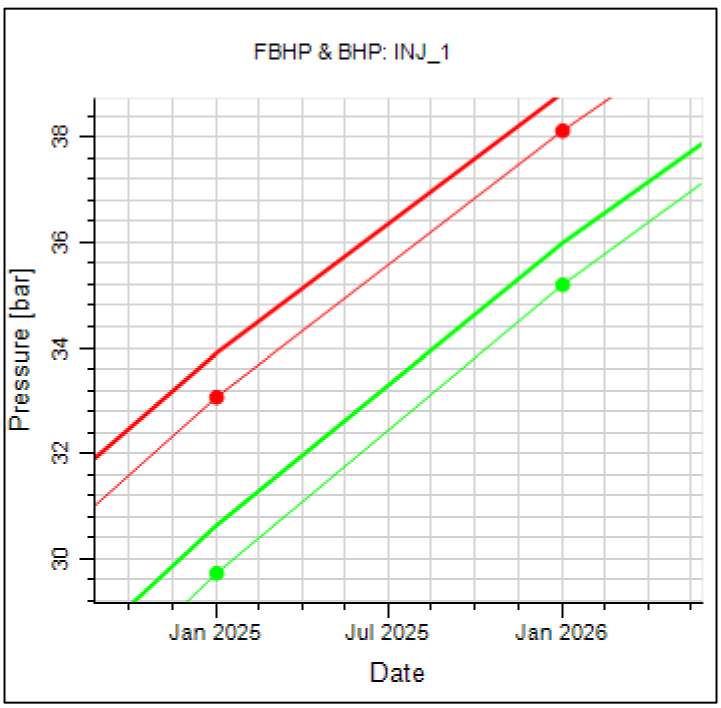

Figure 6-14: INJ_1 WBHP (dotted curve) vs WBPC_3 (continuous curve). 10 °C injection (red) and 40 °C injection (fluo green)

7. SPECIALISTIC STUDIES

7.1. GEOMECHANICAL STUDY CHARACTERIZATION

In order to perform a suitable geomechanical and thermo-mechanicall characterization for both cap rock and reservoirs, the following data are needed:

- Density, compressional and shear sonic logs
- Geomechanical tests results on reservoir and, possibly, cap rocks
- In situ stress measurements/data
- Thermal parameters for the formations under investigation

Data search has been performed in HQ and Eni UK databases and in the National Data Repository of the UK Oil & Gas Authority.

The results of the data scouting can be summarized as follows:

- No suitable set of logs, for geomechanical analyses, available for any Hewett wells
- No stress measurement performed in Hewett field (with the exception of some Leak Off Tests results)
- One report from Imperial College [3] concerning multi stage triaxial tests, perfomed on samples from wells 48/29-7, 48/29-B9, 48/30-13. Such geomechanical tests have been perfomed, however, on deeper reserovoir in the area and not on the Bunter sandstone.

In order to attempt building a consistent geomechanical model for the Bunter sandstones it has been decided to go on with the following program:

<u>Geomechanical & Thermal parameters</u>

- Extend the review of available geomechanical data to include wells' data from nearby fields and of eventual analogues from literature

<u>In situ stresses</u>

- Vertical stress: re-evaluation from available logs and implementation in 1D geomechanical model
- Horizontal stresses direction: update information from World Stress Map [4]
- Horizontal stress magnitudes: extend the review of available fields data to include wells' data from nearby fields (Dawn, Deborah) then use Deborah frac tests to calibrate stresses in Leman sandstone and its cap-rock and propagate the results to Bunter sandstones and their cap rocks.
- Implement a poro-elastic model, based upon Deborah calibration, for initial and actual stresses magnitudes
- Pore pressure from reservoir model

7.1.1 Geomechanical modelling: rock parameters

For the estimate of the rock strength, laboratory data and sonic logs from well 48/29-B9 have been used. In Table 7-1 are reported the results of the laboratory tests: it has to be highlighted that the Uniaxial Compressive Strength reported is computed form the Mohr-Coulomb failure envelope and not measured and refers to samples cut from the Leman sandstone reservoir.

Well	Depth	Log depth	UCS	UCS	Friction angle
	ft	ft	psi	MPa	deg
48/29-B9	6581.6	6601.6	1394	9.61	49
48/29-B9	6613.2	6633.2	894	6.16	39
48/29-B9	6648.2	6668.2	2039	14.06	33
48/29-B9	6737.9	6757.9	2396	16.5	32
48/29-B9	6795.9	6815.9	1432	9.87	25

Table 7-1: Summary of lab test performed on samples from well 48/29-B9.

Some literature available correlations between DTC and trength have been evaluated, focusing on the ones more appropriate for the lithologies of the North Sea. It turned out that the best result was obtained with the correlation (named as FORMEL) taken from ref. [5]:

$$UCS = 140 - 2.1 \cdot DTCO + 0.0083 \cdot DTCO^2$$

where DTCO is in us/ft and the resulting UCS in MPa.

In the last track of Figure 7-1 are reported the experimental UCS points and the estimated UCS curve: the agreement has been considered good for the purpose of the study and therefore the the FORMEL correlation has been used to estimate strength.

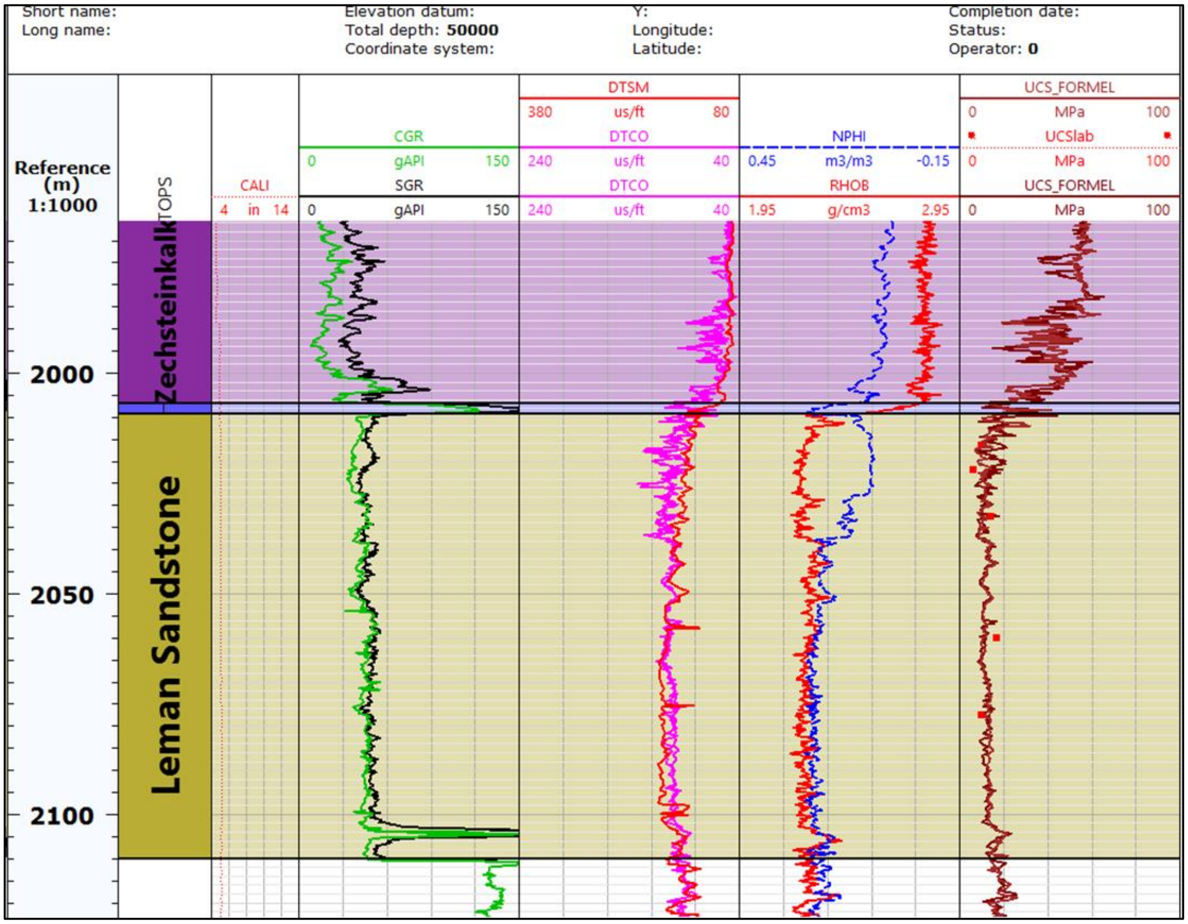

Figure 7-1: Geomechanical parameters -Well 48/29-B9

Another rock parameter useful to set up the mechanical earth models is the Poisson’s ratio: this has been evaluated from sonic logs and assuming that the dynamic Poisson’s ratio is equal to the static one.

Dynamic Young's modulus (E_{dyn}) has been evaluated from density and sonic logs. The static Young's modulus (E_{sta}), which is the one used for geomechanical evaluation, has been estimated from the following generic correlation, available in Techlog:

$$E_{sta} = 0.032 \cdot E_{dyn}^{1.632}$$

The correlation is reported to be based on a sandstone data set from the North Sea and it has been used as such, since it could not be calibrated due to the lack of experimental data.

Finally, the following rock thermal properties are needed for the thermomechanical models: thermal dilation coefficient, thermal conductivity and heat capacity. These data have been selected from literature data ([6], [7]), chosing average values reported for sandstones and shales.

In Table 7-2 the final geomechanical and thermal parameters are summarized that have been used for the modelling activities.

	Lower Bunter	**Bunter Shale**	**Upper Bunter**	**Hailsborough**
E [GPa]	8	5	8	5
ν [-]	0.22	0.3	0.28	0.30
φ [-]	0.20	0.027	0.20	0.07
K [mD]	1500	0.006	500	25
α [1/°C]	1e-5	1e-6	1e-5	1e-6
Thermal conductivity [W/(m·K)]	3	3	3	3
Heat capacity [J/(kg·K)]	1000	1400	1000	1400

Table 7-2: Final geomechanical and thermal parameters

7.1.2 In situ stresses

The direction of the horizontal stresses has been derived from the World Stress Map database [4], due to the lack of image or 4-arm caliper logs. The results are shown in Figure 7-2 where are reported the Hewett field together with the indicators of the maximum horizontal stress direction, both from well's breakout analyses (in black) and from earthquakes focal mechanisms (in colors).

It appears that the general trend of the maximum horizontal direction in the Hewett area is NW-SE and an average azimuth of 130 deg can be reasonably assumed for the field.

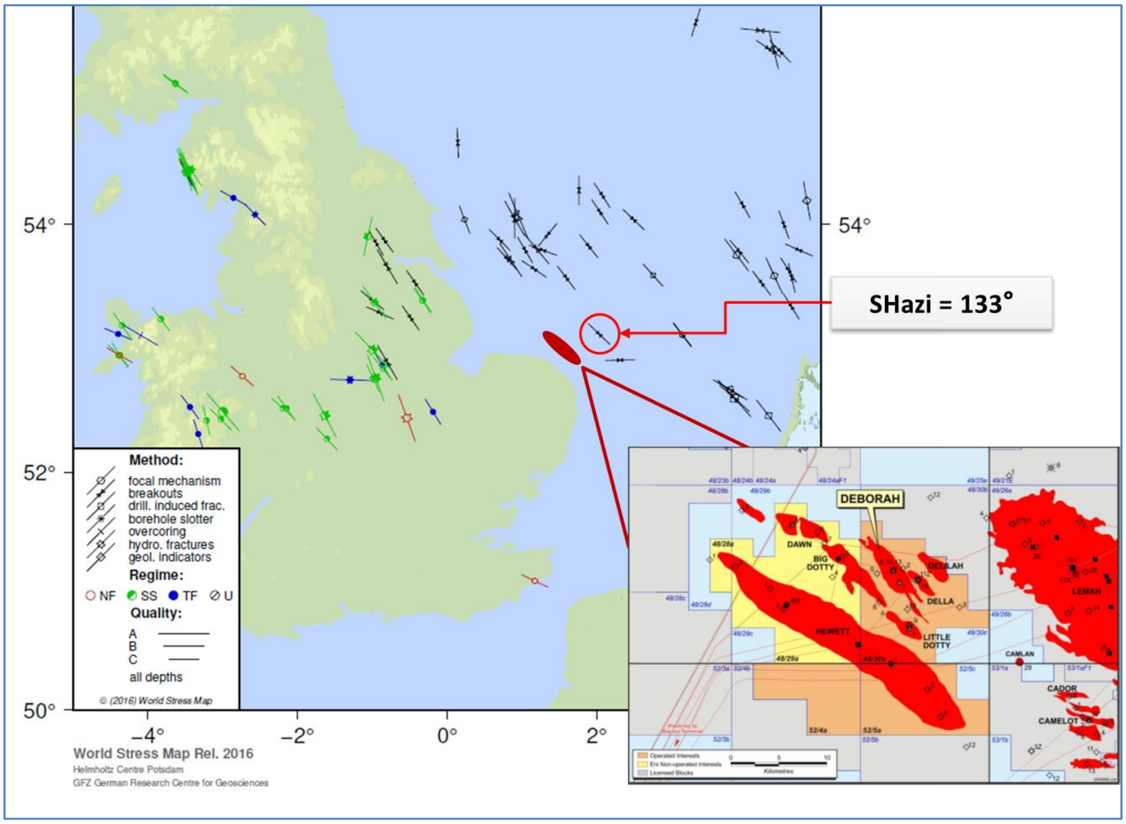

Figure 7-2: Maximum horizontal stress direction for UK and Central North Sea area (from [4]).

The horizontal stress magnitudes has been estimated according to the subsequent workflow:

- Stress data (frac tests) and the minimum required set of logs (density, compressional and shear sonic slwnesses) were available from Deborah wells 48/30A-20, both in Bunter sandstone (aquifers in Deborah) and Bunter shales.
- Closure pressure –i.e. minimum horizontal stress magnitude, from stress tests, available in Leman sandstone (Deborah reservoir) and its shale/carbonate caprock (Figure 7-2)
- With the data derived from the logs, namely the overburden stress and the Poisson's ratio, and the pore pressure values available from the former Deborah study, setup and calibration of a poro-elastic stress model for the Leman sandstone and its caprock.
- Extend the derived stress model in Bunter shale and sandstones. Normal state of stress (with certain horizontal anisotropy) has been assumed, according to both regional stress information and verification against wellbore behaviour.
- Where no shear sonic log is available, (e.g. Dawn well 48/29-9) the Greenberg-Castagna model has been used, calibrating it from the 48/30A-20 data and using the calibrated model to estimate shear slowness from the compressional one.

The uniaxial strain condition has been assumed for the evaluation of the variation of horizontal stress vs. the depletion; the total stress variation ΔS_h for a given depletion ΔP is given by:

$$\Delta S_h = \frac{1-2\nu}{1-\nu}\Delta P$$

where ν is the Poisson's ratio.

In Figure 7-3 are summarized the resulting vertical and minimum horizontal stresses in Leman sandstone and its cap rocks (thin Kupferschiefer shale and Zechsteinkalk layers). In particular, in track 5 are shown:

Vertical stress (black line)
Initial Pore pressure (blue line)
Pore pressure after depletion (blue dashed line)
Initial minimum horizontal stress (green line)
Minimum horizontal stress after depletion (green dashed line)
Closure pressure from frac tests (red diamonds)
Measured breakdown pressure (blue circles)
Estimated break down pressure (in reservoir, thin dashed blue curve)

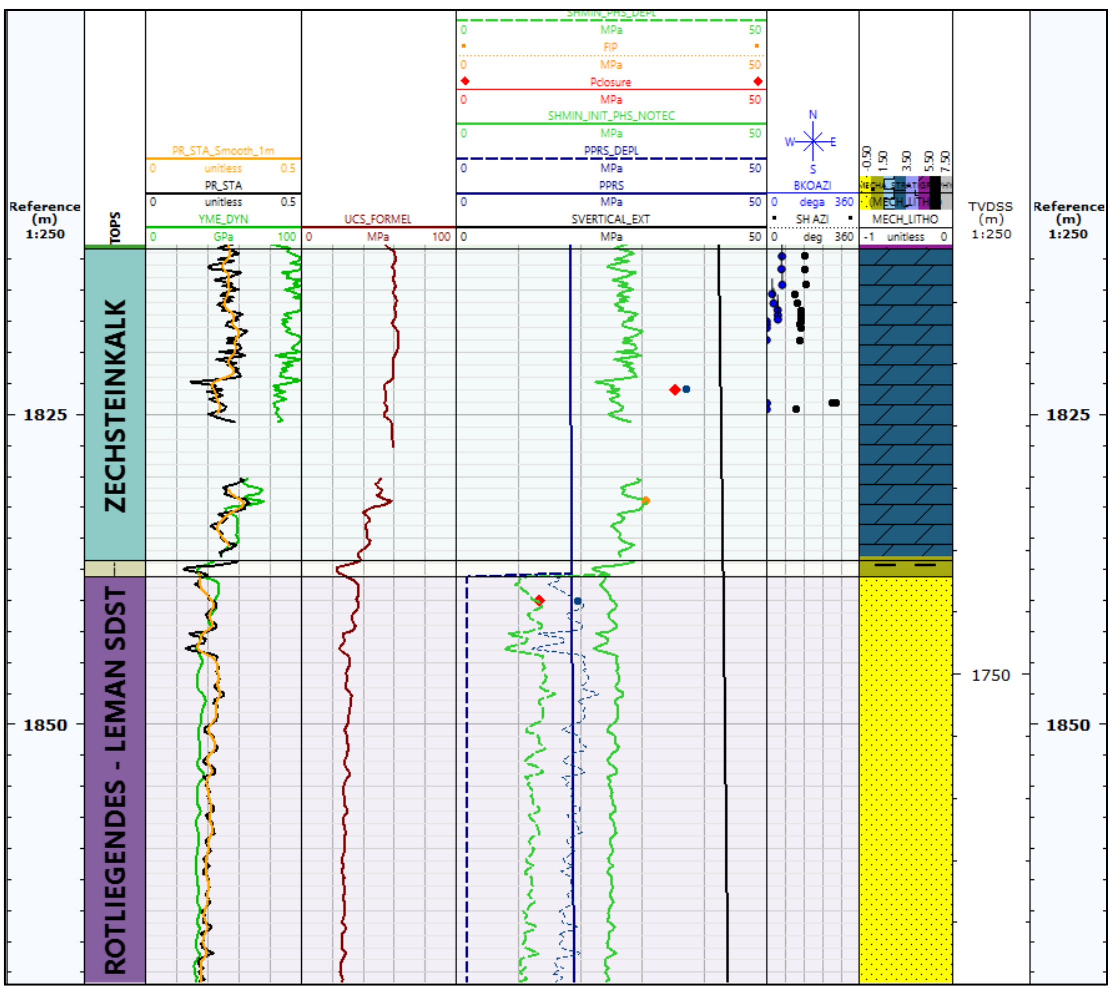

Figure 7-3: Well 48/30A-20: Stresses and rock parameters for the top of Leman sdst. and caprocks.

It can be observed that in the reservoir the measured closure pressure is well captured by the poro-elastic minimum stress evaluation, as well as it is the observed breakdown pressure vs. the estimated one.

In the Zechsteinkalk dolomitic cap rock, the agreement is not so good. One possible justification could be that the fracture did not close completely, indeed the closure pressure is quite close to the breakdown one, due to the low permeability of the caprock.

Given the good match obtained in Leman sandstone, the standard poro-elastic stress model has been used to estimate the horizontal stress for the shallower Bunter sandstones and shales.

Like in Figure 7-3, in **Errore. L'origine riferimento non è stata trovata.**Figure 7-4 and **Errore. L'origine riferimento non è stata trovata.Errore. L'origine riferimento non è stata trovata.** are reported the data for the Lower Bunter and its caprocks (Brockelshiefer shale and Bunter shale) and for the Upper Bunter and its caprock, which in well 48/30A-20 is given by dolomitic and shale interlayers.

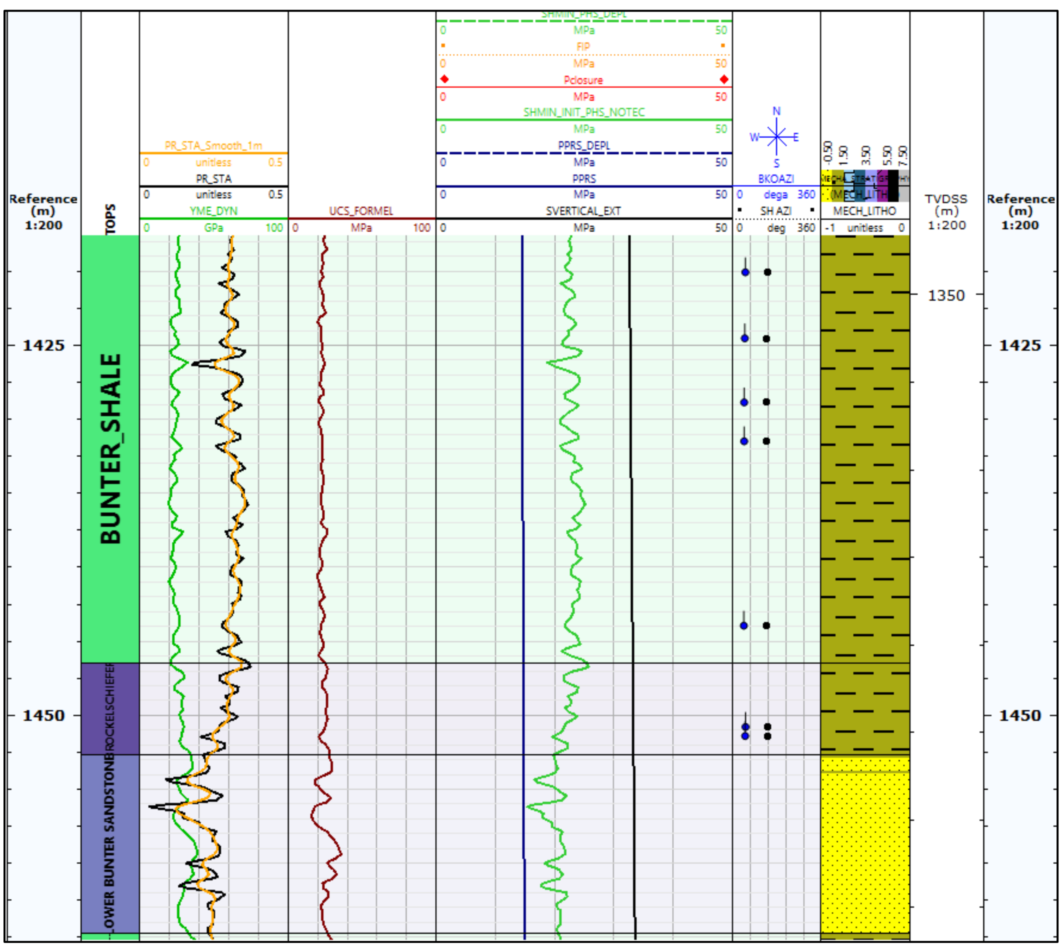

Figure 7-4: Well 48/30A-20: Stresses and rock parameters for the Lower Bunter and its caprocks.

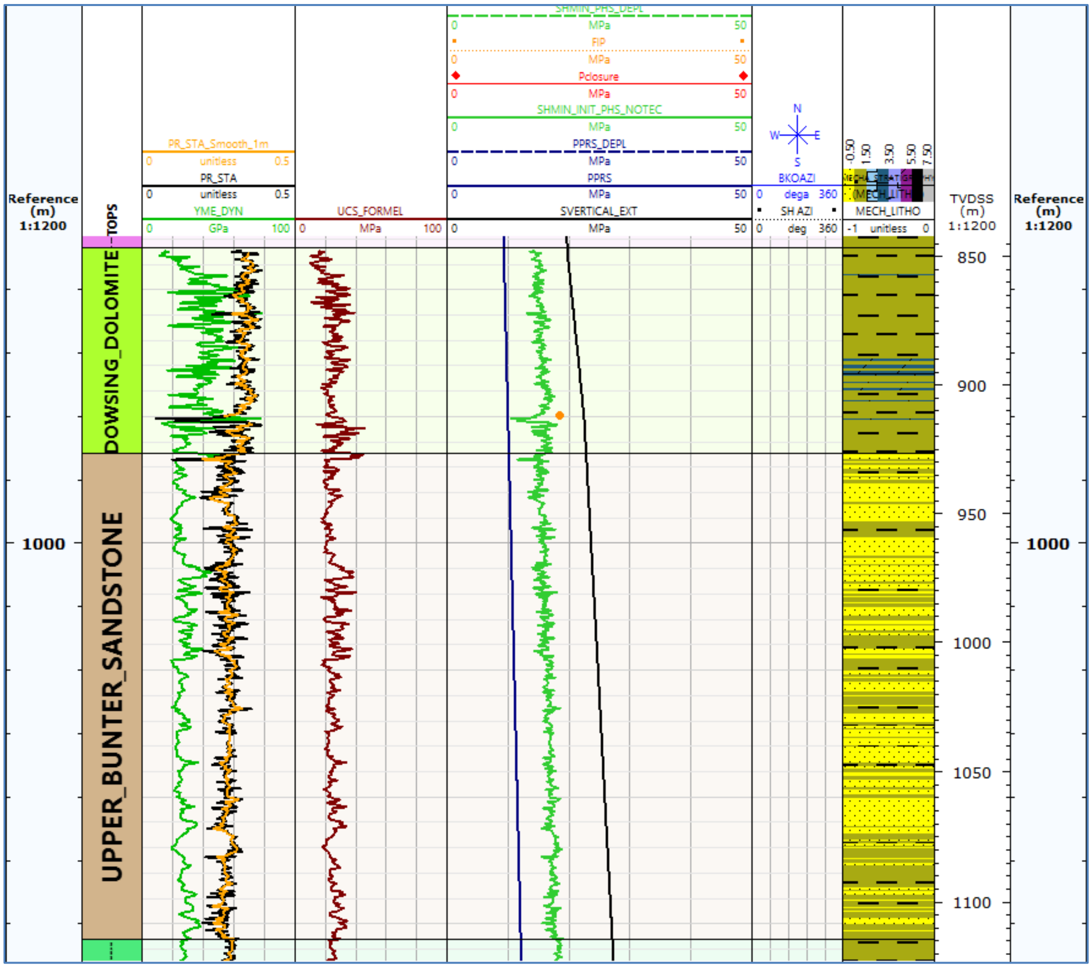

Figure 7-5: Well 48/30A-20: Stresses and rock parameters for the Upper Bunter and its caprocks.

In Figure 7-6 are reported the stresses and rock parameters for well 48/29-9 where logs were available for the Lower Bunter layer and for the the lowermost part of the Bunter Shale. For the evaluation of the depleted stress condition, a pore pressure equal to 0.3 MPa has been assumed.

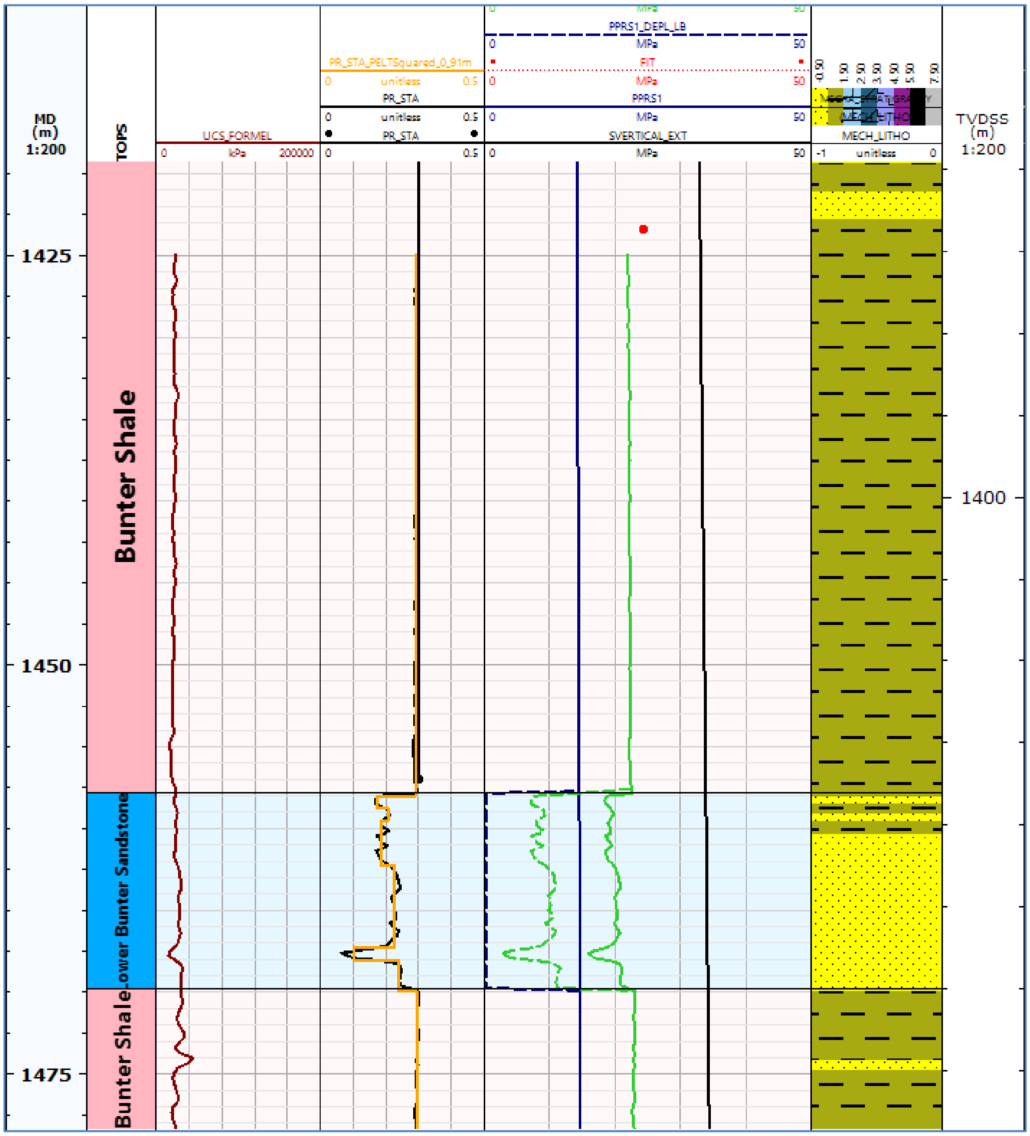

Figure 7-6: Well 48/29-9: Stresses and rock parameters for the Upper Bunter and its caprocks

7.1.3 GEOMECHANICAL MODEL

In this section are summarized the results of the geomechanical modelling activities performed, which were related to:

- Analytical estimate of the reservoir state of stress during depletion and repressurization;
- Thermo-poro-mechanical modelling to evaluate the risk of thermal induced fracture (TIF) to happen.

7.1.4 Stress state during depletion and repressurization

The uniaxial strain model has been used to estimate the actual horizontal stress and evaluate how the minimum horizontal stress will increase upon injection.

According to the uniaxial strain model, when a pore pressure variation ΔP takes place, the total vertical stress variation is null (i.e. no stress arching taking place) while the variation of the total minimum horizontal stress ΔS_h is given by:

$$\Delta S_h = \frac{1-2\nu}{1-\nu}\Delta P$$

where ν is the Poisson's ratio.

The simple analytical evaluation provide an envelope of the horizontal stress value, which can be considered as a threshold limit for the bottom hole injection pressure. The results for the Lower Bunter injection are summarized in Table 7-3 and Figure 7-7.

Lower Bunter				
Depth	4100	ft	1249.68	m
Svert	**Sh_init**	**Ppore_init**	**Sh_depl**	**Ppore_depl**
MPa	MPa	MPa	MPa	MPa
30	17.7	13	8.7	0.3

Table 7-3: Initial and actual minimum stress in reservoir, Lower Bunter.

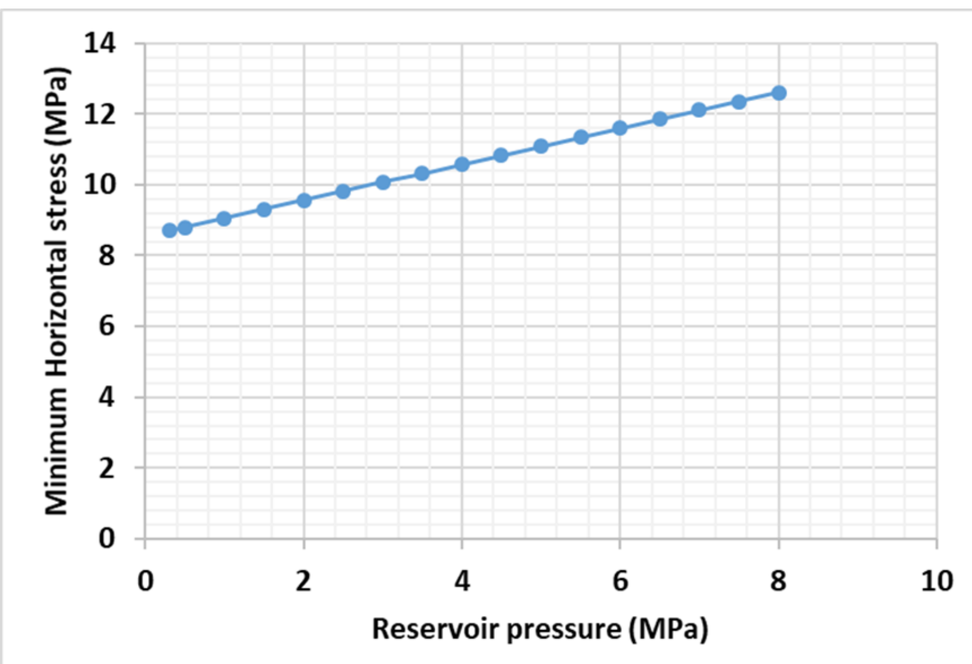

Figure 7-7: Min. horizontal stress vs. reservoir pressure, Lower Bunter

According to the model's result, cap rock integrity is not an issue, under actual hypotheses, as the maximum repressurization value (8 MPa) is lower than the original reservoir pressure (13 MPa) and no reservoir integrity issues have been reported during the production phase of the field.

The following comments have to be however underlined:

- A more comprehensive stress model would require the set-up of a 3D geomechanical model, including not only the reservoir but also overburden and underburden.
- More exhaustive cap rock integrity evaluation would also require a 3D geomechanical model, to evaluate the deformations happened during the production phase of the field, how such deformations, and the stresses variations, have eventually impacted the reservoir and the cap rock and if the repressurization could lead to critical situations.

The analytical model considers isothermal conditions; since the CO2 injection will take place at bottom hole temperature lower than the reservoir temperature, a more complex analysis have been performed to evaluate if such temperature variations could lead to the development of induced fractures in the near wellbore region and if the cap rock could be affected as well.

7.1.5 Thermo-poro-mechanical modelling of CO_2 injection

In this section are outlined the activities performed to evaluate the risk of generating induced fractures (TIF) due to the thermal effects originating while injection CO_2.

The injection conditions of three new wells, whose objective is to inject 180 10^6 of CO_2 in 30 years. The imposed rate, assumed equal for each well, is 5.5 kton/d. The target area is the Lower Bunter formation and a Bottom Hole Temperature (BHT) equal to 40°C is assumed.

The results of the geomechanical characterization, outlined in section 7.1.2, have been used for the thermal modelling while the estimate of the TIF occurrence has been performed assuming different scenarios of rock deformability, i.e. Young's modulus, which is the parameter that greatly affect TIF development.

An analytical evaluation of the Joule-Thomson effect has been performed in advance, to check if such effect could contribute to further decrease the temperature in the near wellbore region and thus impacting the conditions of TIF development.

The simplest analytical model of the Joule-Thomson effect assumes that adiabiatic cooling/heating occurs, i.e. no thermal exchanges occur between the fluid and the surrounding enviroment. The following relationship describes the J-T effect:

$$\Delta T = \mu_{JT} \, \Delta P$$

Where μ_{JT} is the Joule-Thomson coefficient, whose numerical values have been taken from the NIST database.

Assuming BHIT=40°C and BHIP=20 bar, the estimated temperature variation is ΔT=0.97x20=19.4 °C.

Since the initial reservoir temperature is about 40-50 °C, Joule-Thomson effect will not likely to induce significant variations in the near wellbore region.Moreover, due to active thermal exchange taking place with the surrounding rock real temperature decrease would be lower than the estimated one. The associated stress variation due to JT cooling is less relevant respect to the one given by change in pore pressure (i.e. mechanical).

The TIF occurrence has been studied using COMSOL Multiphysics®, a commercial software able to manage different type of physical phenomena and to couple them, by solving them simultaneously.

Since COMSOL cannot manage two phase flow and thermal coupling at the same time, a simplified analysis has been performed by considering monophasic fluid flow.

As first step, a simplified but full size simulation Figure 7-8 has been performed in order to diagnose an eventual interference radius between the wells and then to isolate a radial sector (smaller) model.

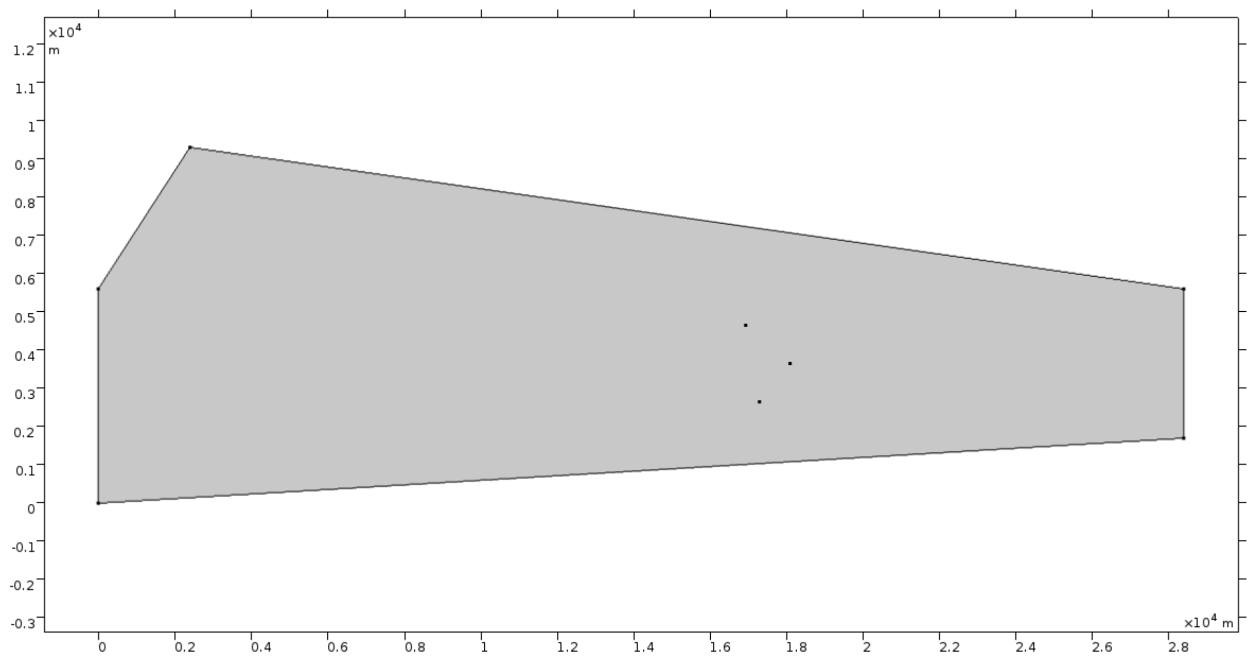

Figure 7-8: Full-size schematic model; the three points represent wells' locations.

Figure 7-9 shows the temperature front propagation between two injectors: in terms of temperature, there is no interference, so a smallest radial sector model has been built.

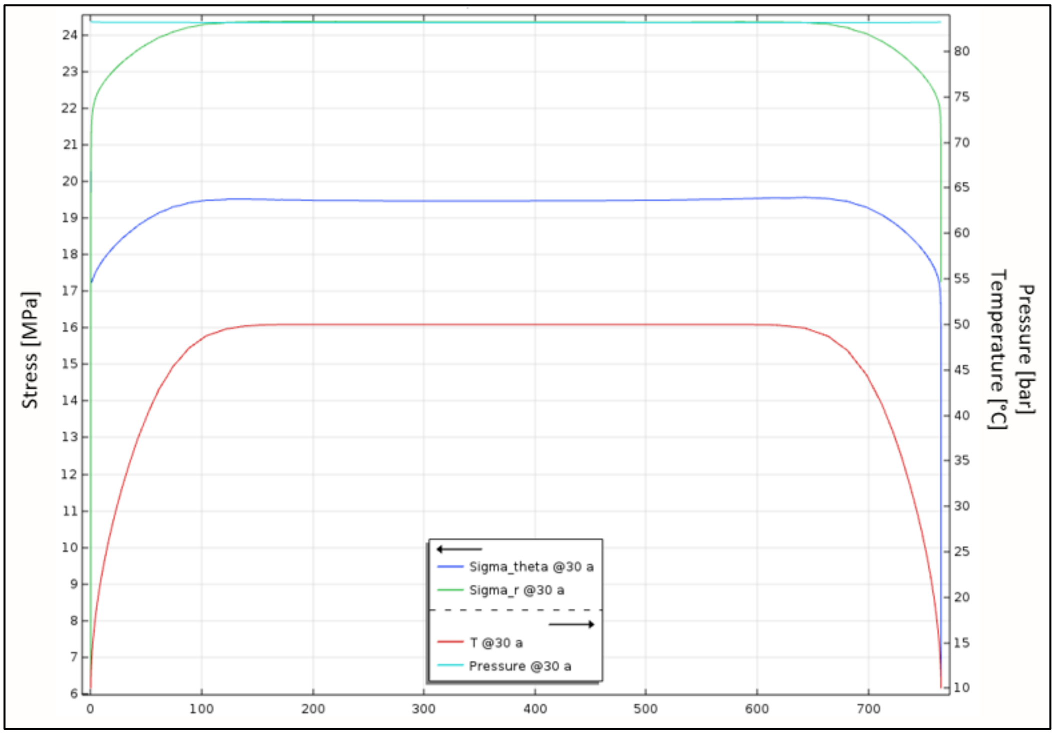

Figure 7-9: Interference evaluation

The smaller model set up for TIF evaluation consists in a cylinder of 500 m radius, the well is coaxial with the domain, the vertical extent includes the two reservoir zone *Lower Bunter* and *Upper Bunter* and the two sealing layers *Bunter Shale* and *Hailsorough* (*Figure 7-10*).

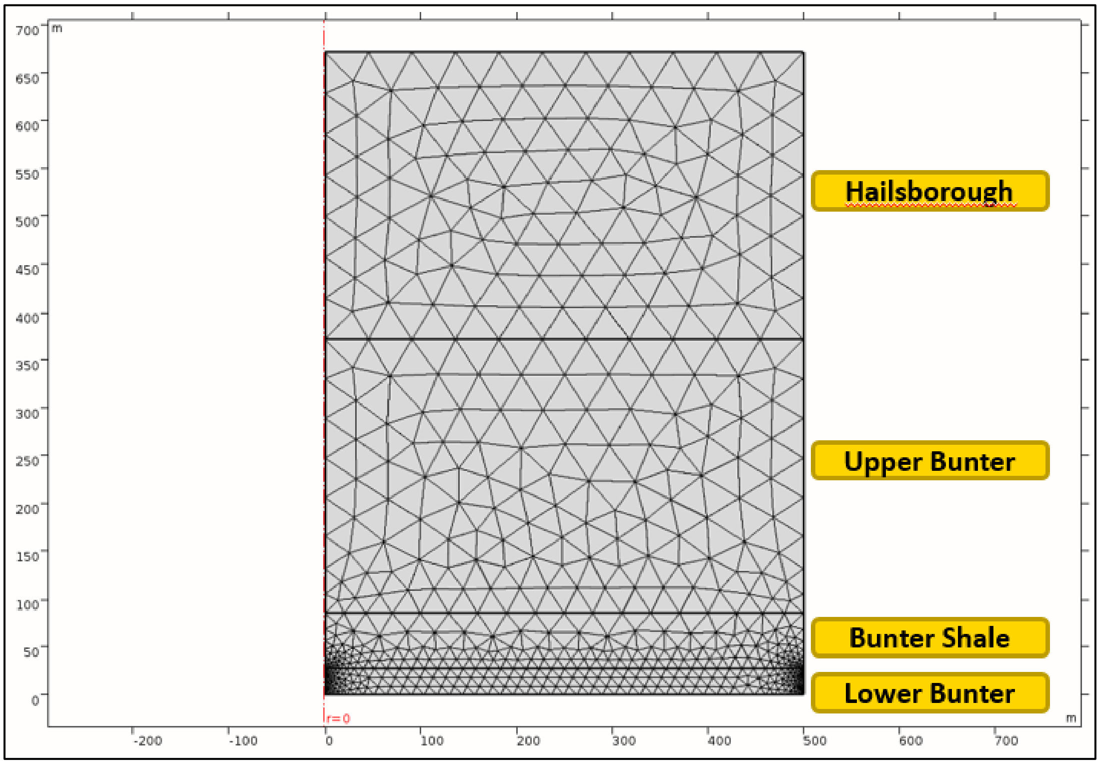

Figure 7-10: Geometry and mesh

In order to reduce the simulation time, the grid has different dimensions: in the Lower Bunter injection layer the elements have the smallest dimension. The mesh has a total number of elements equal to about 1200. The domain is modeled as a linear elastic material; the material parameters are summarized in Table 7-4:

	Lower Bunter	**Bunter Shale**	**Upper Bunter**	**Hailsborough**
E [GPa]	8	5	8	5
ν [-]	0.22	0.3	0.28	0.30
φ [-]	0.20	0.027	0.20	0.07
K [mD]	1500	0.006	500	25
α [1/°C]	1e-5	1e-6	1e-5	1e-6
Thermal conductivity [W/(m·K)]	3	3	3	3
Heat capacity [J/(kg·K)]	1000	1400	1000	1400

Table 7-4: List of parameters

The phenomenon of TIF is governed by the following equation:

$$\Delta\sigma = \frac{\Delta T \cdot \alpha \cdot E}{2 \cdot (1-\nu)} \cdot \left[1 + \frac{1}{1 + 1.45\,(h/d)^{0.9} + 0.35(h/d)^2}\right]$$

Where α is the coefficient of thermal expansion, E is the Young's modulus, ν is the Poisson's coefficient, h is the height of the reservoir, d is the time-dependent diameter of the cooled zone.

The most impacting and uncertain parameter is the Young's modulus E (the coefficient of thermal expansion α and the Poisson's coefficient ν have small variation). So, a sensitivity analysis, based on different combination of Young's modulus of the reservoir and the cap-rock, has been performed.

In Table 7-5 are summarized the four cases considered. The values of the elastic modulus are the maximum and the minimum resulting from log's correlation.

	$E_{Lower\ Bunter}$ [GPa]	$E_{Bunter\ Shale}$ [GPa]
Base Case	8	5
Case 1	3	5
Case 2	8	3,5
Case 3	3	3,5

Table 7-5: Sensitivity parameters

The aim of this analysis is to evaluate the occurrence of TIF both at the sand face and at the interface with the cap rock.

In the next figures (Figure 7-11 and Figure 7-12) are summarized the main results in terms of temperature and stress field. The graphs report on the x axis the distance from the well (in meters), on the left y axis the pressure in bar and the hoop stress in MPa, on the right y axis the temperature in Celsius degree.

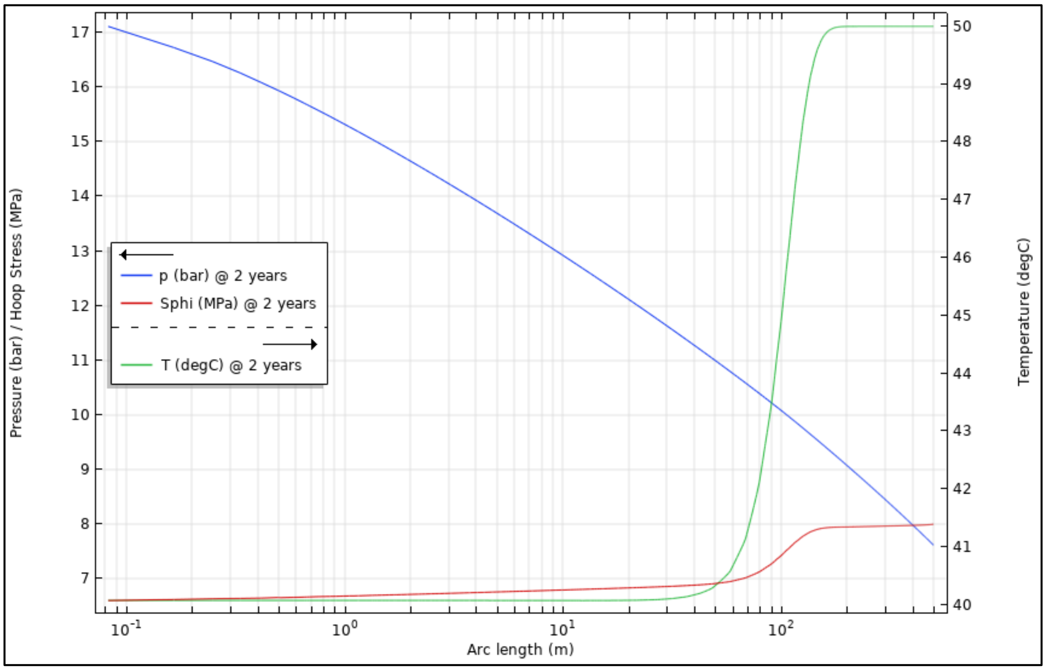

Figure 7-11: Reservoir results at minimum BHT (after 2 years of continuous injection) – Base Case

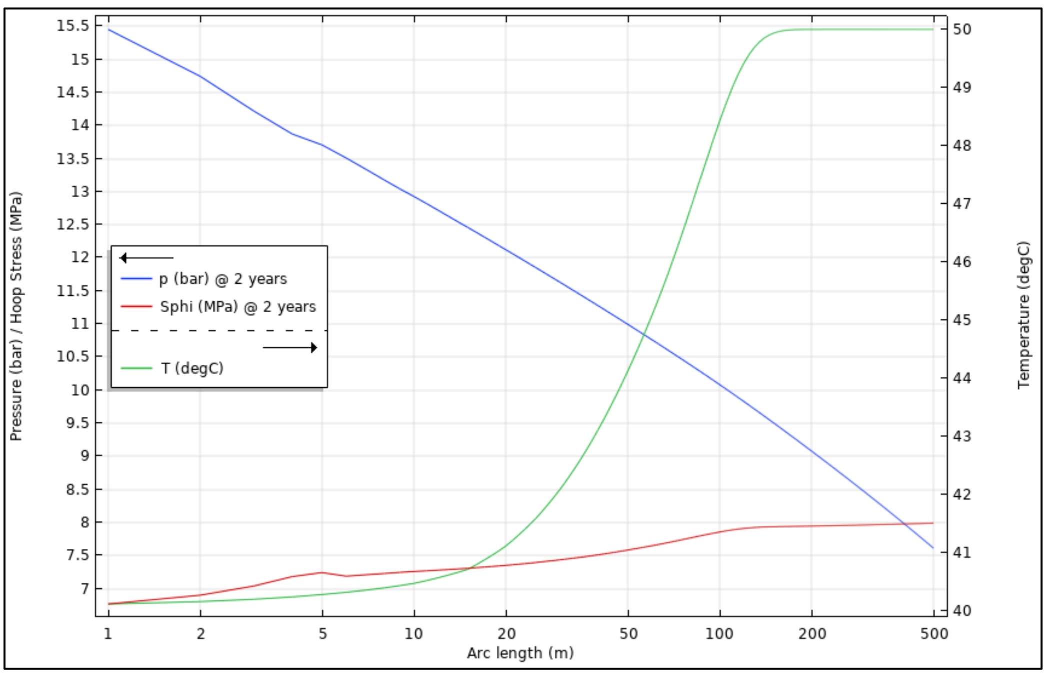

Figure 7-12: Interface results at minimum BHT (after 2 years of continuous injection) – Base Case

Figure 7-13Figure 7-11 and Figure 7-12Figure 7-14 show the pressure, stress and temperature profiles after two years of injection, when the minimum BHT is reached and the maximum reduction of tangential stress will occur.

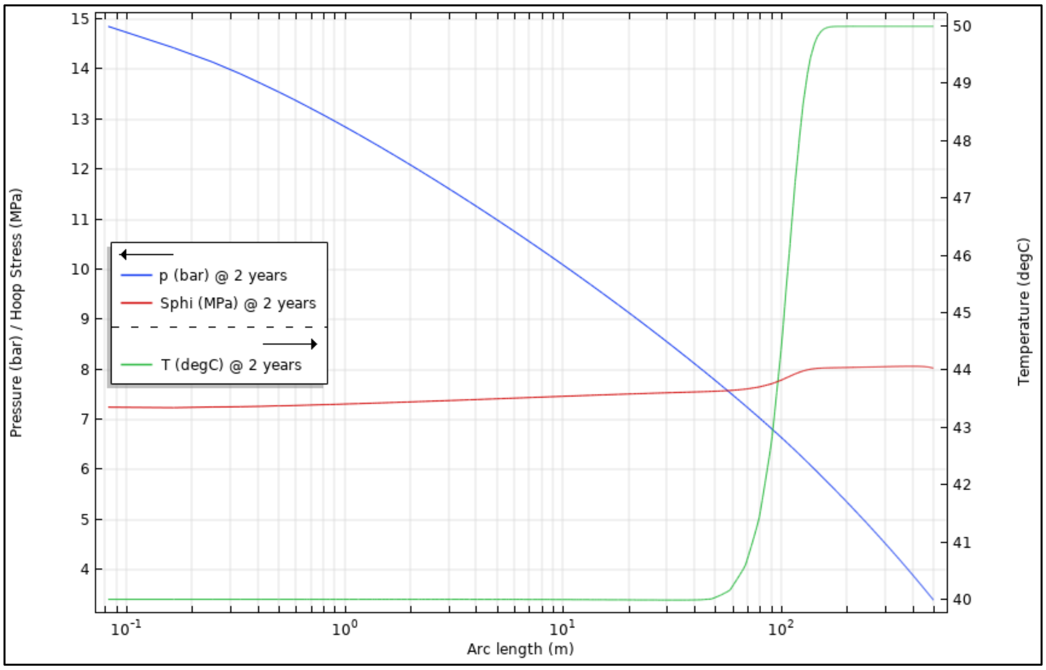

Figure 7-13: Reservoir results at minimum BHT (after 2 years of continuous injection) – Case 1

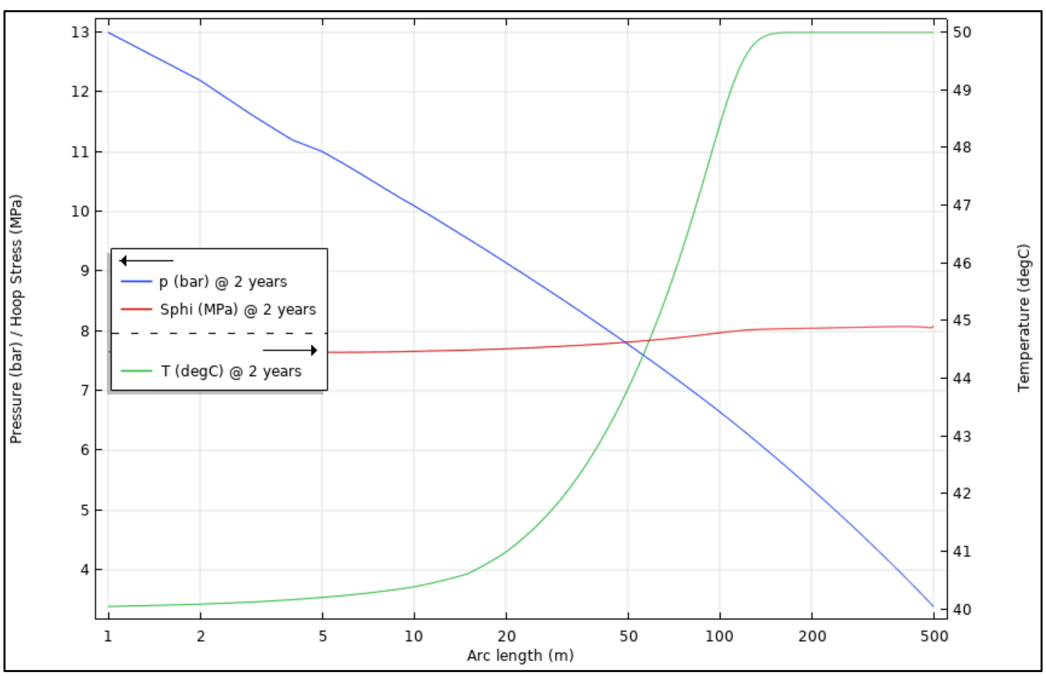

Figure 7-14: Interface results at minimum BHT (after 2 years of continuous injection) – Case 1

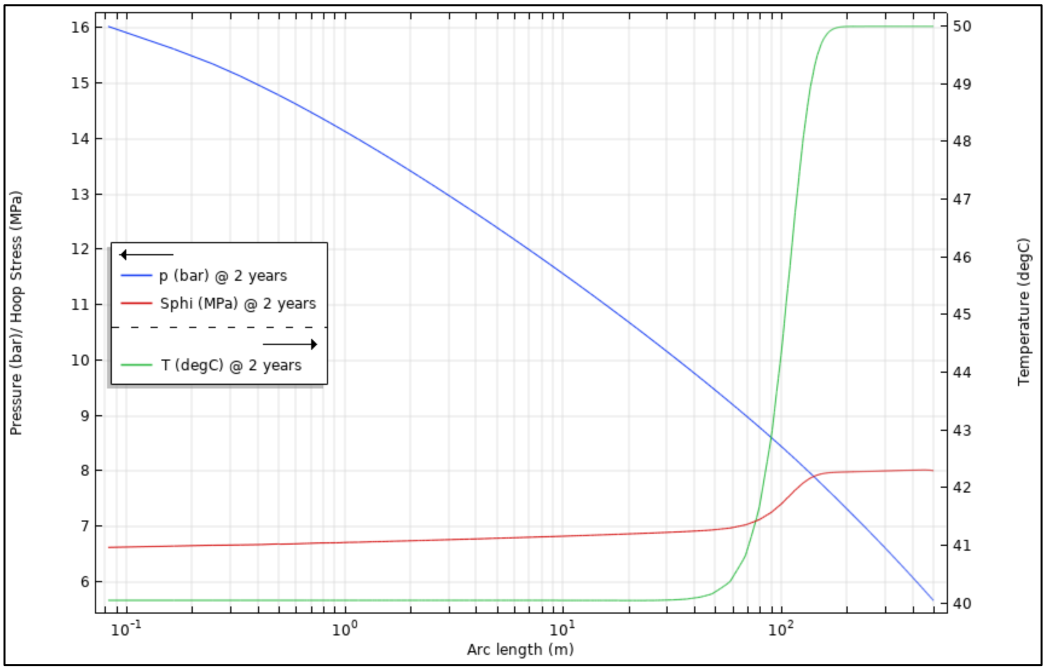

Figure 7-15: Reservoir results at minimum BHT (after 2 years of continuous injection) – Case 2

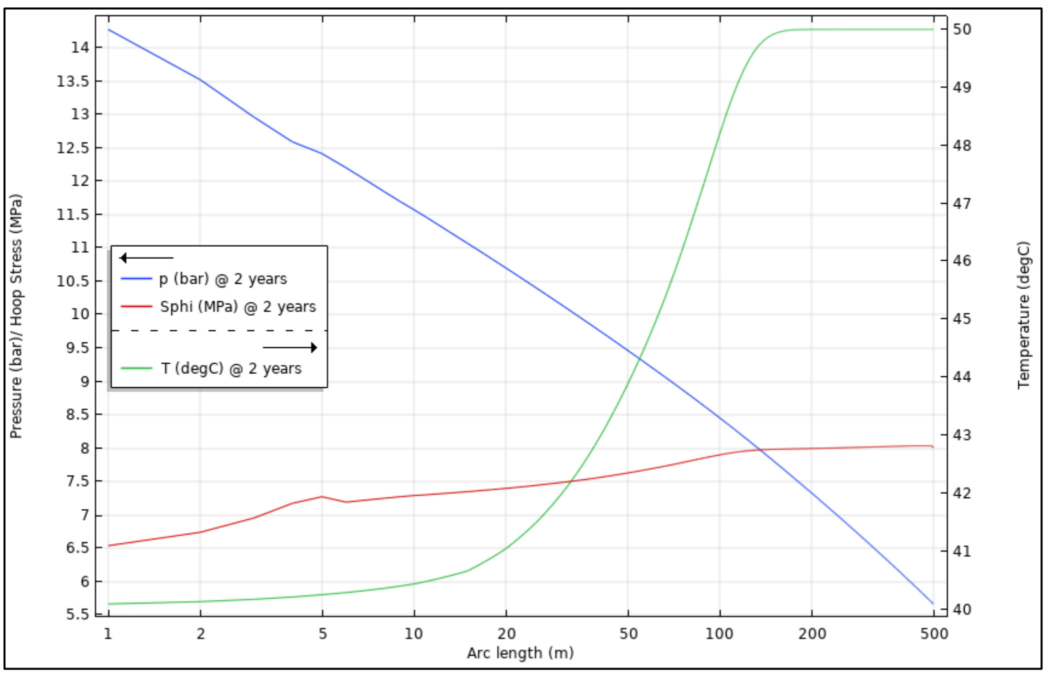

Figure 7-16: Interface results at minimum BHT (after 2 years of continuous injection) – Case 2

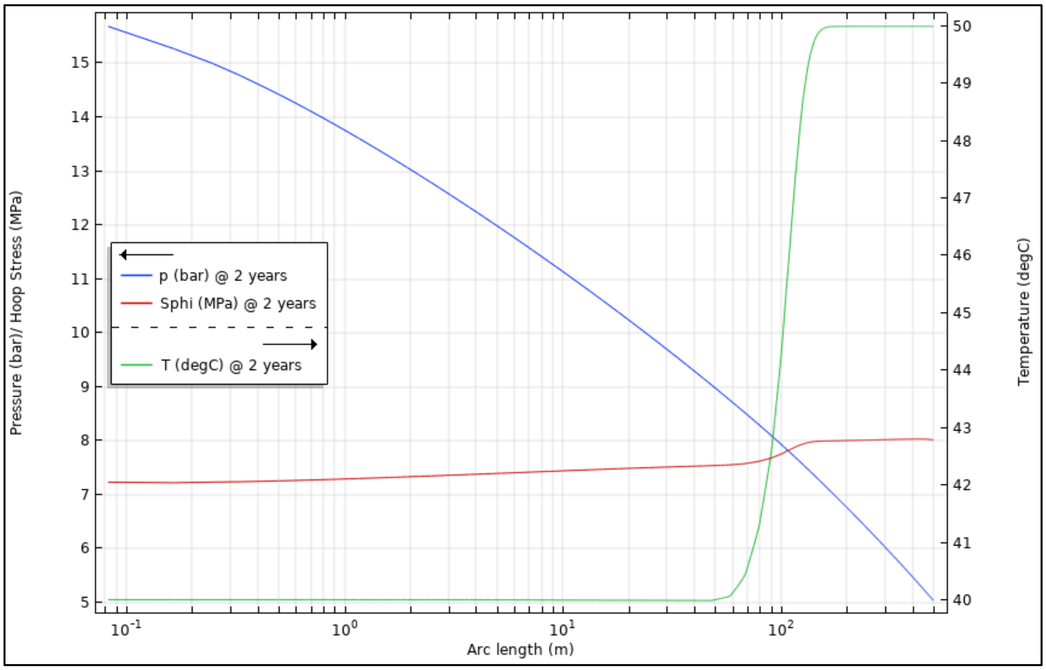

Figure 7-17: Reservoir results at minimum BHT (after 2 years of continuous injection) – Case 3

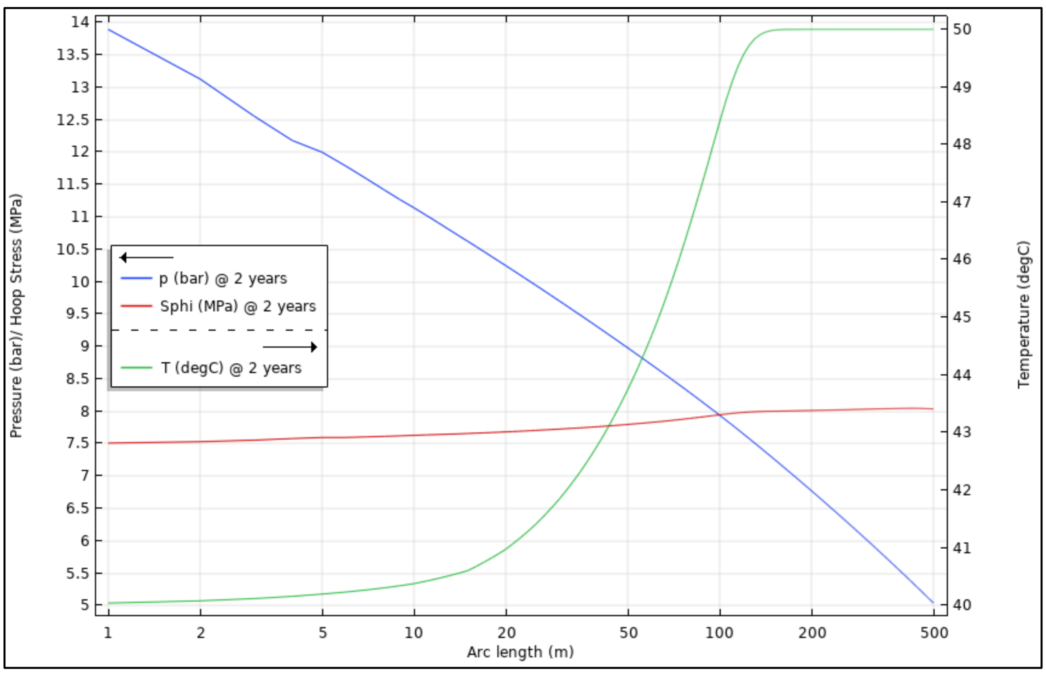

Figure 7-18: Interface results at minimum BHT (after 2 years of continuous injection) – Case 3

In Figure 7-13 to Figure 7-18 are shown the pressure, stress and temperature profiles after two years of injection, for the Case 1, 2 and 3.

It can be observed that the most critical combination of parameters is the one of the base case, in which both the Young's moduli have the highest values, therefore the maximum stress reduction is originated. Anyway, the occurrence of TIF is not foreseen in any of combinations considered.

7.2. GEOCHEMICAL ASSESSMENT

Regarding geochemical assessment and modelling, the data acquirement followed two main lines:

- Preliminary bibliographic and report review
- Laboratory analysis

7.2.1 Bibliographic review

In the early phases of the study a bibliographic and report review has been performed to verify whether the collected data were suitable to set up a geochemical model. This analysis was mainly focused on the definition of the formation mineralogical composition and on the chemical composition of the formation water, the two pillars input data needed for a complete geochemical assessment.

- *Mineralogical composition*

From available data it was not possible to obtain a definitive mineralogical composition both for the Upper and the Lower Bunter.
For the Upper Bunter a bulk mineralogical composition of the rock was taken from literature (*Aminu et al. 2018*) and, although not site-specific for the Hewett field, was used to initialize the geochemical model. Very few data for the Lower Bunter were found in the reports and no data was found in literature. The bulk mineralogical composition for this interval was therefore estimated from the few available report information (*Capacity Assessment– Reservoir/Caprock Characterisation - E.ON, 2010*) being aware that more constraining mineralogical data are needed to properly set up a reliable modelling.

- *Water Chemical composition*

From available data it was not possible to obtain a definitive water chemical composition both for the Upper and the Lower Bunter.
The only data available for the formation water was total salinity (70K to 90K ppm NaCl equivalent for Upper Bunter interval, 120-140 for Lower Bunter interval) indicated in report *Capacity Assessment– Reservoir/Caprock Characterisation - E.ON, 2010*). Two synthetic formation waters were computed by using numerical procedure which considers the equilibrium with the mineralogical compositions of the two respective intervals. PHREEQC software was used to obtain the chemical composition of the synthetic formation waters at the intervals P-T condition.

7.2.2 Laboratory analysis

New mineralogical data are under acquisition by using X-Ray Diffraction and X-Ray Fluorescence, on 12 samples belonging to well 48/29-a1, and on 2 samples of well 48/29-2. Both the intervals are covered by these samples.

Detailed Scanning Electron Microscope chemical analyses are ongoing on thin sections derived from the same samples used for X-Ray Diffraction and X-Ray Fluorescence analyses. A detailed chemical composition is needed to estimate the thermochemical parameters (Eni developed procedure,

PEPITA: Parameter Estimation and Parameter Interpolation for Thermochemical Analysis) to augment with site-specific data the database used in the reactive geochemical models.
Due to both rock and formation waters heterogeneities between Upper and Lower Bunter interval, two different geochemical investigations are performed.

7.2.3 Upper Bunter interval

Mineralogical phase	% weight
Quartz	42.6
Albite	18.1
Ankerite	17.8
Clay (mica)	7.9
K-feldspar	7.8
Halite	1.1
Chlorite	0.8
Hematite	0.5
Calcite	0.1

Table 7-6: Bulk mineralogical composition of Bunter Sandstone Formation of well 43/12-1 (Aminu et al. 2018)

The Upper Bunter bulk mineralogy was reconstructed using the data in the table above (Table 7-6). The clay (mica) mineral phase is supposed to be muscovite. Chlorite component is divided, in equal parts, in chamosite and clinochlore mineralogical phases. Microcline is considered as a proxy for the k-feldspar. Halite and hematite are not considered in this first assessment.
The synthetic formation water is characterized by the chemical composition reported in the table below (Table 7-7). Total water salinity and temperature used in the computation are respectively 80000 ppm and 42.2 °C.

Element	Molality (mol/kg of water)
Al	9.430e-09
C	1.104e-02
Ca	6.524e-03
Cl	1.271e+00
Fe	4.543e-05
K	3.402e-03
Mg	1.178e-02
Na	1.404e+00
Si	2.688e-04

Table 7-7: Reconstructed Upper Bunter water chemical composition

CO2 is added to the geochemical system step by step to mimic an isothermal increase of the CO2 partial pressure from 10 to 80 bar (injection process). The results of the simulation (Figure 7-19) show two distinct processes: a progressive dissolution of albite driving the precipitation of dawsonite and quartz is the main process which can be casted in the following equation:

$$NaAlSi_3O_8 + CO_2 + H_2O \rightarrow NaAlCO_3(OH)_2 + SiO_2$$

Albite *Dawsonite* *Quartz*

A secondary process involves a very negligible reactivity of carbonates, chlorites and muscovite.

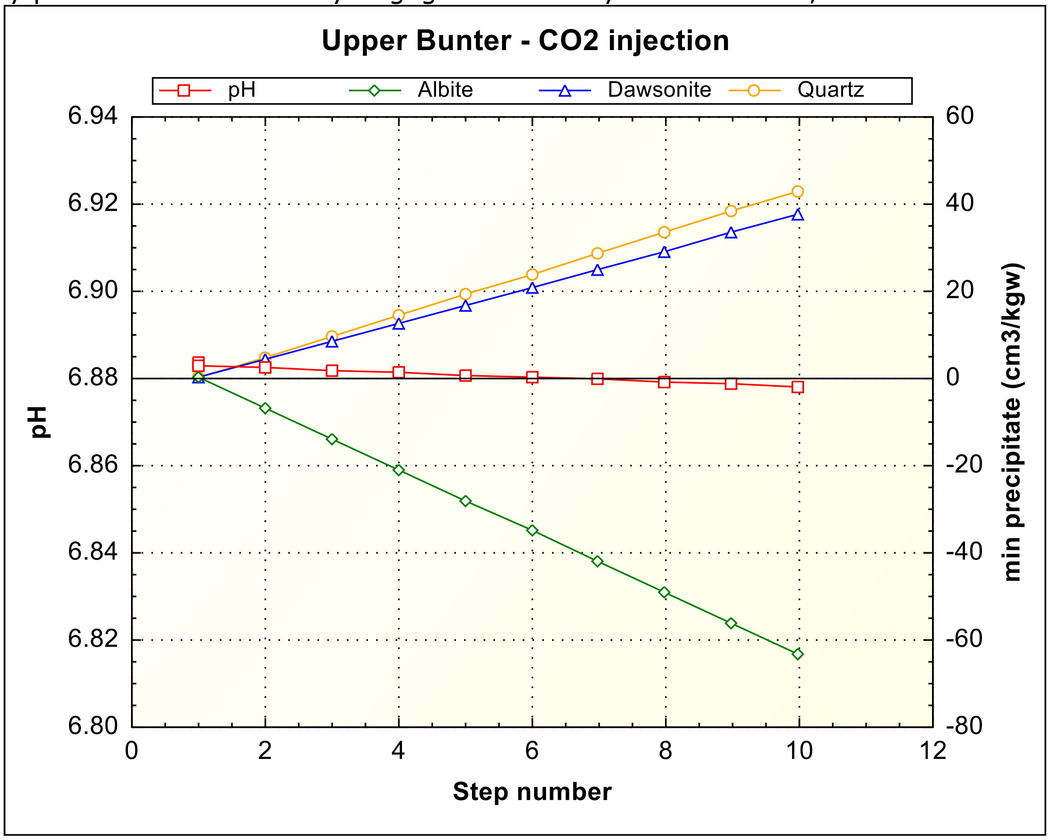

Figure 7-19: Upper Bunter minerals precipitation/dissolution during CO2 injection.

The progress of the simulation (CO2 addition) is represented by the reaction step number, since the injected CO_2, being sequestered by dawsonite, cannot be used as a variable with a linear increment suitable for plotting the advancement of the simulation.
To increase the reliability of the assessment, new mineralogical and chemical data have been acquired and a more precise investigation is being performed.

7.2.4 Lower Bunter interval

Due to the lack of detailed mineralogical data of Lower Bunter interval, a bulk mineralogical composition has been reconstructed taking into account the reports indications and reported in the table below (Table 7-8): *slightly micaceous quartzose sandstone, containing anhydritic cement and calcareous cement* (*Capacity Assessment– Reservoir/Caprock Characterisation - E.ON, 2010*).

Mineralogical phase	% weight
Quartz	85
Calcite	2.5
Anhydrite	2.5
Microcline	5
Muscovite	5

Table 7-8: Reconstructed bulk mineralogical composition of Lower Bunter.

The synthetic formation water is characterized by the chemical composition reported in the table below (Table 7-9). Total water salinity and temperature used in the computation are respectively 130000 ppm and 52.2 °C.

Element	Molality (mol/kg of water)
Al	1.886e-07
C	3.318e-05
Ca	5.946e-02
Cl	2.105e+00
K	3.707e-04
Na	2.105e+00
S	5.943e-02
Si	5.618e-04

Table 7-9:synthetic water composition.

CO2 is added to the geochemcial system step by step to mimic an isothermal increase of the CO2 partial pressure from 7 to 95 bar (injection process).

The numerical model predicts (Figure 7-20):

- Dissolution of microcline and precipitation of muscovite, quartz (with the concomitant increase of the potassium dissolved in the aqueous phase) according to the following mechanism:

  $$3\,KAlSi_3O_8 + 2H^+ \rightarrow KAl_2(AlSi_3)O_{10}(OH)_2 + 6\,SiO_2 + 2K^+$$

  Microcline *Muscovite* *Quartz*

  The microcline dissolution process is likely driven by brine acidification induced by CO2 injection.

- Dissolution of calcite and precipitation of anhydrite (with reduction of the sulphate in the aqueous phase)

  $$CaCO_3 + SO_4^{-2} \rightarrow CaSO_4 + CO_3^{-2}$$

  Calcite *Anhydrite*

  This process could be emphasized by an overestimation of initial anhydrite content and does not seem related to the CO2 injection.

- Dawsonite does not play a significant role in this geochemical condition

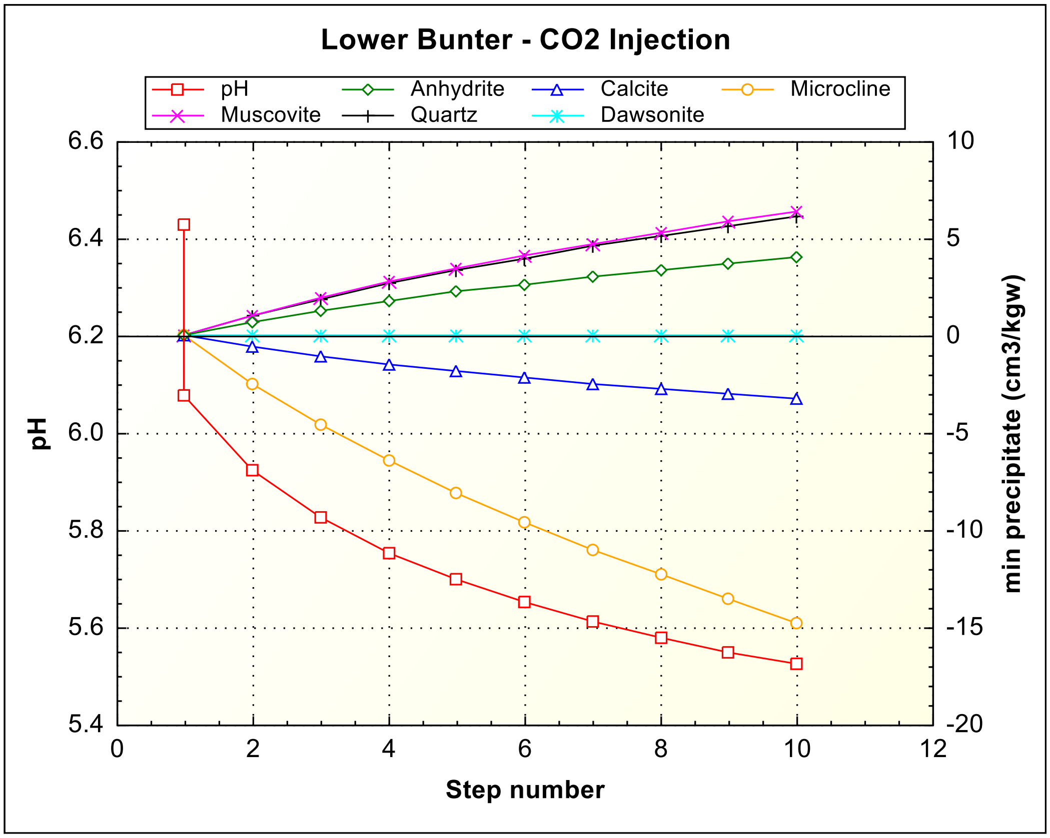

Figure 7-20: Lower Bunter minerals precipitation/dissolution during CO2 injection.

The progress of the simulation can be represented either by the reaction step number or the added CO2 since this two parameter are linearly correlated (CO_2 is not sequestered by dawsonite).

New mineralogical and chemical data have been acquired to perform a more constrained geochemical investigation.

REFERENCES

[1] Aminu at al. (2018) - *CO2-brine-rock interactions: The effect of impurities on grain size distribution and reservoir permeability*; International Journal of Greenhouse Gas Control 78 (2018) 168–176

[2] E.ON. (2010) – *Kingsnorth Carbon Capture & Storage Project - Capacity Assessment–Reservoir/Caprock Characterisation*

[3] Marsden, J.R and Dennis, J.W. 5-Stage multiple failure state drained triaxial extension tests – Wells 48/29-7, 48-29-B9 and 48/30-13. Imperial College Report 337/020, March 1994.

[4] Heidbach, O.; Rajabi, M.; Reiter, K.; Ziegler, M.; WSM Team (2016): World Stress Map Database Release 2016. V. 1.1. GFZ Data Services. http://doi.org/10.5880/WSM.2016.001

[5] Raaen, A. M., Hovem, K. A., Joranson, H., & Fjaer, E. (1996). FORMEL: A Step Forward in Strength Logging. Society of Petroleum Engineers. doi:10.2118/36533-MS.

[6] Charlez, P. A. *Rock Mechanics, vol. 1 – Theoretical Fundamentals*. 1991. Editions Technip

[7] Berest, P. (ed.). *La Thermomécanique des roches*. 1988. BRGM Editions

Global Projects Organization

Global Concept Development

Hewett Drilling & Completions Feasibility Study (Incl Time & Cost Estimates)

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HEWETT GAS FIELD CONVERSION INTO CARBON SEQUESTRATION SITE - DRILLING AND COMPLETION FEASIBILITY STUDY

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INDEX

1. SCOPE OF WORK

The present document is a Feasibility study for the Drilling and Completion activities to convert and reutilize Hewett Gas Producer Field as a Carbon Sequestration Site.
The scope of this study is to assess the well design for the appraisal and development scenario from a D&C engineering point of view.

Time and cost estimation will be included in a separate document.

This report presents methodology, results, analysis and recommendations for the design of the wells. All data used for this study are the most updated and available during document preparation.

Any change from the original data received could affect the future estimation.

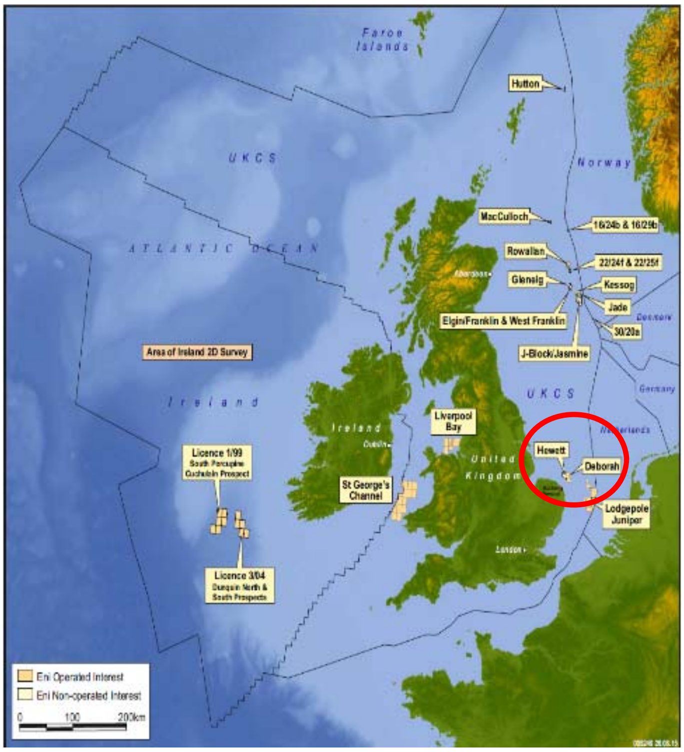
2. DEFINITION, ACRONYMS & ABBREVIATIONS

Acronym	Definition
BHST	Bottom Hole Static Temperature
BOP	Blow Out Preventer
CAPEX	Capital Expenditure
CCS	CO2 Capture Storage
CP	Conductor Pipe
CRA	Corrosion Resistant Alloy
D&C	Drilling and Completion
DHE	DownHole Equipment
DLS	Dog Leg Severity
DP	Drill Pipe
ECD	Equivalent Circulating Density
FG	Fracture Gradient
FW-PO-KC	Fresh Water – Polimer – Potassium Chloride
GRE	Glassfiber Reinforced Epoxy
KOP	Kick-Off Point
LB	Lower Bunter
MAASP	Maximum Allowable Annular Surface Pressure
MADF	Minimum Acceptable Design Factor
MAWHP	Maximum Anticipated Wellhead Pressure
MD	Measured Depth
MLS	Mud Line Suspension
MSL	Mean Sea Level
MW	Mud Weight
OPD	Opportunity & Project Development
P&A	Plugging & Abandonment
PPG	Pore Pressure Gradient
PPFG	Pore Pressure and Fracture Gradient
RKB	Rotary Kelly Bushing
SCSSV	Surface Controlled – Sub-surface Safety Valve
SG	Specific Gravity
TD	Total Depth
THP	Tubing Head Pressure
THT	Tubing Head Temperature
TOC	Top Of Cement
TOL	Top Of Liner
TVD	True Vertical Depth
TVDss	True Vertical Depth Sub Sea
UB	Upper Bunter
WBM	Water Base Mud
WBS	Wellbore Stability
WD	Water Depth
WPR	Working Pressure Rating
XT	Christmas (Production) Tree

3. PROJECT INTRODUCTION

Hewett is a mature field, been on production for over 40 years. It was discovered in 1966 with first production in 1969. Eni took ownership of the Hewett installation and infrastructure in 2008.

The field has a length of approx 29 km and lies in a water depth ranging between 20 and 40 m, at about 16 km from the coastline.



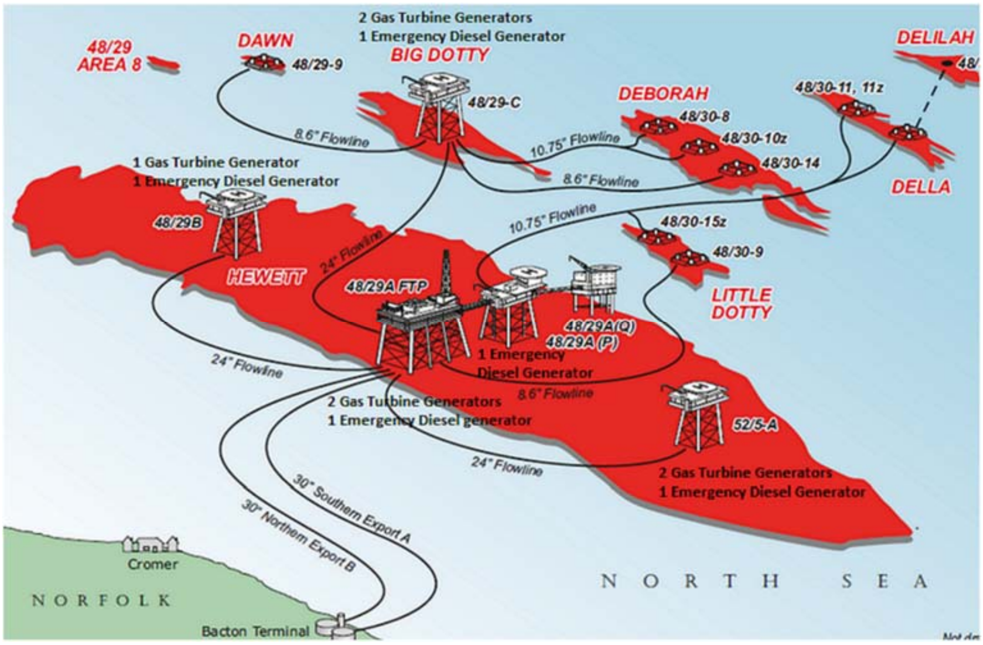


Table 3.1: Location map and evidence of blocks and permits

The asset has 32 platform wells spread over 4 platforms plus 8 subsea production wells and one suspended subsea P&A well. All wells were drilled between 1967 and 2008 by a different operator.

The reservoir includes 5 separate stacked layers:

- Upper Bunter (shallowest)
- Lower Bunter
- Plattendolomit
- Zechsteinkalk
- Rotliegend (deepest)

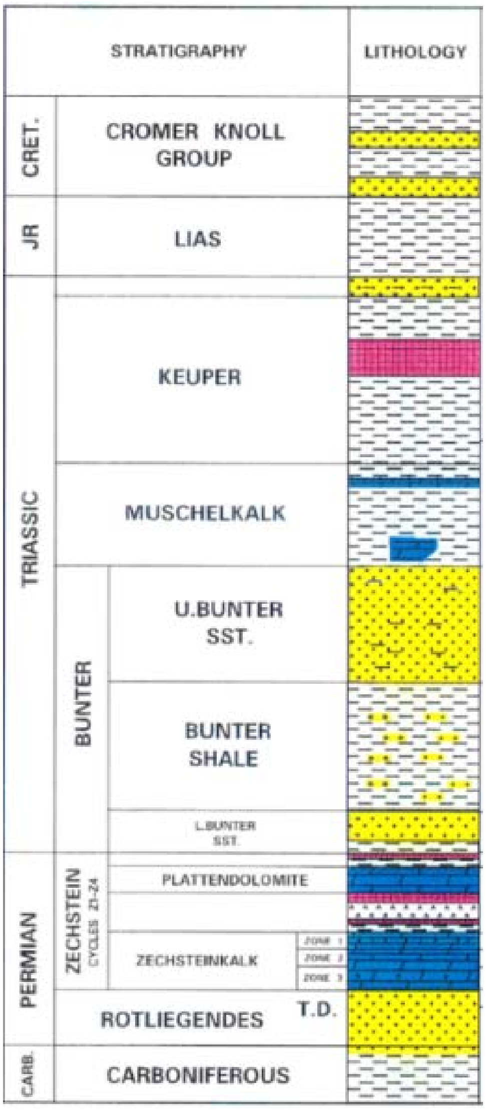


Figure 3.2: Typical lithological sequence of the field

Only two layers are selected for the purpose of CO_2 injection and storage:

- Upper Bunter, secondary target (827 – 964 m TVD MSL)
- Lower Bunter, primary target (1200 – 1268 m TVD MSL)

Both formations are highly depleted, PPG values are around 0.1 $kg/cm^2/10m$.

Eni is now on starting a decommissioning campaign of all the subsurface and surface infrastructures. The campaign will include the Plugging & Abandoning of all the 40 wells, the isolation of the subsea well flowlines and umbilicals to make the platforms hydrocarbon free and the dismantling of all the platforms.

In the preliminary phases of the project to convert Hewett field into a CO2 sequestration site different options have been considered and they included also the possibilities to utilize the existing wells.

Reusing or sidetracking the existing wells has been considered in the first instance but has been rejected as it showed elevated risk mainly related to well integrity issues but also to directional plan limitation.

The current well integrity status has been verified and found in poor condition both for casing condition both for cement reliability in respect of newest CO2 reservoir fluid.

Moreover the sidetracking strategy foresees to perform cased hole side track inside the 9 5/8" casing and completing the well with a 7" production liner. This appeared to be not in line with the requirement of displacement distance and minimum rate of injection.

Therefore Eni approached the life extension of the field considering only new appraisal and new injector wells to be drilled.

Drilling and completion activities are intended to be carried on through a Jack-Up rig. A water depth of 33 m and an RKB elevation of 40 m have been considered during the design of the wells.

The development scenario foresees five wells to be drilled from a unique new platform:

- One appraisal vertical well with 7" production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7" production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8" production liner

For all the deviated wells, inclination was limited to 45°, as per preliminary output of Eni geomechanical study.

4. BASIS OF DESIGN

All data used for this study are the most updated provided by Reservoir Department and Flow Assurance teams at the time of document preparation. In addition to that, also information gathered from offset well already drilled in the Field have been considered.

Due to the innovative nature of this project and the uncertainties associated with the use of a depleted reservoir for CO2 storage, the integrity of the wells is mainly ensured by the fact that it will be avoided having in the well CO2 status changes from liquid / dense / critical to gaseous. The modulation of the injection rate and of the all main parameters will take place in such a way as to inject at wellhead CO2 in gaseous form only, by limiting pressure and temperature drops in the wellbore too.

Still remains a margin of uncertainty in the CO2 behavior simulation's with softwares currently in use, especially during phase changes.

To overcome the current assumption of CO2 injected in gas phase only, the following aspects should be further explored:

- Evaluation of the possible ram stroke on the fixed elements of the completion (packer, hanger);
- Possible formation of hydrates and / or dry gas depending on the composition of the mixture, under different conditions of temperature and pressure;
- Possible effects on tubular materials and connections following rapid cooling of the fluid along the string;
- Evaluation of the possible freezing of the annuli of the well and effects on the closed rooms.

Any variation on the current input data could affect the proposed drilling strategy.

5. EXECUTIVE SUMMARY

The scope of this document is to provide a Drilling & Completion feasibility study concerning Hewett gas field conversion into a carbon sequestration site.
On the basis of the data available, the basis of design and the main assumptions considered the Drilling & Completion feasibility is confirmed for all foreseen wells typologies.

Five wells will be drilled from a unique new platform with a conventional jack up rig:

- One appraisal vertical well with 7” production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7” production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8” production liner

No specific surface location was requested to be considered for the time being.
The wells have been designed with a slant profile, a maximum inclination of 45° and KOP short below surface casing seat.

The main features of the three proposed well profiles are presented in the table below:

Well type	Profile	Wells number	TVD [m MSL]	MD [m RKB]	KOP [m RKB]	Max Incl. [°]	Max DLS [°/30 m]	Casings number	Prod. lnr size [in]
Appraisal	S-shape	1	1268	1308	-	0	0	5	7
Injection Upper Bunter	Slanted	1	1004	1117	330	45	2	3	9 5/8
Injection Lower Bunter	Slanted	3	1268	1535	330	45	2	5	7

Table 5.1: Well profiles features

For the trajectories design, a water depth of 33 m and a RKB elevation of 40 m have been considered.

All wells are designed to allow a single completion with a slotted liner set in the reservoir zone (monobore). Selective completion options are not considered.

The proposed operations sequence will be:

- Rig mobilization for appraisal campaign
- Drilling Appraisal well + log + P&A
- Rig demobilization
- Rig re-mobilization for development campaign
- Re-entry Appraisal well and Completion
- Drilling and Completion Upper Bunter Injection well
- Drilling and Completion 3 Lower Bunter Injection wells

6. DRILLING STUDY

The scope of this document is to provide a drilling feasibility study concerning Hewett gas field conversion into a carbon sequestration site.
The project foresees the drilling of:

- 1 appraisal well
- 4 Injection wells
    - 1 well to Upper Bunter formation
    - 3 wells to Lower Bunter formation

All wells are designed to allow a single completion with a slotted liner set in the reservoir zone (monobore). Selective completion options are not considered.
All wells are designed in order to inject with the maximum tubing head pressure expected and well integrity is satisfied also in case of back flow during well shut-in.

The study is based on the following main input data (reported in the following paragraphs):

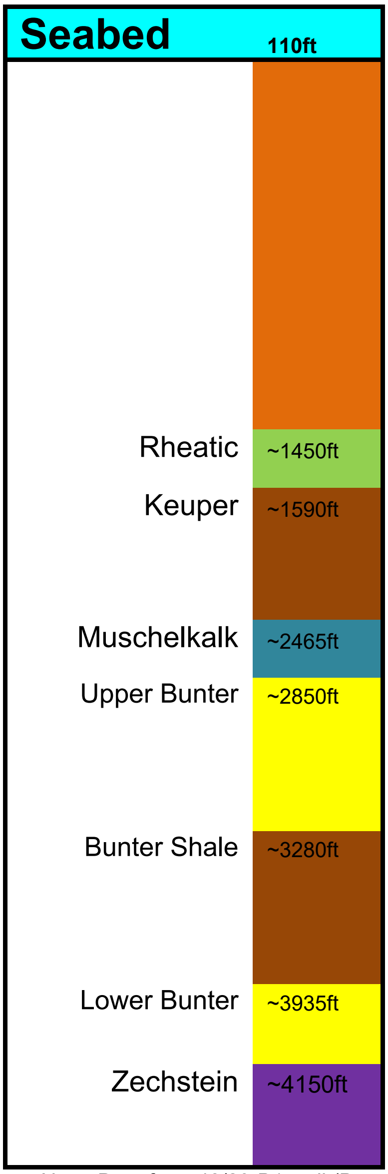
- Lithostratigrafic column
- PPFG curves estimate

The study includes the following main objects:

- Casing setting depths
- Deviation profiles
- BOP/Wellhead selection
- Casing design
- Fluid selection
- Cement study

6.1 LITHOSTATIGRATIC COLUM AND PRESSURE GRADIENTS ESTIMATE

The following lithological column and PPFG gradient estimate have been considered



Note: Data from 48/29-B1 well (Bunter well)

Figure 6.1: Lithological prognosis

Eni Reservoir department confirmed to consider the following depths as reference for the current document.

- Top Upper Bunter: 827 m
- Bottom Upper Bunter: 964 m
- Top Lower Bunter: 1200 m
- Bottom Lower Bunter: 1268 m

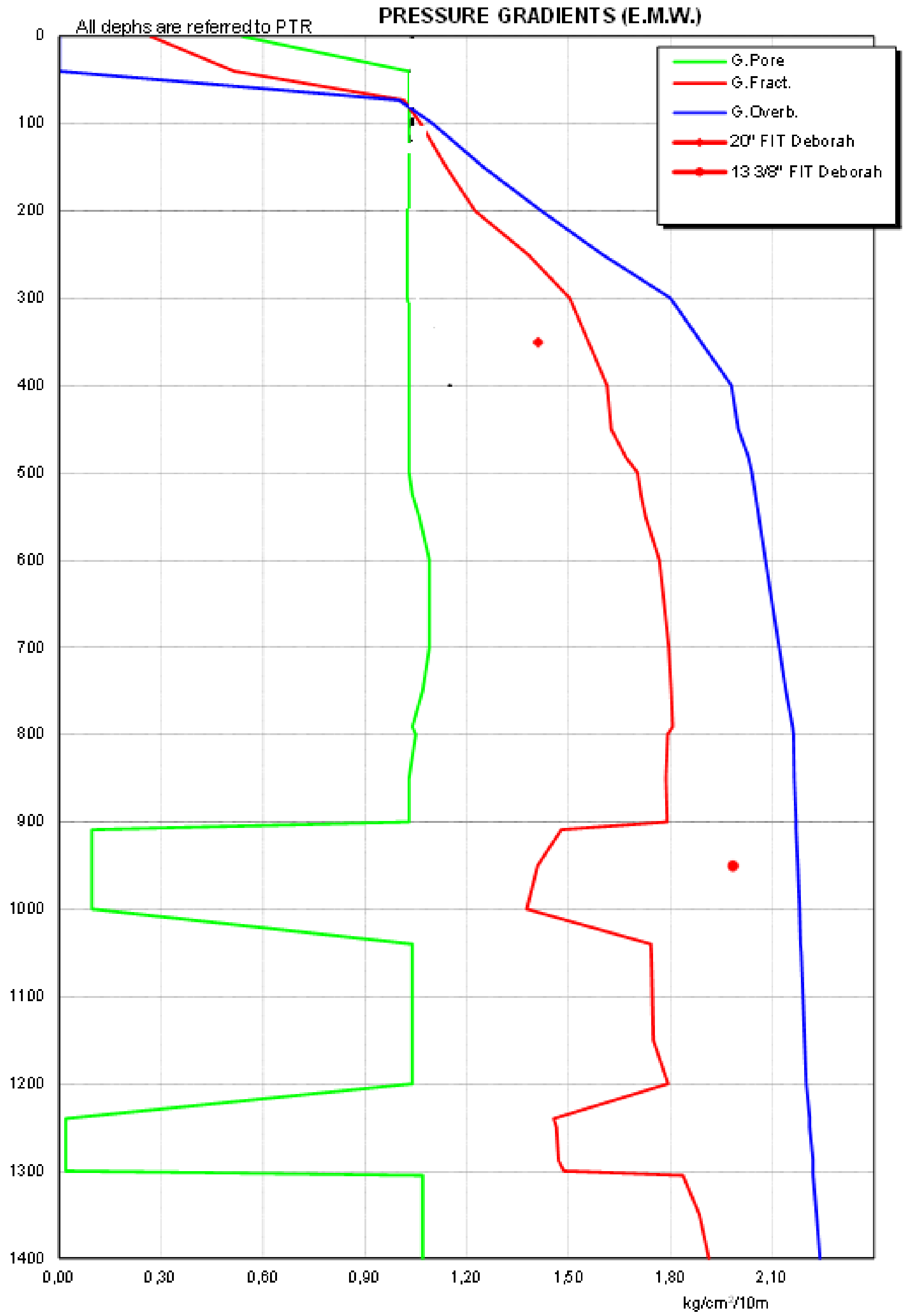


Figure 6.2: PPFG estimate

6.2 TEMPERATURE GRADIENTS ESTIMATE

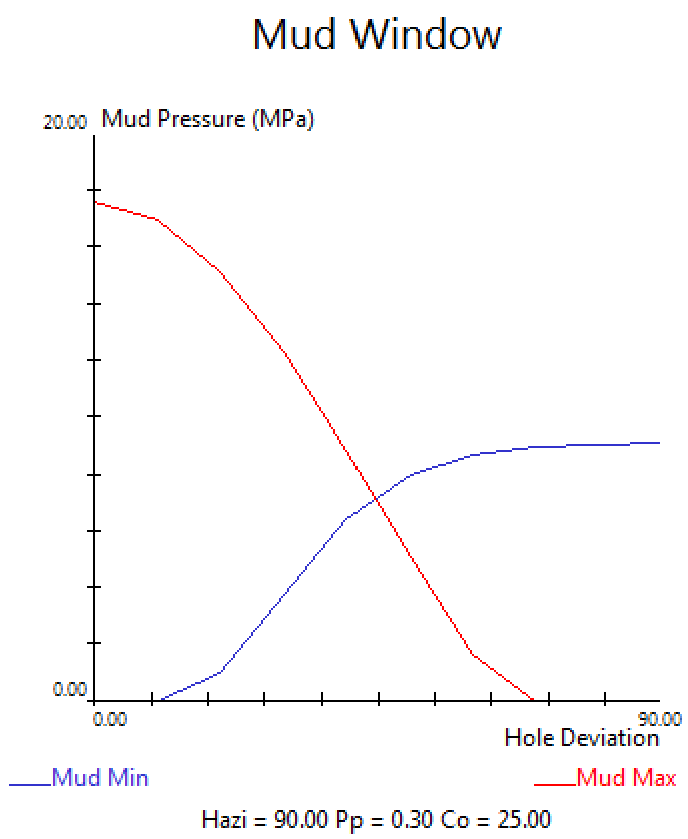
The temperature gradient is assumed to be standard (3°C/100 m).

6.3 WELLBORE STABILITY

At the current stage, a dedicated WBS study has not been performed.

However, a preliminary geomechanical analysis highlights that the maximum well inclination shall be set lower then 45° degree in order to guarantee drilling feasibility inside the depleted reservoirs.

This assumption has been considered as one of the main driver of this drilling feasibility study.



Reference Model:
Lade 3D

Input data:
Depth 4100 ft
Svertical = 30 MPa
Actual Shmin = SHmax = 8.7 MPa
Actual Ppore = 0.3 MPa
UCS = 25 MPa

Figure 6.3: MW range vs hole deviation (preliminary)

6.4 CASING SEAT

The purpose of this section is to provide a well scheme for the development wells included in the project. Based on the actual information, casing seat has been designed in order to reach the desired well targets according to Eni minimum requirements.

The herebelow tables report the two well profiles:

- the first one for the appraisal well and the injection wells targeting Lower Bunter formation (4 casings profile);
- the second one for the injection well targeting Upper Bunter formation (2 casings profile).

All the casing depths,TVD and MD, refer to Mean Sea Level.

Casing	*Diameter*	*TVD (m)*	*Drilling Phase*
Conductor Pipe	30”	70	
Surface Casing	20"	300	24”
Intermediate Liner	16"	827	17 ½ ”
Production Casing	13 3/8"	964	14 ¾ ”
Production Liner	9 5/8"	1200	12 ¼”
Slotted liner	7”	1268	8 ½”

Table 6.1. Proposed csg scheme Appraisal /Lower Bunter Injection wells

Casing	*Diameter*	*TVD (m)*	*Drilling Phase*
Conductor Pipe	30”	70	
Surface Casing	20"	300	24”
Production Casing	13 3/8"	827	17 ½ ”
Slotted liner	9 5/8"	964	12 ¼ ”

Table 6.2. Proposed csg scheme for Upper Bunter Injection wells

In appraisal/Lower Bunter wells, after surface casing setting at 340 m, the 16” intermediate liner will be set at the top of Upper Bunter formation. 13 3/8” casing is run to cover Upper Bunter depleted formation and to drill the following phase till the top of the Lower Bunter where 9 5/8” casing is set. Reservoir zone is drilled in 8 ½” section and completed with 7” slotted liner.

This casing design include 16” casing run in 17 ½” hole and 13 3/8” casing in 14 ¾” hole. It takes the advantages of Lean Profile technique that has been developed by Eni E&P in the last fifteen years by reducing the clearance between casing and open hole. This well profile significantly reduced sizes of the sections drilled, without affecting the final production casing and tubing size. Major benefits of this technics are an enhancement of operational performances, a reduced environmental impact, a better hole quality and related drilling costs saving. This techninque is currently the base case of Eni CSG design.

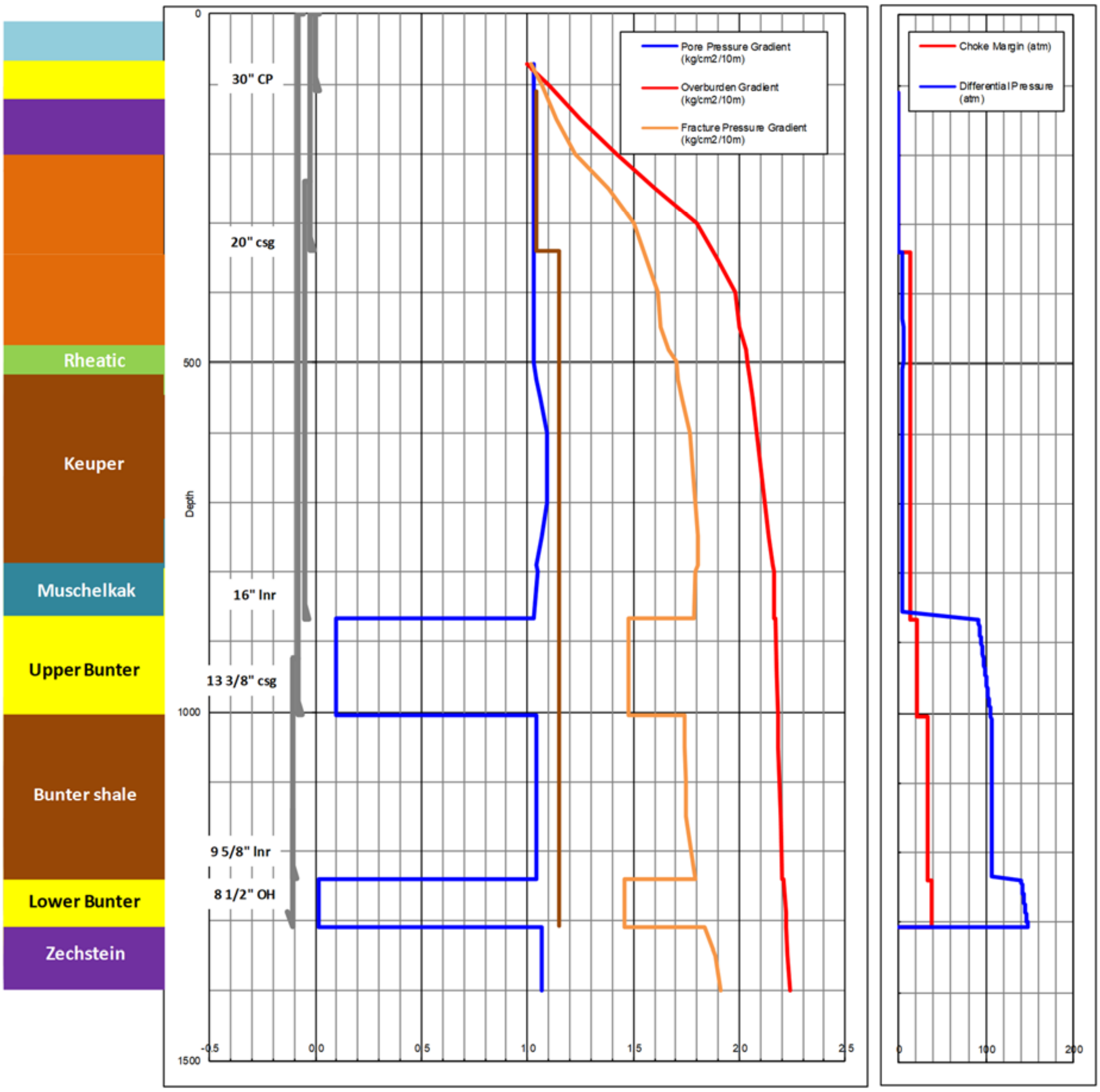
In Upper Bunter well, after setting surface casing at 340 m, 13 3/8” intermediate/production casing is set at the top of Upper Bunter formation. Reservoir zone is drilled in 12 ¼” section and completed with 9 5/8” slotted liner.

The here presented well profiles do not report any contingency phase/s, but a preliminary strategy could foresee a 11 ¾” liner and a 9 5/8” near flush casing. Related time and cost estimations are captured in the risk assessment and probabilistic model (see releted paragraph for more details).

6.4.1 APPRAISAL WELL

The following pictures include the different well profiles, considering an RKB elevation of 40 m as reference. The main drilling margin required by Eni policies are highlighted.

Well name :	Hewett appraisal			Subsea Wellhead	no
Water depth :	33.0 m	Rotary Table	40.0 m	Used Gov deep water Ref.	no
RKB-Mud line	73.0 m	Rig	TBD		



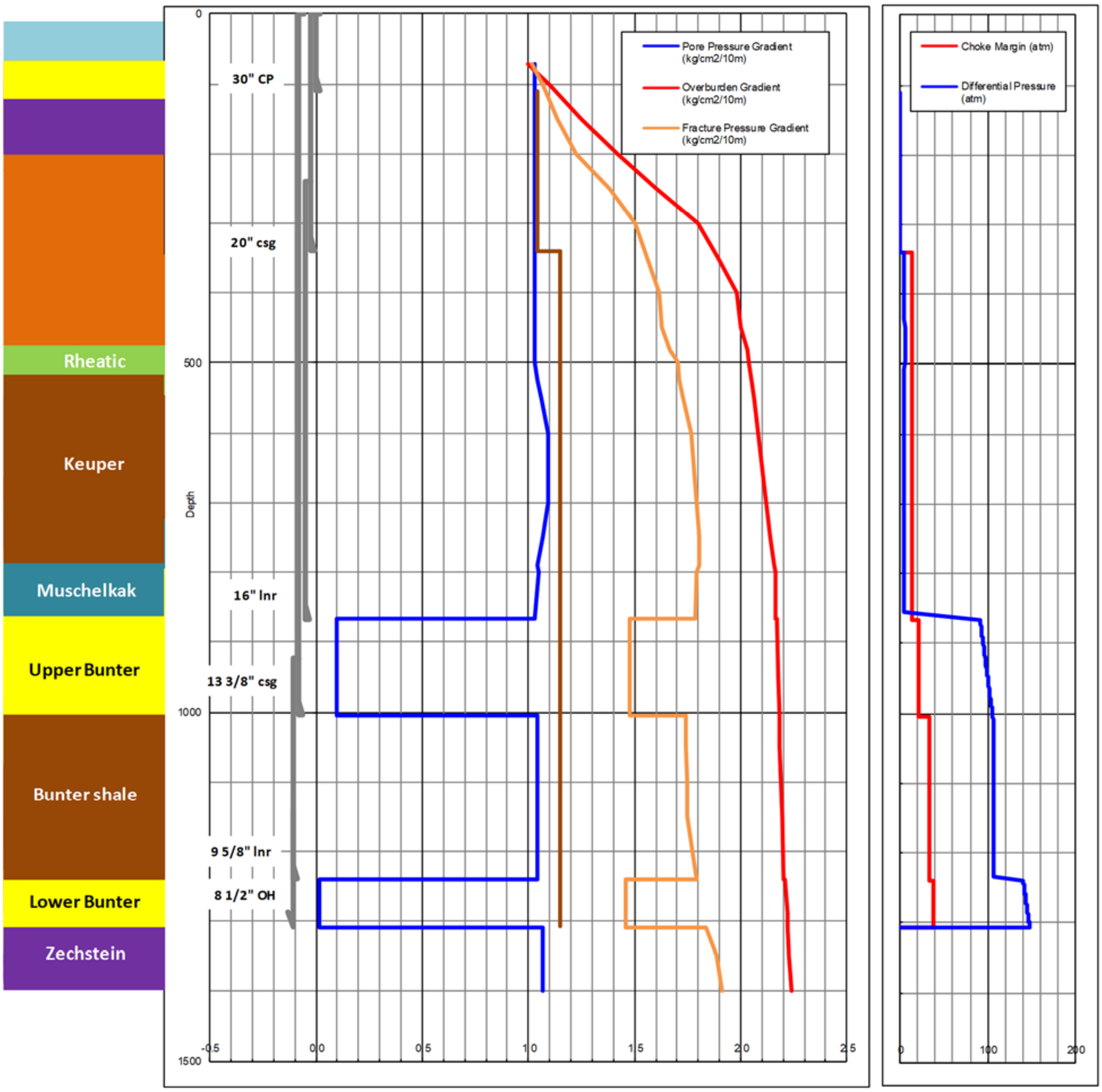
n°	CSG	Type	TVD msl	TVD RKB	Open Holes	Drive	Max. MW	Max. Gp	@ Depth	Drill. Bal.	Min. Gp	@ Depth	Diff. Pres	Gf @ weak point	Choke Marg.	DP	BHA DC	BHA Lng	Gi (*)	Kick Tol.
			m	m	Inch	yes/no	s.g.	kg/cm²/10m	m	kg/cm²	kg/cm²/10m	m	kg/cm²	g/cm²/10m	kg/cm²	inch	inch	m	s.g.	m3
1	36"	c.p.	70	110	36	YES	1.04	1.03	100	-	0.00	73	-	1.08	-	6 5/8	8 1/4	100	-	-
2	20"	csg	300	340	24	NO	1.04	1.03	110	0	1.03	110	0	1.55	0	6 5/8	8 1/4	100	1.05	0.0
3	16"	lnr	827	867	17 1/2	NO	1.15	1.09	600	4	0.10	867	91	1.48	14	6 5/8	8 1/4	100	1.16	10.2
4	13 3/8"	csg	964	1004	14 3/4	NO	1.15	0.10	867	91	0.10	867	91	1.74	28	6 5/8	8 1/4	100	1.16	o.h.
5	9 5/8"	lnr	###	1240	12 1/4	NO	1.15	1.04	1005	11	0.02	1240	140	1.46	38	6 5/8	8 1/4	100	1.16	o.h.
6	8 1/2"	o.h.	###	1308	8 1/2	NO	1.15	0.02	1240	140	0.02	1240	140	1.84	38	5	6 1/2	100	1.16	o.h.

* kick tollerance has been calculated using a pore pressure greater than MW of	1%
** If the "Gov deep water ref." is used the Gf is recalculated using parameter K ==>	Fixed by GEOPR dept.
NOTE: For choke margin calculation, the friction losses in choke and kill line are not considered.	

Figure 6.4: Wellbore and Casing Seat Profile for Appraisal Well

6.4.2 INJECTION WELLS TO LOWER BUNTER

Well name :	Hewett Lower Bunter			Subsea Wellhead	no
Water depth :	33.0 m	Rotary Table	40.0 m	Used Gov deep water Ref.	no
RKB-Mud line	73.0 m	Rig	TBD		



n°	CSG	Type	TVD msl	TVD RKB	Open Holes	Drive	Max. MW	Max. Gp	@ Depth	Drill. Bal.	Min. Gp	@ Depth	Diff. Pres	Gf @ weak point	Choke Marg.	DP	BHA DC	Lng	Gi (*)	Kick Tol.
			m	m	Inch	yes/no	s.g.	kg/cm^2/10m	m	kg/cm^2	kg/cm^2/10m	m	kg/cm^2	g/cm^2/10r	kg/cm^2	inch	inch	m	s.g.	m3
1	36"	c.p.	70	110	36	YES	1.04	1.03	100	-	0.00	73	-	1.08	-	6 5/8	8 1/4	100	-	-
2	20"	csg	300	340	24	NO	1.04	1.03	110	0	1.03	110	0	1.55	0	6 5/8	8 1/4	100	1.05	0.0
3	16"	lnr	827	867	17 1/2	NO	1.15	1.09	600	4	0.10	867	91	1.48	14	6 5/8	8 1/4	100	1.16	10.2
4	13 3/8"	csg	964	1004	14 3/4	NO	1.15	0.10	867	91	0.10	867	91	1.74	28	6 5/8	8 1/4	100	1.16	o.h.
5	9 5/8"	lnr	###	1240	12 1/4	NO	1.15	1.04	1005	11	0.02	1240	140	1.46	38	6 5/8	8 1/4	100	1.16	o.h.
6	8 1/2"	o.h.	###	1308	8 1/2	NO	1.15	0.02	1240	140	0.02	1240	140	1.84	38	5	6 1/2	100	1.16	o.h.

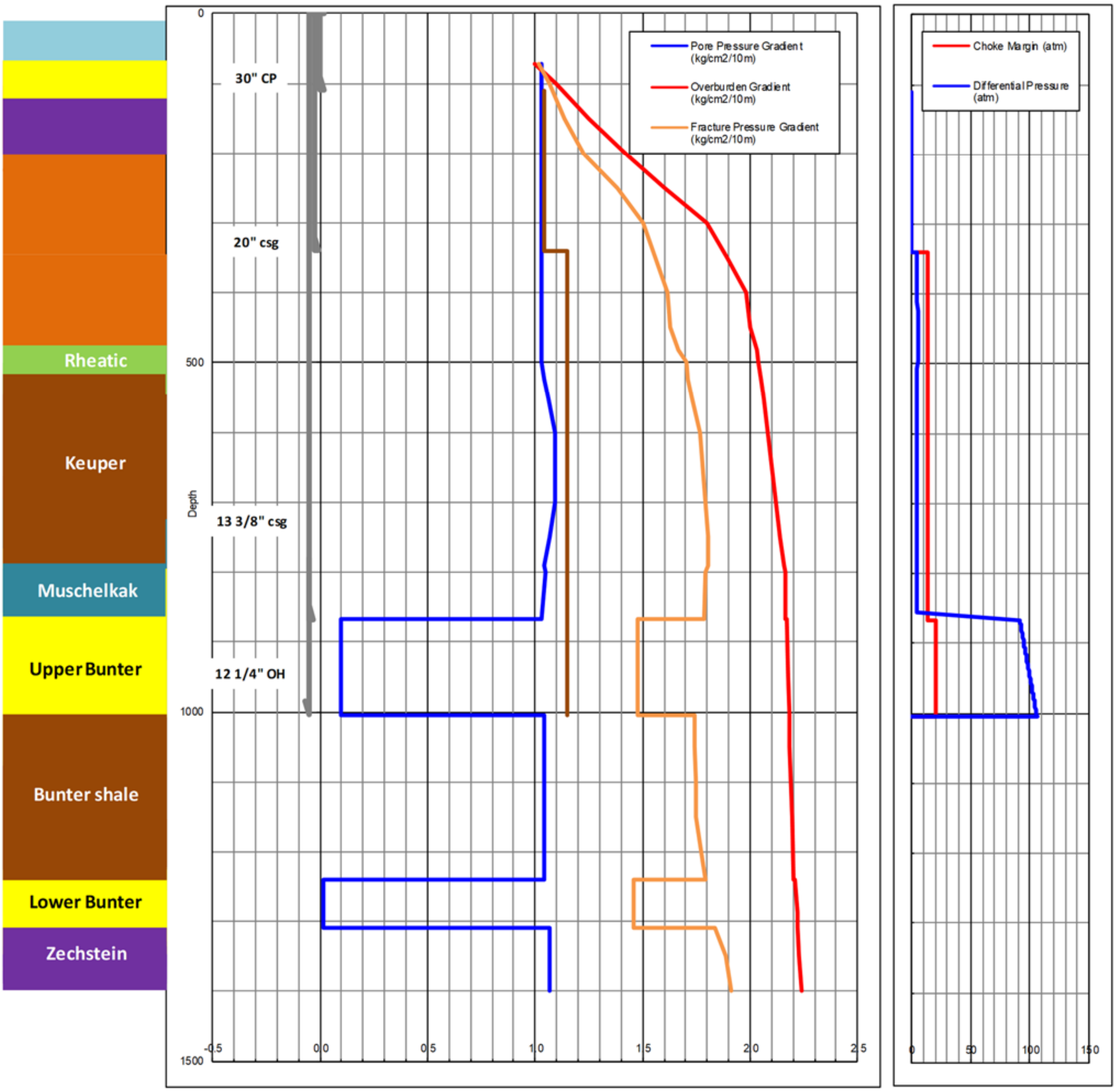
* kick tollerance has been calculated using a pore pressure greater than MW of	1%
** If the "Gov deep water ref." is used the Gf is recalculated using parameter K ==>	Fixed by GEOPR dept.

NOTE: For choke margin calculation, the friction losses in choke and kill line are not considered.

Figure 6.5: Wellbore and Casing Seat Profile for Lower Bunter Well

6.4.3 INJECTION WELL TO UPPER BUNTER

Well name :	Hewett Upper Bunter			Subsea Wellhead	no
Water depth :	33.0 m	Rotary Table	40.0 m	Used Gov deep water Ref.	no
RKB-Mud line	73.0 m	Rig	TBD		



n°	CSG	Type	TVD msl	TVD RKB	Open Holes	Drive	Max. MW	Max. Gp	@ Depth	Drill. Bal.	Min. Gp	@ Depth	Diff. Pres	Gf @ weak point	Choke Marg.	DP	BHA DC	Lng	Gi (*)	Kick Tol.
			m	m	Inch	yes/no	s.g.	kg/cm²/10m	m	kg/cm²	kg/cm²/10m	m	kg/cm²	g/cm²/10r	kg/cm²	inch	inch	m	s.g.	m3
1	36"	c.p.	70	110	36	YES	1.04	1.03	100	-	0.00	73	-	1.08	-	6 5/8	8 1/4	100	-	-
2	20"	csg	300	340	24	NO	1.04	1.03	110	0	1.03	110	0	1.55	0	6 5/8	8 1/4	100	1.05	0.0
3	13 5/8"	csg	827	867	17 1/2	NO	1.15	1.09	600	4	0.10	867	91	1.48	14	6 5/8	8 1/4	100	1.16	10.2
4	12 1/4"	o.h.	964	1004	12 1/4	NO	1.15	0.10	867	91	0.10	867	91	1.74	28	6 5/8	8 1/4	100	1.16	o.h.

* kick tollerance has been calculated using a pore pressure greater than MW of 1%

** If the "Gov deep water ref." is used the Gf is recalculated using parameter K ==> Fixed by GEOPR dept.

NOTE: For choke margin calculation, the friction losses in choke and kill line are not considered.

Figure 6.6: Wellbore and Casing Seat Profile for Upper Bunter Well

6.5 DIRECTIONAL PROFILE

All wells directional profiles are studied by drilling department and verified by Reservoir department using reservoir model.

The appraisal well is designed with a vertical profile.

A 2D trajectory has been designed for all injection wells, in order to reach an inclination of about 35° for UB and 45° for LB wells.

Surface casing nudging is considered for anticollision issue: max inclination at surface casing shoe of 4° and DLS less then 1°/30 m.

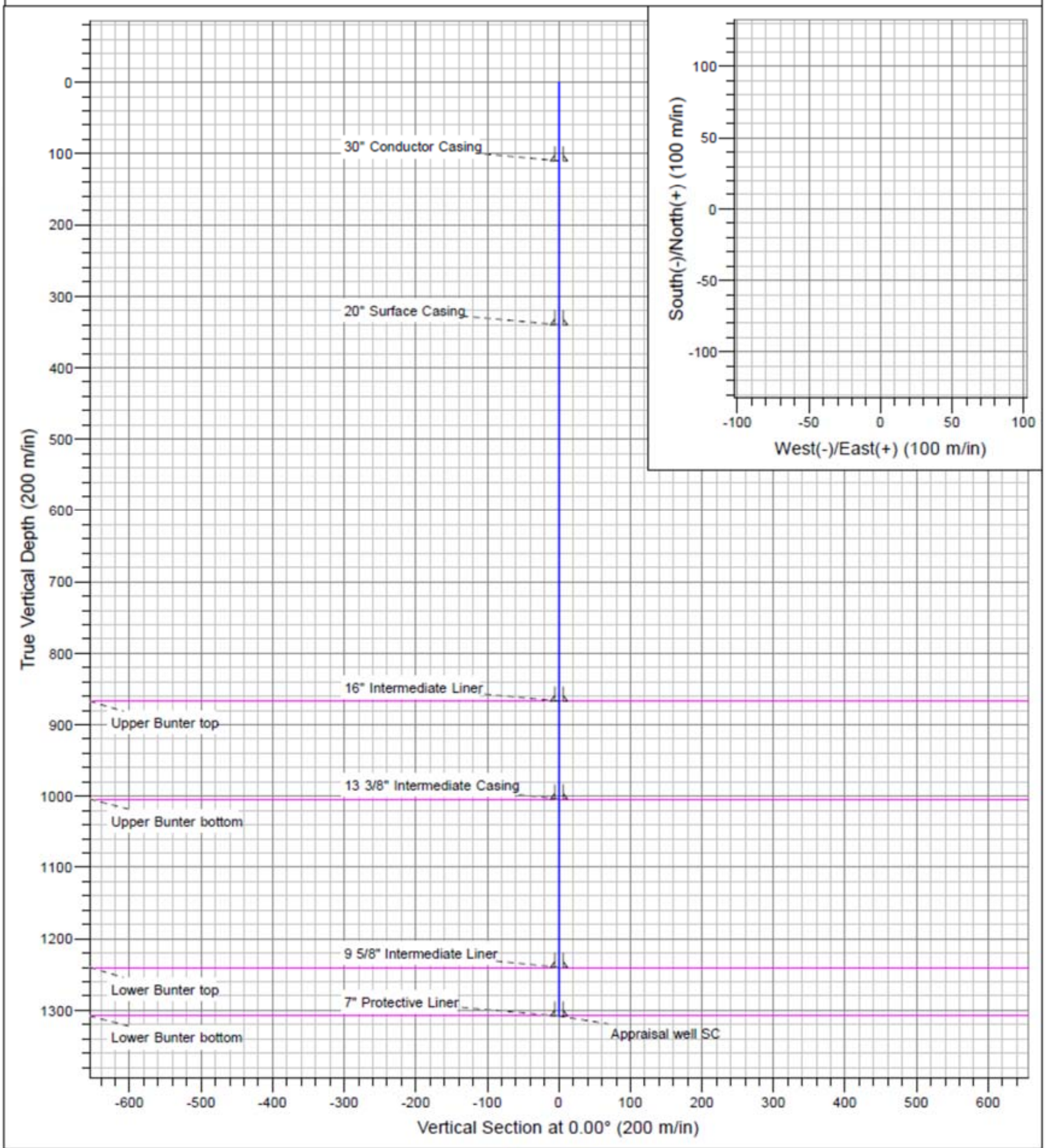
KOP is kept at about 340 m TVD RKB, meanwhile DLS values are planned considering the maximum value during the 17 1/2” section (2°/30 m)

All the wells trajectories are reported in the next pages and the mentioned depths (TVD-MD) refer to an RKB elevation of 40 m.

WELL DETAILS: Appraisal well

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	1308.00	0.00	0.00	1308.00	0.00	0.00	0.00	0.00	0.00	

CASING DETAILS

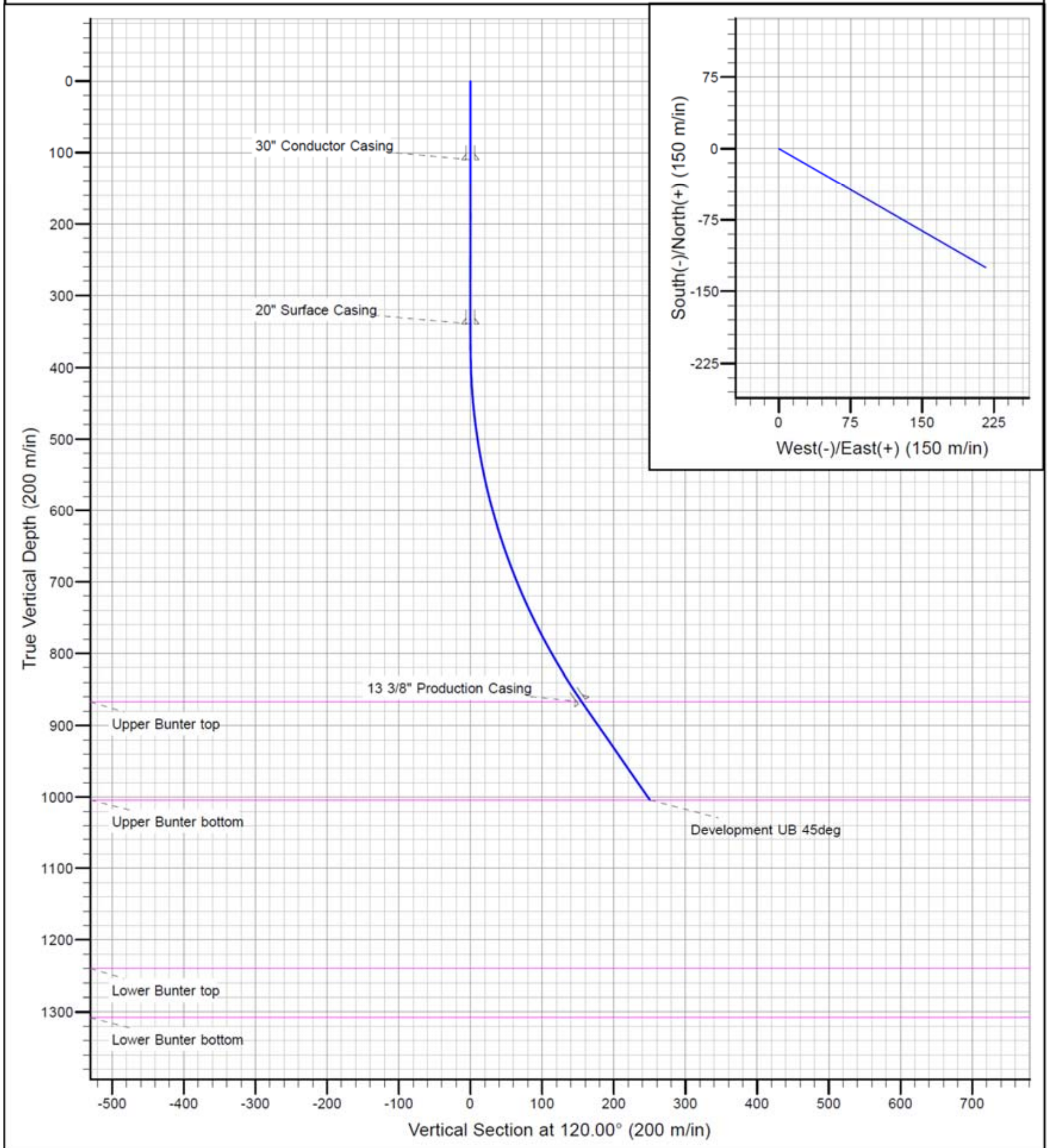
TVD	MD	Name	Size
110.10	110.10	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	867.00	16" Intermediate Liner	16.000
1004.00	1004.00	13 3/8" Intermediate Casing	13.375
1240.00	1240.00	9 5/8" Intermediate Liner	9.625
1308.00	1308.00	7" Protective Liner	7.000

Figure 6.7: Appraisal well trajectory

WELL DETAILS: Development well upper Bunter

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	370.00	0.00	120.00	370.00	0.00	0.00	0.00	120.00	0.00	
3	898.72	34.69	120.00	867.00	-77.62	134.44	2.00	120.00	155.24	
4	1065.34	34.69	120.00	1004.00	-125.04	216.58	0.00	0.00	250.08	

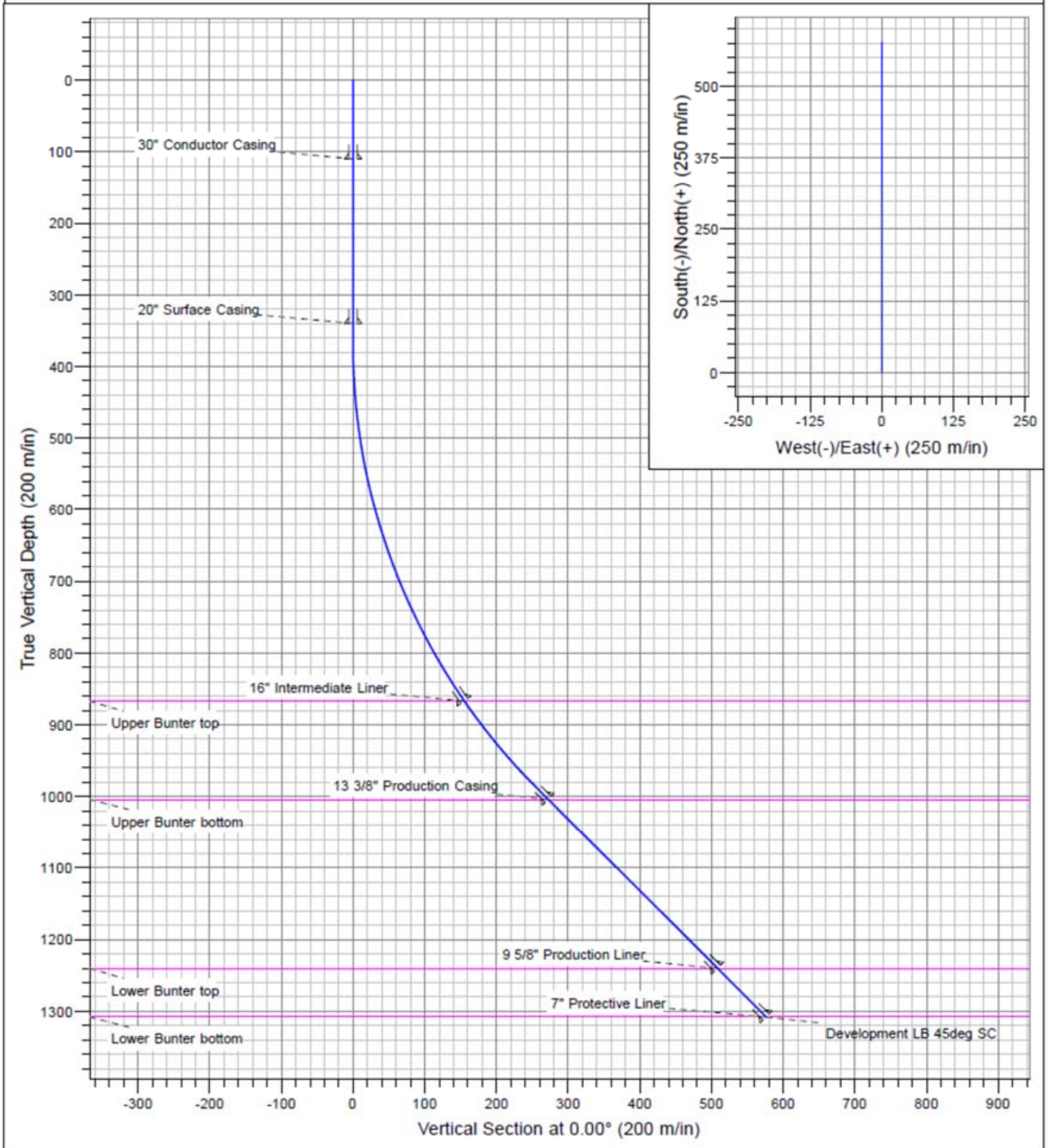
CASING DETAILS

TVD	MD	Name	Size
110.00	110.00	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	898.72	13 3/8" Production Casing	13.375
	1079.22	9 5/8" Production Liner	9.625

Figure 6.8: Upper Bunter injection well trajectory

WELL DETAILS: Development well Lower Bunter

Water Depth:	34.00
Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	370.00	0.00	0.00	370.00	0.00	0.00	0.00	0.00	0.00	
3	1055.80	45.00	0.00	987.44	255.75	0.00	2.00	0.00	255.75	
4	1509.14	45.00	0.00	1308.00	576.31	0.00	0.00	0.00	576.31	

CASING DETAILS

TVD	MD	Name	Size
110.00	110.00	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	898.72	16" Intermediate Liner	16.000
1004.00	1079.22	13 3/8" Production Casing	13.375
1240.00	1412.98	9 5/8" Production Liner	9.625
1308.00	1509.14	7" Protective Liner	7.000

Figure 6.9: Lower Bunter injection wells trajectory

6.5.1 SPIDER PLOT

The following map shows the injection scheme currently proposed by reservoir dept.

The three injectors to the Lower Bunter are equally phased with 120° azimuth variation.

The injector to the Upper Bunter (which will be activated once the pressure of the two reservoirs are approximately equalized) will be directed to an azimuth between two LB wells.

Based on the planned well trajectories currently it is not foreseen any collision risk. If modification will be required, the need of an anticollision analysis will be evaluated.

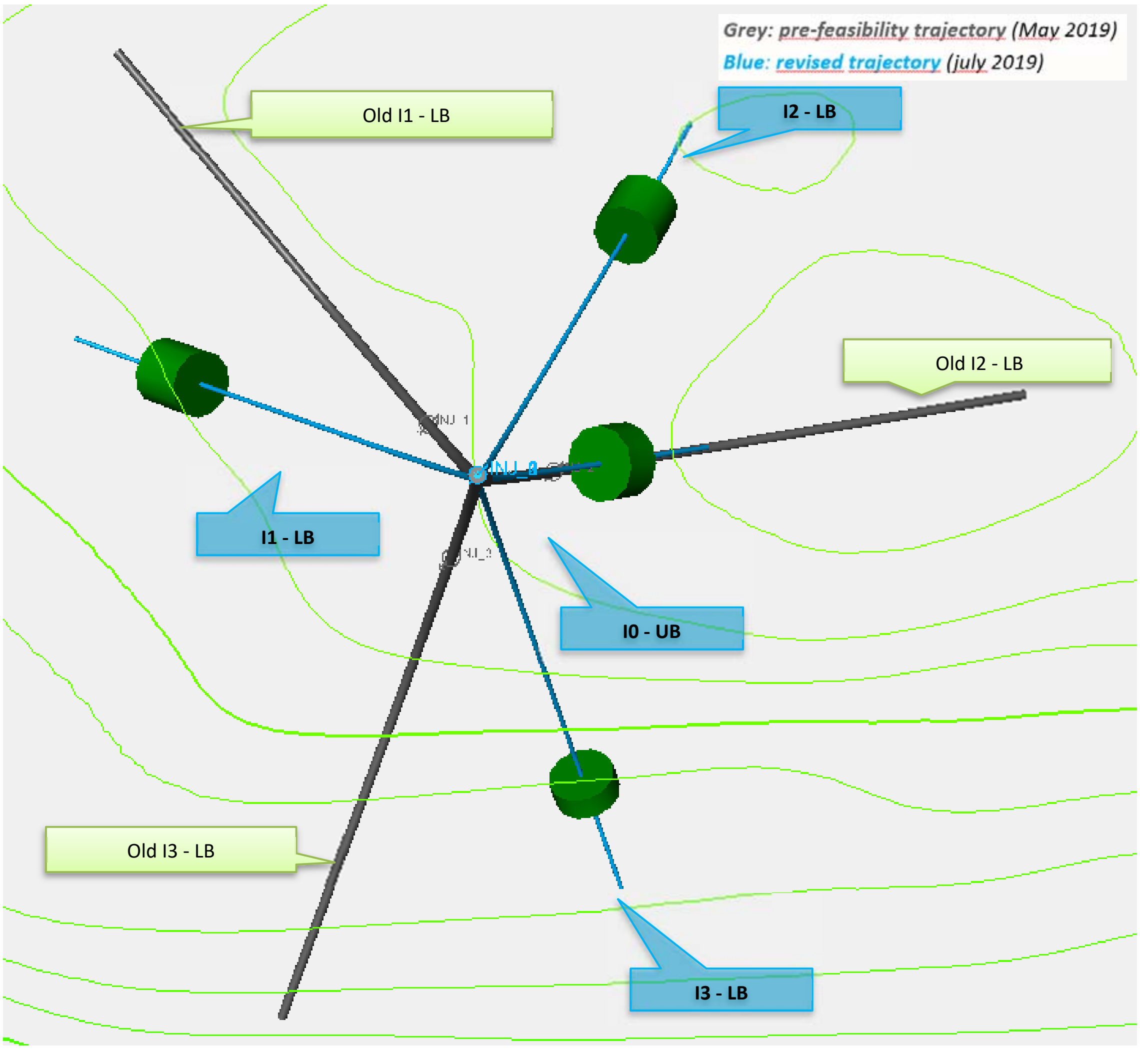


Figure 6.10: Spider Plot

6.6 CASING DESIGN

The casing design has been evaluated according to the pressure gradient prognosis curves currently available.

The selected tubular material shall be considered as the minimum required.

Casings design studies have been verified in compliance with the ENI company policies, as summarized in the table below.

All the here reported well profiles consider an RKB elevation of 40 m.

6.6.1 APPRAISAL WELL

The appraisal well was designed considering the drilling load only. The injection scenario is not considered.

String	OD, Weight, Grade	Connection	MD Interval (m RKB)	Drift Dia. (in)	Minimum Safety Factors (Abs)			
					Burst	Collapse	Axial	Triaxial
Surface Casing	20", 106.5 ppf, J-55	Coupled	10 - 340	18.813	1.21	1.55	16.79	1.51
Intermediate Liner	16", 94.5 ppf, K-55	Semiflush*	240 - 899	14.75 SD	1.95	1.32	6.30*	2.44
Production Casing	13 3/8", 68 ppf, N-80	Semiflush Premium*	10 - 1079	12.259	1.87	1.38	5.63*	2.29
Production Liner	9 5/8", 40 ppf, N-80	Coupled premium	980 - 1413	8.5	3.31	1.52	23.60	2.38

* The near flush connection are assumed with 70% of efficiency

Table 6.3: Casing Design for Appraisal well

6.6.2 INJECTOR WELLS

6.6.2.1 WELL TO UPPER BUNTER

The design are verified for drilling, injection and back flow load.

String	OD, Weight, Grade	Connection	MD Interval (m RKB)	Drift Dia. (in)	Minimum Safety Factors (Abs)			
					Burst	Collapse	Axial	Triaxial
Surface Casing	20", 106.5 ppf, J-55	Coupled	10 - 340	18.813	1.21	1.55	16.79	1.51
Production Casing	13 3/8", 68 ppf, N-80	Coupled premium	10 - 899	12.259	2.32	1.60	7.91	2.64

Table 6.4: Casing Design for injection well to Upper Bunter

The production casing considers two different scenarios:

- Tubing leak during injection with max expected pressure for ordinary operations.
  - Injection pressure 60 kg/cm^2 (maximum expected)
  - Packer fluid density 1.15 SG (last phase mud density)
- Tubing leak during backflow from pressurized reservoir.
  Due to the preliminary stage ad current modelling in progress, the maximum reservoir pressure is not available. The casing design verification are performed considering the reservoir pressure equal to cap rock fracture pressure (the most possible conservative approach).
  - CO_2 gas density 15.7 kg/m^3 (minimum expected)
  - Packer fluid density 1.15 SG

  With these assumption, the maximum tubing head pressure reaches 141 Kg/cm^2, meanwhile the reservoir pressure is 240 Kg/cm^2

Furthermore, the maximum injection pressures applicable in particular operations (stimulation, acid job..) is 310 kg/cm^2, with minimum requirement tubulars (as per table above) and considering the packer fluid density equal to 1.15 SG

For the lower portion of the13 3/8” casing (~150-200 m) CRA material shall be used. The casing joints shall be of same weight (68#) and yield strength (80 Kpsi).

6.6.2.2 WELLS TO LOWER BUNTER

The design is verified for drilling, injection and back flow load.

String	OD, Weight, Grade	Connection	MD Interval (m RKB)	Drift Dia. (in)	Minimum Safety Factors (Abs)			
					Burst	Collapse	Axial	Triaxial
Surface Casing	20", 106.5 ppf, J-55	Coupled	10 - 340	18.813	1.21	1.55	16.79	1.51
Intermediate Liner	16", 94.5 ppf, K-55	Semiflush*	240 - 899	14.75 SD	2.12	1.32	3.44*	2.65
Production Casing	13 3/8", 68 ppf, N-80	Semiflush Premium*	10 - 1079	12.259	1.15	1.38	4.21*	1.41
Production Liner	9 5/8", 40 ppf, N-80	Coupled premium	980 - 1413	8.75	1.95	1.52	10.43	2.42

* The near flush connections are assumed with 70% of efficiency

Table 6.5: Casing Design for injection wells to Lower Bunter

The production casing considers two different scenarios:

- Tubing leak during injection with max expected pressure for ordinary operations.
    - Injection pressure 60 kg/cm^2 (maximum expected)
    - Packer fluid density 1.15 SG (last phase mud density)
- Tubing leak during backflow from pressurized reservoir.

  Due to the preliminary stage ad current modelling in progress, the maximum reservoir pressure is not available. The casing design verification are performed considering the reservoir pressure equal to cap rock fracture pressure (the most possible conservative approach)
    - CO_2 gas density 15.7 kg/m^3 (minimum expected)
    - Packer fluid density 1.15 SG

  With these assumption, the maximum tubing head pressure reaches 203 Kg/cm^2, meanwhile the reservoir pressure is 345 Kg/cm^2

Furthermore, the maximum injection pressures applicable in particular operations (stimulation, acid job..) is 215 kg/cm^2, with minimum requirement tubulars (as per table above) and considering the packer fluid density equal to 1.15 SG

For the lower portion of the 9 5/8” liner (~150-200 m) CRA material shall be used. The casing joints shall be of same weight (40#) and yield strength (80 Kpsi).

6.7 WELLHEAD, X/MAS TREE AND BOP SELECTION

As per ENI policy, well surface equipment such as:

- BOP
- Wellhead
- Xmas Tree
- SCSSV
- Choke manifold

shall have a Working Pressure Rating value of 10% more than the Maximum Anticipated Wellhead Pressure, calculated as the maximum between the two values here given:

$$MAWHP_{drilling} = \frac{0.6(G_{frac}^{shoe} - \rho_{gas})H_{shoe}}{10} \qquad MAWHP_{prod} = \frac{(G_{pore}^{perf} - \rho_{fl})H_{perf}}{10}$$

The highest values for the two MAWHP values are expected for the deepest casing and the respective calculation results are here given:

APPRAISAL WELL WPR CALCULATION	Units	Drilling scenario
Reference depth TVD RKB	*metres*	1240
Gradient value (FG)	*g/cc*	1.46
Fluid density	*g/cc*	0.3
MAWHP	*psi*	1227
WPR	*psi*	2000

UPPER BUNTER INJECTION WELL WPR CALCULATION	Units	Drilling scenario	Injection scenario	Tbg Leak (Back Flow sensitivity)
Reference depth TVD RKB	*metres*	867		
Gradient value (FG or PPG)	*g/cc*	1.48		
Fluid density	*g/cc*	0.3		
MAWHP or Injection pressure	*psi*	873	853	2005
WPR required	*psi*	2000	2000	3000

UPPER BUNTER INJECTION WELL WPR CALCULATION	Units	Drilling scenario	Injection scenario	Tbg Leak (Back Flow sensitivity)
Reference depth TVD RKB	*metres*	1240	2661	
Gradient value (FG or PPG)	*g/cc*	1.46	1.25	
Fluid density	*g/cc*	0.3	0.3	
MAWHP or Injection pressure	*psi*	1227	853	2887
WPR	*psi*	2000	2000	5000

Table 6.6: WPR calculation

Then, **5000 psi WPR** is the requirement for the equipment (as per Eni's minimum standard for new wells)

Currently not foreseen fracture scenario for wellhead and Xmas tree are not included in this evaluation.

7. DRILLING FLUIDS AND CEMENT STUDY

7.1 DRILLING FLUIDS

Drilling fluids selection and their definition are based on the experiences gained in the field considering technical, economic and environmental aspects. General mud proposal is summarized in table. Actual mud weight will be defined according to real pore gradient development and wellbore conditions.

The current estimation is based on the worst case scenario: wells to Lower Bunter.

24" phase will be drilled using KCl Polymer mud system and High Vis Sweeps. This interval will be drilled to 340 m MD/VD RKB and mud weight will be 1.04 SG. Upon reaching section TD, it is recommended to pump a 15-20 m^3 Hi-Vis Pill and then spot enough 1.20 SG FW-PO-KC Mud volume to fill the open hole prior to short trip to mud line and RIH csg. Prior to drill the phase, build up 70 m^3 of 1.4 SG WBM kill mud for emergency in case of shallow hazard presence. This interval will be cemented with 20" casing. FW-PO-KC mud system with additives of shale stabilizer is selected in order to inhibit shale hydration and mitigate the effect of cuttings on viscosity rising. It is expected to minimize the problems such as excessive dilution rates, increasing torque and drag, high surge and swab pressures and bit balling.

17 ½" phase will be drilled using inhibitive KCl Polymer mud system. This interval will be drilled to 867 m VD RKB and mud weight will be 1.15 SG. This interval will be cemented with 16" liner. Design objectives identified for this phase are the following:

- Borehole stability
- Clay inhibition and bit balling prevention
- Provide efficient hole cleaning

14 ¾" phase will be drilled using inhibitive KCl Polymer mud system. This interval will be drilled 1004 m VD RKB and mud weight will be 1.15 SG. This interval will be cemented with 13 3/8" casing. Design objectives identified for this phase are the following:

- Borehole stability
- Preventing differential sticking in depleted zone
- Provide efficient hole cleaning
- Prevention of losses in depleted zone

12 ¼" phase will be drilled using inhibitive KCl Polymer mud system. This interval will be drilled to 1240 m VD RKB and mud weight will be 1.15 SG. This interval will be cemented with 9" 5/8. Design objectives identified for this phase are the following:

- Borehole stability

- Clay inhibition and bit balling prevention
- Provide efficient hole cleaning

8 ½" phase will be drilled using inhibitive KCl Polymer mud system. This interval will be drilled to 1308 m VD RKB and mud weight will be 1.15 SG. Design objectives identified for this phase are the following:

- Borehole stability
- Preventing differential sticking in depleted zone
- Provide efficient hole cleaning
- Prevention of losses in depleted zone

Reservoir phases in both lower and upper Bunter will be drilled using a 1.15 SG mud weight. Bridging material will prevent and limit downhole losses in these depleted intervals. In case of need acid treatments will be evaluated to increase injectivity.

The estimated mud volumes to be built up for each section are referred to the here below table:

Phase	24"	17 ½"	14 ¾"	12 ¼"	8 ½"
Mud type	FW-PO-KC Hi Vis pills	FW-PO-KC	FW-PO-KC	FW-PO-KC	FW-PO-KC
Density (SG)	1.04/1.20	1.15	1.15	1.15	1.15
MD RKB (m)	340	914	1104	1438	1534
Hole Volume (m^3)	98	89	21	25	4
Surface Volume (m^3)	150	150	150	150	150
Casing Volume (m^3)	64	60	113	84	53
Dilution factor	150%	150%	150%	150%	150%
Dilut.Volume (m^3)	147	133	31	37	6
Mud volume for phase (m^3)	459	432	315	296	213
Vol. received from previous section (m^3)	0	283	263	234	203
Build Volume (m^3)	459	149	52	62	10

Table 7.1: Mud volumes per section

7.2 CEMENTING

Estimates relevant to cementing operations to be performed on the wells are herein reported. Current figures, especially those related to volumes, and slurries compositions, have to be considered provisional since final estimation will be dictated by actual operational requirements. In particular, the final recipe, final slurry volume, final chemical composition and operation details will be provided after field and lab tests results, prior to commence the cementing job.

Depending on the different hole sections, TOC and slurry height will be as follows (see table below):

- 20” casing will be cemented up to well head with single slurry 1.9 SG.
- 16” liner will be cemented till Top of Liner (TOL 100 m inside previous csg shoe) with two slurries (150 meters of 1.9 SG Tail slurry + 524 meters of 1,50 SG Lead slurry).
- 13” 3/8 casing will be cemented up to 700 m (about 200 m inside previous csg shoe) with two slurries (150 meters of 1.68 SG tail slurry+ 229 meters of 1,44 SG Lead slurry).
- 9”5/8 liner will be cemented till Top of Liner (TOL 100 m inside previous csg shoe) with single slurry.

Cement design will be verified in relation to the possible local authorities requirements before the execution phase.

All volume and characteristics have to be considered only preliminary:

*** 13 3/8" casing volume are based on worst scenario with 17 ½" section (UB well).

CASING SIZE	**20" CSG**	**16 " LNR**	**13 3/8" CSG**	**9 5/8" LNR**
Casing Shoe MD / VD from RKB (m)	340/340	899/867	1079/1004	1413/1240
Top Of Cement (m)	0	240	700	980
Hole size (in)	26"	17 ½"	17 ½" ***	12 ¼"
Excess	150 %	100 %	50 %	30 %
TYPE OF SLURRY / VOLUME				
TYPE SLURRY	**Class G**	**Extender + Class G**	**Extender + Pozzolanic**	**Extender + Pozzolanic + weighting**
TOTAL VOLUME (mc)	120	40	38	20
LEAD SLURRY VOLUME (mc)	0	32	23	0
TAIL SLURRY VOLUME (mc)	120	8	15	20
Possible issues	Losses	Losses	Losses + CO_2 reservoir	CO_2 reservoir cover
MUD				
Mud type	FW-PO-KC Hi Vis pills	FW-PO-KC	FW-PO-KC	FW-PO-KC
mud density (sg)	1.04-1.20	1.15	1.15	1.15
SPACER				
Type	Compatible with WBM and Slurries and suitable to remove mud filter cake			
Density/ Rheology	Higher than Mud / lower than Slurry			
Contact time	Enough to cover at least 150 m in OH and/or guarantee more than 10 minutes of Contact Time			

Table 7.2. General information

7.3 CEMENT WELLBORE INTEGRITY CONSIDERATIONS FOR CO_2 INJECTION AND STORAGE WELLS

7.3.1 INTRODUCTION

Well Design, Construction and Abandonment is a challenge in fields where high rate CO_2 injection is planned due to the conversion of Portland cement (neat Class G cement) to calcium carbonate and its dissolution in an acid environment. The negative effect of CO_2-containing fluids on set cement slurries is caused by the fact that CO_2 can destroy their structural integrity as a consequence of the reactions taking place among CO_2, water and some components of the cement, first of all calcium carbonate, $CaCO_3$, and the C–S-H gel. In fact, CO_2 reacts with water giving carbonic acid, H2CO_3, which in turn transforms $Ca(OH)_2$ and the C-S-H gel into the insoluble calcium carbonate, $CaCO_3$ and an amorphous gel.

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$
$$Ca(OH)_2 + H^+ + HCO_3^- \rightarrow CaCO_3\downarrow + 2H_2O$$
$$C\text{-}S\text{-}H\ gel + H^+ + HCO_3^- \rightarrow CaCO_3\downarrow + C\text{-}S\text{-}H\ gel$$

As the water containing CO_2 continues to invade the set cement matrix, other equilibrium conditions are established, which convert the insoluble $CaCO_3$ into water-soluble calcium bicarbonate, $Ca(HCO_3)_2$.

$$CO_2 + H_2O + CaCO_3 \leftrightarrow Ca(HCO_3)_2$$

The bicarbonate can be transported outside the cement matrix by the percolating water or can react with calcium hydroxide giving again water and calcium carbonate.

$$Ca(HCO_3)_2 + Ca(OH)_2 \leftrightarrow 2CaCO_3\downarrow + H_2O$$

The "free water", obtained during this last reaction, can dissolve more calcium bicarbonate with the final result that this process:

- Leaches out of the cement matrix a considerable quantity of cementitious material,
- Increases cement porosity, and consequently
- Decreases its mechanical properties.

The degradation rate of Class G cement exposed to CO_2 can be evaluated according to the Barlet – Gouedard experimental formula[1]:

$$d = a * (t)^{1/2}$$

where:
d: degraded cement thickness (mm)
a: constant 0.262 - supercritical CO_2 / 0,218 – CO_2 saturated water
t: time (hours)

According to this, it takes about 1 year to degrade 25 mm of cement.

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[1] SPE 98294 Mitigation Strategies for the risk of CO2 Migration through Wellbores Barlet Gouedard et al.

7.3.2 BASIS OF CEMENT DESIGN

Slurries must be formulated both to chemically resist to aggressive environments and to be mechanically durable. In fact, after setting, cement sheath must withstand stresses imposed by changes of pressure regime during post cementing operations such as stimulation treatments, casing pressure test, fluid injection. Moreover, sudden changes of temperature can also cause change in the wellbore stress field: all these issues may lead to a loss of zonal isolation. For all those reasons cement slurry shall be designed to:

- Provide zonal isolation ensuring no communication between different formations
- Match the changing stresses in the wellbore
- Have low permeability, good compressive strength, enhanced flexibility and chemical resistance to acid environments
- Expand to seal micro-annuli both outward and inward, ensuring complete hydraulic isolation

From a mechanical point of view elasticity shall be preferred to mechanical resistance, below the recommended Young Modulus and Expansion ratio:

- Young Modulus 0,8 - 1,0 Mpsi
- Net Expansion between 0,3 – 1,0%

Also cement placing has to be optimized trying to displace drilling fluid in turbulent flow or, if not possible, optimize the fluids (mud, spacers, cement) hierarchy according to following rules:

- Minimum Difference in Density between mud and cement: 20%
- Friction Pressure Drop ratio between fluids: 1.2
- Minimum Pressure Gradient: The wall stress for the displacing fluid shall be always greater than its yield stress.

In the slurry selection two different approach will be considered:

- Use of Portland modified cement to slow or prevent reaction with CO_2 (eg Class G cement + fly ash, as per table below) based on the Eni experience acquired in harsh environment fields;

Slurry Main Components
Class G cement
Fly Ash
Elastic particle
Friction reducer
Fluid loss reducer
Defoamer
Fibers
Expanding agent
Retarder
Water

Or

- use a CO2 cement slurries like EverCRETE, Welllife or PermaSet that are currently under study for this specific application.

8. PRELIMINARY COMPLETION STUDY

The objective of this section is to provide a feasibility engineering design study for the project.

The following main technical requirements have been considered:

- The completion design is based on the results produced by Eni flow assurance team with OLGA simulator, which is currently considered the most reliable tool for this analysis.
- The maximum well-head injection pressure considered for completion design is 60 Bar as it covers all the design features of the field life.
- Tubing sizes has been selected to allow the daily average CO2 injection rate that during the project life will range from 1066 SMm3/d to 3046 SMm3/d.
- In compliance with Eni procedure, the completion design includes: a tubing retrievable surface controlled sub-surface safety valve (TR-SCSSV) and a production packer.
- Completion design of the injector wells includes a permanent downhole gauge above the production packer for monitoring purposes.
- Tubing size has to allow the use of wire-line tools for corrosion monitoring, execution of other possible logs and P/T measurements during the well life.

More details on the completion equipment are provided in the following sections.

8.1 MATERIAL SELECTION

Regarding material selection of the Hewett wells, previous Eni studies related to CO_2 injection have been taken as reference. Based on that, Chrome material has been preliminarily considered suitable also for this project.

Considering that the cost range for the chromium steel is significantly variable, as a conservative approach, the preliminary material selection for the tubing string and the downhole equipment considered is the nickel alloy (28Cr). In a future phase of the project a dedicated study can be performed to optimize the most suitable material selection and to improve the potential cost optimization.

According to a preliminary benchmark, Glassfiber Reinforced Epoxy (GRE) resin lining technology has been used by manufactures in some CO_2 injector wells and it may be considered as a cost effective alternative to the chromium steel. Nevertheless, this possibility shall be better assessed in the future project phases.

8.2 COMPLETION EQUIPMENT

According to the two reservoir targets planned for the CO2 injection (Lower Bunter and Upper Bunter), different completion architecture have been evaluated.

The main objective of the completion design is to maximize tubing size.

Injector wells targeting Upper Bunter reservoir

For the injector wells targeting the shallowest reservoir the following completion architecture have been proposed:

- Lower completion: 9 5/8” slotted liner
- Upper Completion: 9 5/8” tubing

  9 5/8” TR-SCSSV

  9 5/8” DH P/T gauge above packer

  9 5/8” Landing Nipples

  13 3/8” x 9 5/8” Production Packer

In order to simplify completion operations the standardization of the downhole equipment has been considered whenever possible.

The completion schematics for the different optiions and the equipment with relevant main features are described in the following sections.

Injector wells targeting Lower Bunter reservoir

For the wells targeting the deepest reservoir two completion options have been proposed:

- **Option 1: 7” monobore completion**
  - Lower completion: 7” slotted liner
  - Upper Completion: 7” tubing

    7” TR-SCSSV

    7” DH P/T gauge above packer

    7” Landing Nipples

    9 5/8” x 7” Production Packer

- **Option 2: 9 5/8” x 7” tapered completion**
    - Lower completion: 7” slotted liner
    - Upper Completion: Tapered 9 5/8” x 7” tubing

      9 5/8” TR-SCSSV

      7” DH P/T gauge above packer

      7” Landing Nipples

      9 5/8” x 7” Production Packer

8.3 PRELIMINARY COMPLETION SCHEMATIC FOR UPPER BUNTER WELLS

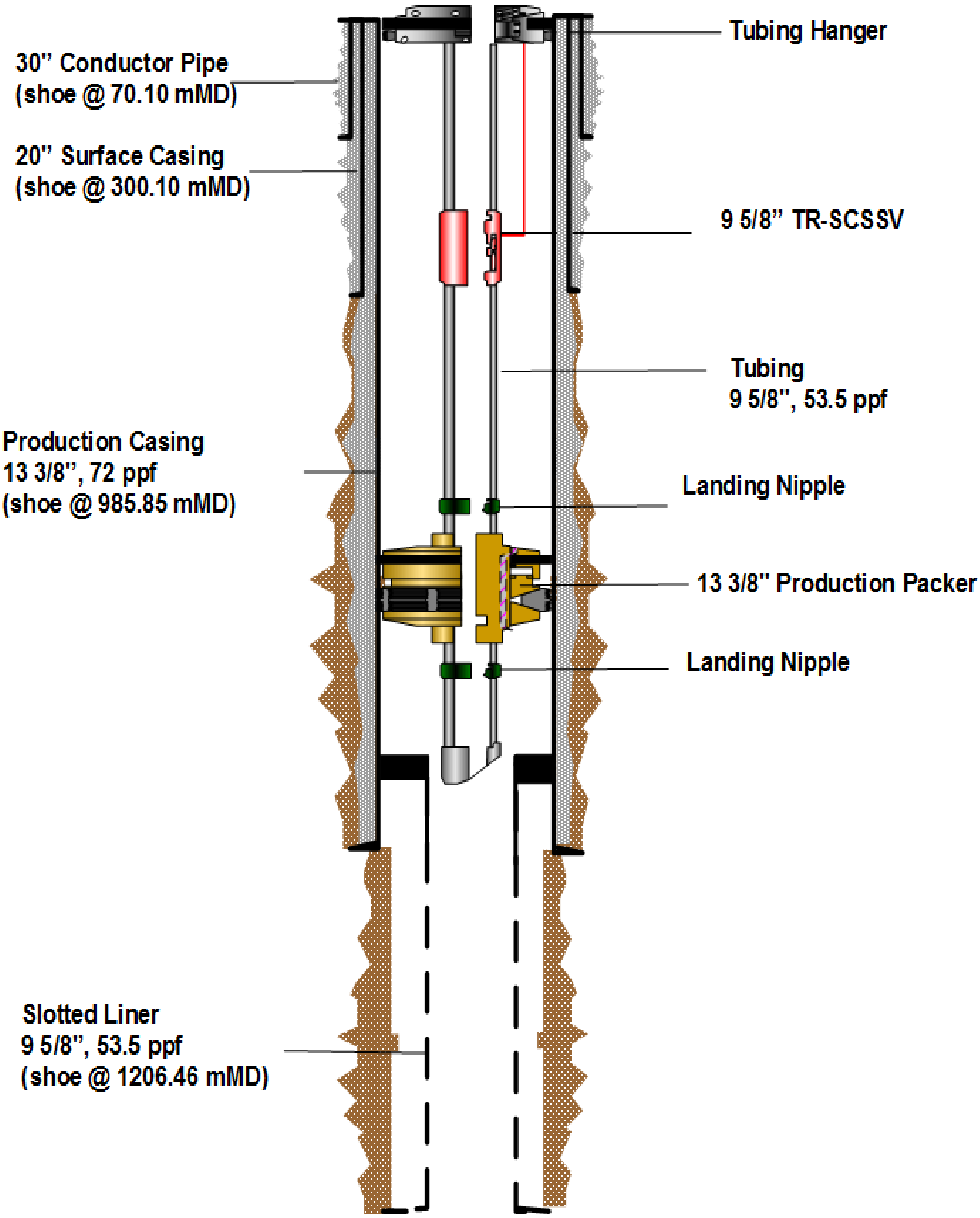

Figure 8.1: Preliminary Completion Scheme for Upper Bunter Wells

8.4 PRELIMINARY COMPLETION SCHEMATIC FOR LOWER BUNTER WELLS

8.4.1 OPTION 1: 7" MONOBORE COMPLETION

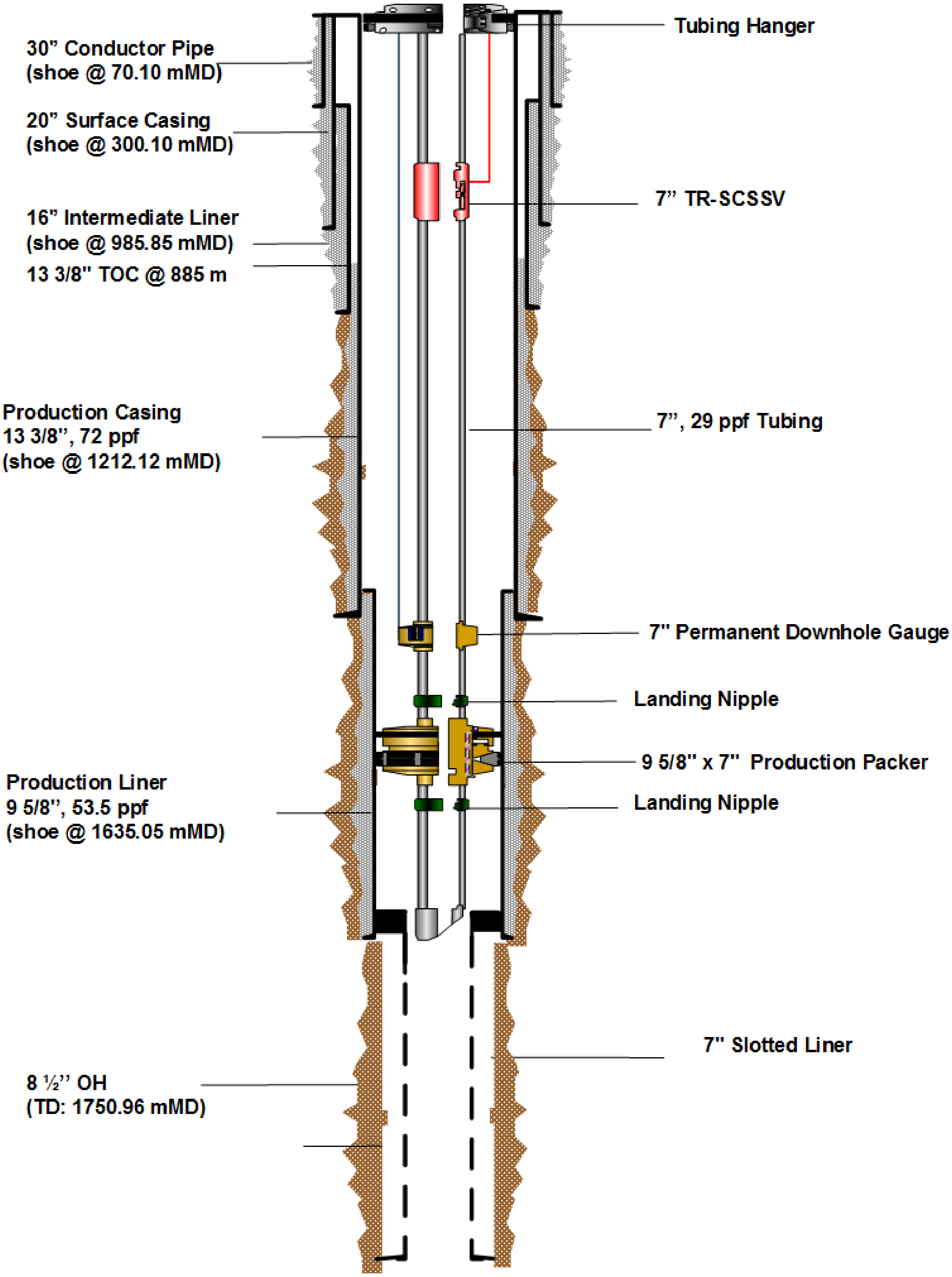

Figure 8.2: Preliminary Completion Scheme for Lower Bunter Wells

8.4.2 OPTION 2: 9 5/8" X 7" TAPERED COMPLETION

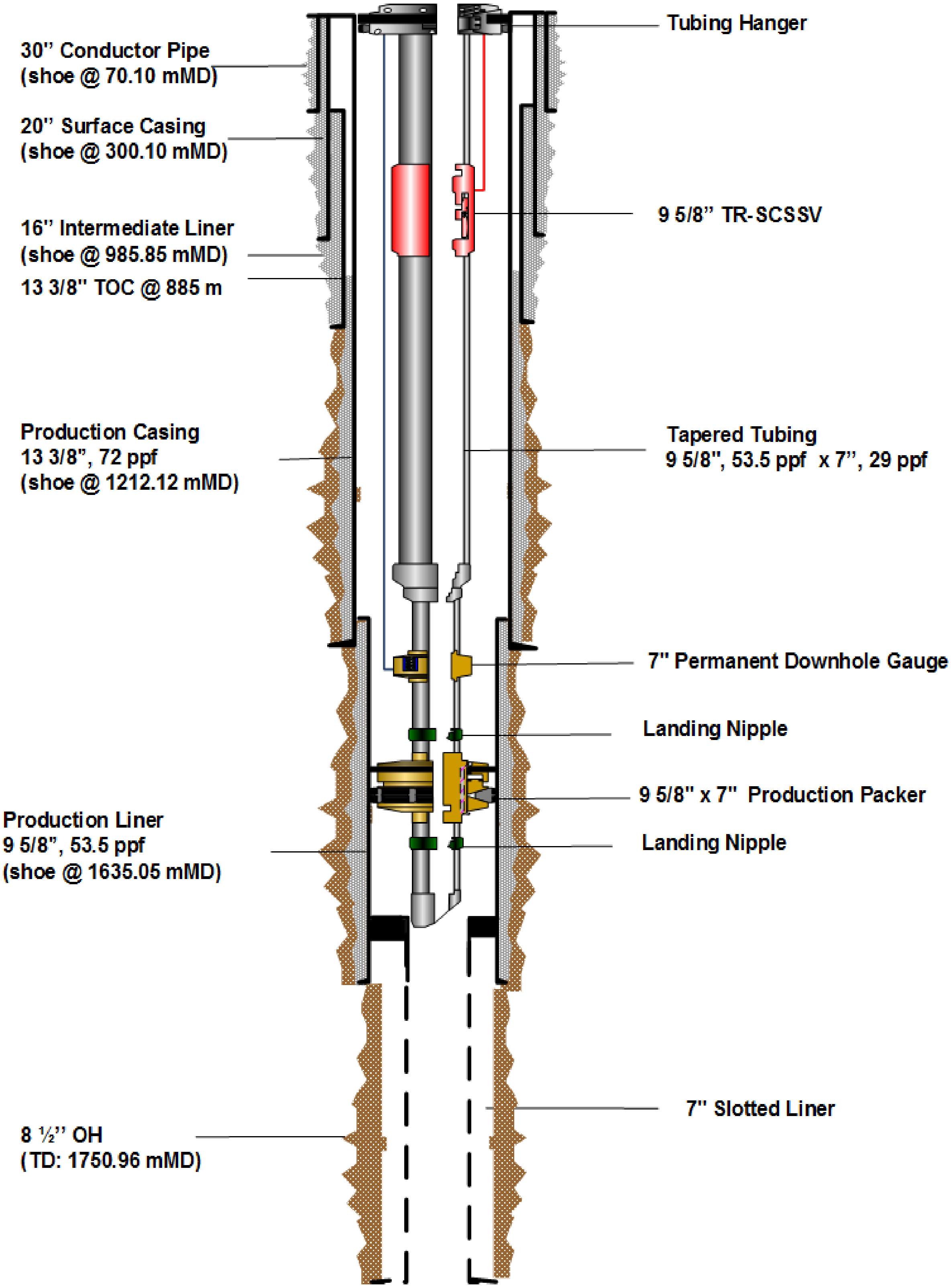

Figure 8.3: Preliminary Tapered Completion Scheme for Lower Bunter Wells

8.5 TR-SCSSV

As per Eni “Well Control Procedure” (STAP-P-1-M-25007), in each well capable to flow at wellhead, any new completion design shall include a Tubing Retrievable Surface Controlled Sub-surface Safety Valve (TR-SCSSV) to ensure safety in the event of an uncontrolled well flow.

Typically the TR-SCSSV is installed below the Xmas Tree and, in case of platform application such as Hewett, below seabed, at shallow depth.

It is recommended to use a tubing retrievable flapper type valve, non self equalizing, rod piston, with lock-open device with the provision of an insert - wire line retrievable valve to be installed in the top no-go landing nipple if required.

With respect to the 9 5/8” TR-SCSSV proposed in the Upper Bunter well and in Option 2 of Lower Bunter wells, it is important to highlight that, as per a preliminary benchmark, different Service Contractors have this valve size currently available in their portfolio, but the confimation on the number of deployments and under which conditions they have been deployed is still pending. Furthermore, it is important to highlight that Eni has no experience on this TR-SCSSV size, but it is in constant contact with providers that declare to have reliable case hystories.

In case time and cost implication will be not viable from a project standpoint, two possible solutions could be evaluated:

1. Reduce tubing and all DHE (including TR-SCSSV) size to 7” as per Option 1
2. Revise 9 5/8” completion design with a 7” TR-SCSSV

The 7” TR-SCSSV can be provided by all major Service Contractors and has already been used within Eni.

Although both options are feasible, among the two, the first one would be preferrable from a completion standpoint since the size of the tubing and DHE is coherent and there is a limited size reduction all along the completion and consequently limited frictions. OLGA simulations will have to be performed to verify the impact of the completion size reduction on the injection conditions, for the full injection life. This may have a potential impact on the cost if the simulations will show that an additional well will be required.

Also for the second option, OLGA simulations would have to be re-run considering that, at the TR-SCSSV depth, there will be a bigger restriction with higher frictions. Also in this case this may have a potential impact on the injection parameters which will have to be calculated.

8.6 PRODUCTION PACKER

The production packer proposed for all the completion configurations is a hydraulically set packer, retrievable by mandrel cutting, with Landing Nipple profiles below and above. The hydrostatic setting packer could be considered as an alternative.

The Nipple/locating profile in the packer bottom sub will be used for setting purpose, in case of hydraulic packer set.

The Nipple/locating profile in the packer top sub will be used to pressure test the string, if required, and as a locating point for thru-tubing mechanical/chemical/jet packer mandrel cut.

With respect to the 13 3/8” x 9 5/8” Production packer proposed for wells targeting the Upper Bunter reservoir, as already explained for the 9 5/8” TR-SCSSV, from a preliminary benchmark some Service Company has a packer of this size in its portfolio. Eni has never used this type of packer but it is in constant contact with providers that declare to have reliable case hystories.

8.7 LANDING NIPPLES

A no-go type Landing Nipple is installed above the TR-SCSSV for installation of a wireline safety valve (WR-SCSSV) in case of failure of the TR-SCSSV.

A no-go type Landing Nipple is installed below the packer to allow hydraulic packer set.

A no-go type Landing Nipple is installed above the packer for tubing pressure test and as locating point for thru-tubing mechanical/chemical/jet packer mandrel cut.

8.8 PRESSURE/TEMPERATURE GAUGE

A pressure and temperature gauge with its electric cable has been included in the completion design in order to provide continuous monitoring of the injection parameters at the gauge installation depth.

The gauge will be installed above the production packer avoiding any feed through across the production packer and therefore any potential leaking point.

A single gauge, quartz type, for the tubing monitoring has been considered but, if deemed useful, a dual gauge for monitoring of the tubing and also the annulus can be considered with minimal impact on costs.

8.9 PRELIMINARY TUBING STRESS ANALYSIS

A Tubing Stress Analysis with Landmark WellCAT software version 5000.15 has been performed in order to verify ability of the tubing string and equipment to withstand the loads applied during the well life, including eventual acid stimulation loads.

Considering the uncertainties of the software to simulate the Joule-Thomson behavior of the CO_2 mixture used as injection fluid, the worst case scenarios have been considered in the well architecture and the Temperatures and Pressures applied as “operations” and “loads”.

Because no feedbacks on the reliability of the outputs for CO_2 fluids injection cases are available for Eni and Landmark software, the applied minimum and maximum Pressures and Temperatures have been taken by OLGA software simulations, which, currently, appears to be the most reliable software in this phase of the project.

Three different WellCAT files have been created to cover all the possible completion alternatives:

1. 9”5/8 production tubing down to the upper Bunter reservoir
2. 7” tubing down to the Lower Bunter reservoir
3. 9” 5/8 x 7” tapered string down to the Lower Bunter reservoir.

A 28 Chrome cold worked material has been considered for the metallurgy.

Several WellCAT “Operations” with different flow rates, injection times Pressures and Temperatures have been created applying the following conditions combinations:

- Injection time of 1 minute and 1 year;
- Tubing head injection Pressure of 8 and 60 bars;
- Tubing head injection Temperature of 0° and 40° C;
- Injection flow rates of 1066 and 3046 SMm^3/d

Results have been analyzed and the worst cases in terms of Temperature variations and maximum Pressures were taken as reference to link the “Load” cases. Moreover “Custom” loads were also added in order to cover all the possible worst stress operative situations.

8.10 CONCLUSIONS FOR COMPLETION DESIGN

Based on tubing stress analysis it is possible to conclude that the following strings:

- 7”, 29ppf, 28Cr-95,
- Tapered 9”5/8, 53ppf, 28Cr-95 and 7”, 29ppf, 28Cr-95
- 7”, 29ppf, 28Cr-95

are completely verified with high safety margin for the expected production flow rates and with safety margin for acid job loads.

Lower production string weights could be optimized in a future phase of the project.

The worst case load during the well life is during the string Pressure test that in any case show safety factor values higher than 2.0.

8.11 INPUT DATA FOR WELLCAT SIMULATION

Bottom hole data

- Lower Bunter Reservoir Temperature 52°C (BHST)
- Upper Bunter Reservoir Temperature 42°C (BHST)
- Initial pumping pressure Lower Bunter 7 Bar
- Initial pumping pressure Upper Bunter 23 Bar
- Final Reservoir Pressure Lower & Upper Bunter 95 Bar

Completion Data

- Tubing string (3 different scenarios foreseen):
  - 7” OD, 29ppf, 28Cr-95
  - tapered 9”5/8 OD, 53ppf, 28Cr-95 and 7”, 29ppf, 28Cr-95
  - 7” OD, 29ppf, 28Cr-95
- Connections: qualified metal to metal seal threads, with 100% efficiencies
- Packer fluid density: 1.15 SG, $CaCl_2$ solution
- Hydraulic Packer initial setting pressure: 1500psi
- Well profile & Casing design: (from Drilling Study)

Load Case analysed (worst case scenario as per Par. 6.9)

<u>Injections</u>

- THT at 0°C and 40°C
- THP at 60bar and 8bar
- Injection times of 1 minute and 1 year
- Flow rate of 1066 Mm^3/d and 3046 Mm^3/d

<u>Pressure tests</u>

- String P test at 5000 psi
- Packer P test from below at 5000 psi
- Packer annulus P test at 3000 psi

<u>Acid job</u>

- Injection P of 3118 psi
- Inlet T of 15°C
- Flow rate 20 bbl/min

<u>Tubing evacuation</u>

- During the “short” injection operation, at 60 bar and 0°C with low flow rate

<u>Tubing leak</u>

- During the “short” injection operation, at 60 bar and 0°C with low flow rate

Eni Safety Factors

Eni “Completion Design Procedure” (doc. Ref. STAP-P-1-M-26543) defines the following safety factors to be used in the tubing stress analysis for the CRA materials:

- Burst: 1.3
- Collapse: 1.125
- Axial Tension: 1.4
- Axial Compression: 1.4
- Triaxial: 1.35

8.12 RESULTS

8.12.1 7" OD PRODUCTION TUBING STRING DOWN TO THE LOWER BUNTER RESERVOIR

The figure below shows the completion scheme used for stress analysis calculations.

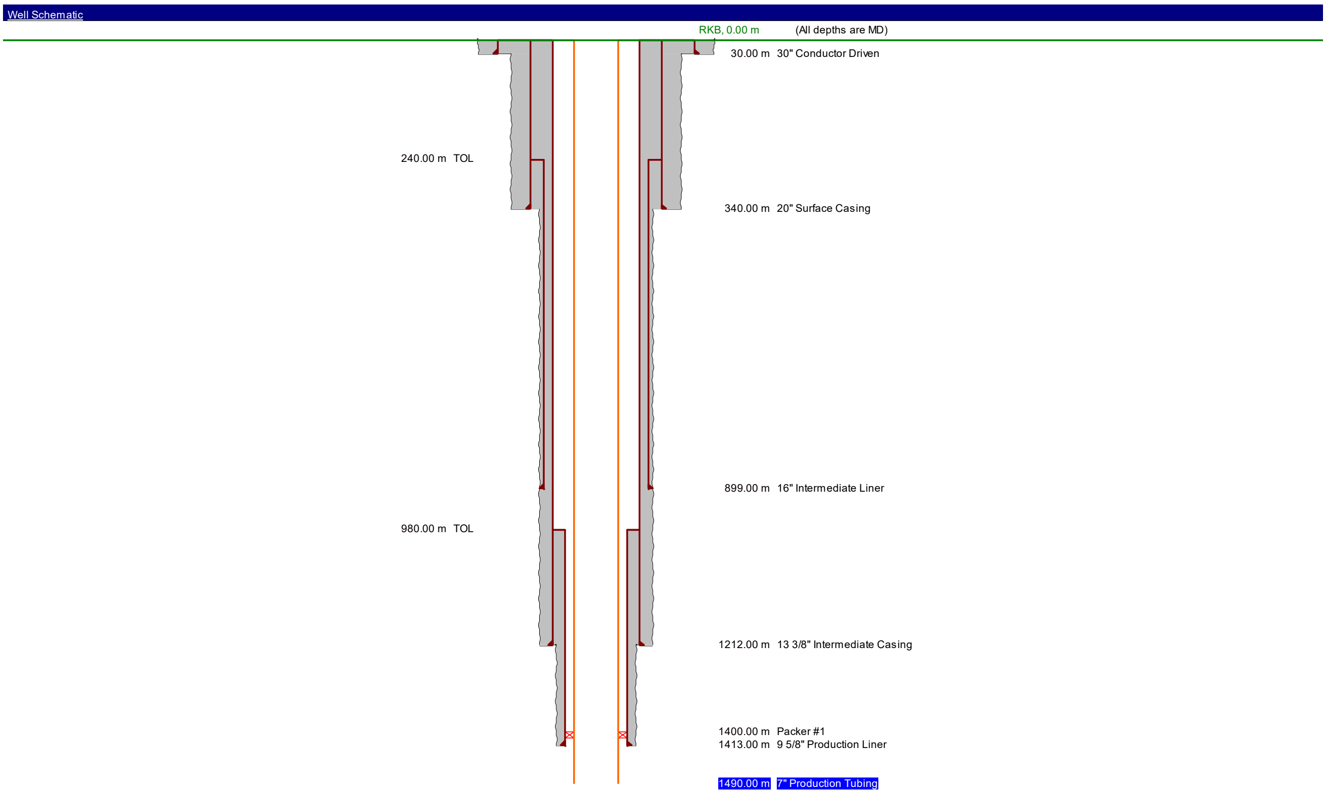

Figure 8.4 - Completion Scheme for stress analysis calculations

The strings verify stress analysis with high safety margin as also confirmed from the graph below.

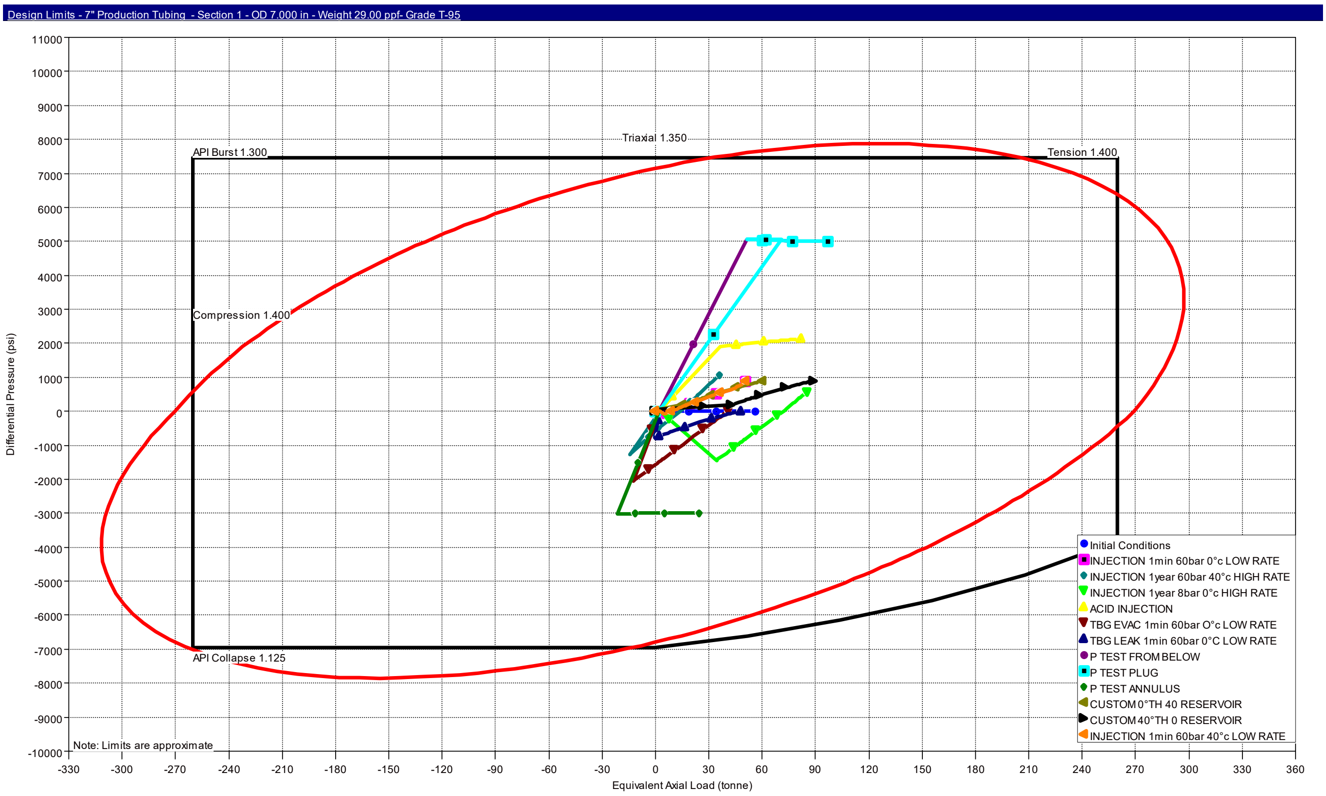

Figure. 8.5 - Design Limit Plot for 7" string case

The figure below shows all the loads acting on the production packer:

Packer Loads - 7" Production Tubing - Packer #1 (Packer @ 1400.00 m MD)

	Load	Tubing-to-Packer Force (tonne)	Axial Load		Annulus Pressure		Temperature (°C)	Latching Force (tonne)	Packer-to-Casing Force (tonne)
			Above (tonne)	Below (tonne)	Above (psi)	Below (psi)			
1	Initial Conditions	-8.1730	2.7843	-5.3908	2014.33	2014.40	37.872	---	-8.1730
2	INJECTION 1min 60bar 0°c LOW RATE	-2.3132	-2.5996	-4.9147	2037.49	1943.39	47.283	---	-1.5137
3	INJECTION 1year 60bar 40°c HIGH RATE	17.1915	-17.1292	0.0605	2029.83	736.31	23.197	---	28.1803
4	INJECTION 1year 8bar 0°c HIGH RATE	-31.7723	32.2087	0.4345	2055.15	595.64	1.946	---	-19.3735
5	ACID INJECTION	-41.4075	24.8580	-16.5516	3044.80	4937.18	18.047	---	-57.4837
6	TBG EVAC 1min 60bar 0°c LOW RATE	14.6045	-11.8858	2.7168	2030.35	0.00	47.338	---	31.8528
7	TBG LEAK 1min 60bar 0°C LOW RATE	2.5694	-8.1692	-5.6019	2900.55	2118.47	47.338	---	9.2133
8	P TEST FROM BELOW	-68.2073	43.6557	-24.5538	2014.25	7014.40	37.872	---	-110.6847
9	P TEST PLUG	19.0731	43.6557	62.7267	2014.25	2014.40	37.872	---	19.0731
10	P TEST ANNULUS	23.2480	-28.6367	-5.3908	5014.25	2014.40	37.872	---	48.7325
11	CUSTOM 0°TH 40 RESERVOIR	-12.8547	6.9811	-5.8756	2014.30	2140.87	37.872	---	-13.9300
12	CUSTOM 40°TH 0 RESERVOIR	-40.6337	34.7601	-5.8756	2014.30	2140.87	0.197	---	-41.7090
13	INJECTION 1min 60bar 40°c LOW RATE	-2.3132	-2.5996	-4.9147	2037.49	1943.39	47.283	---	-1.5137
14									
15	Negative forces are in the upward direction.								

Table 8.1 - Packer envelope table for 7" string case

It is possible to plot the table above in F *vs* (delta) p diagram where all the loads have to remain inside the packer envelope area. The packer suitable for all the foreseen operations needs to include all the loads plotted in the below graph.

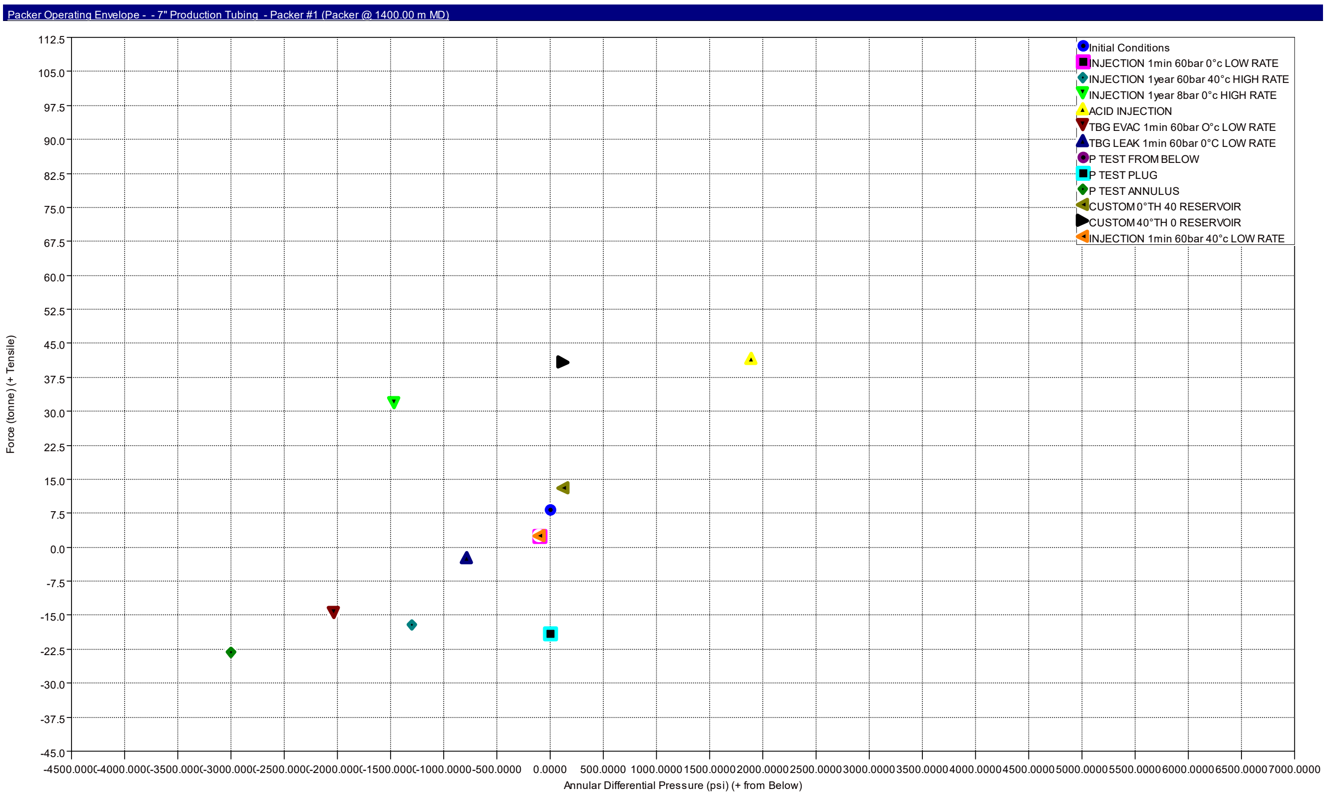

Figure 8.6 - Packer envelope for 7" string case

8.12.2 9”5/8 X 7” OD TAPERED PRODUCTION TUBING STRING DOWN TO THE LOWER BUNTER RESERVOIR

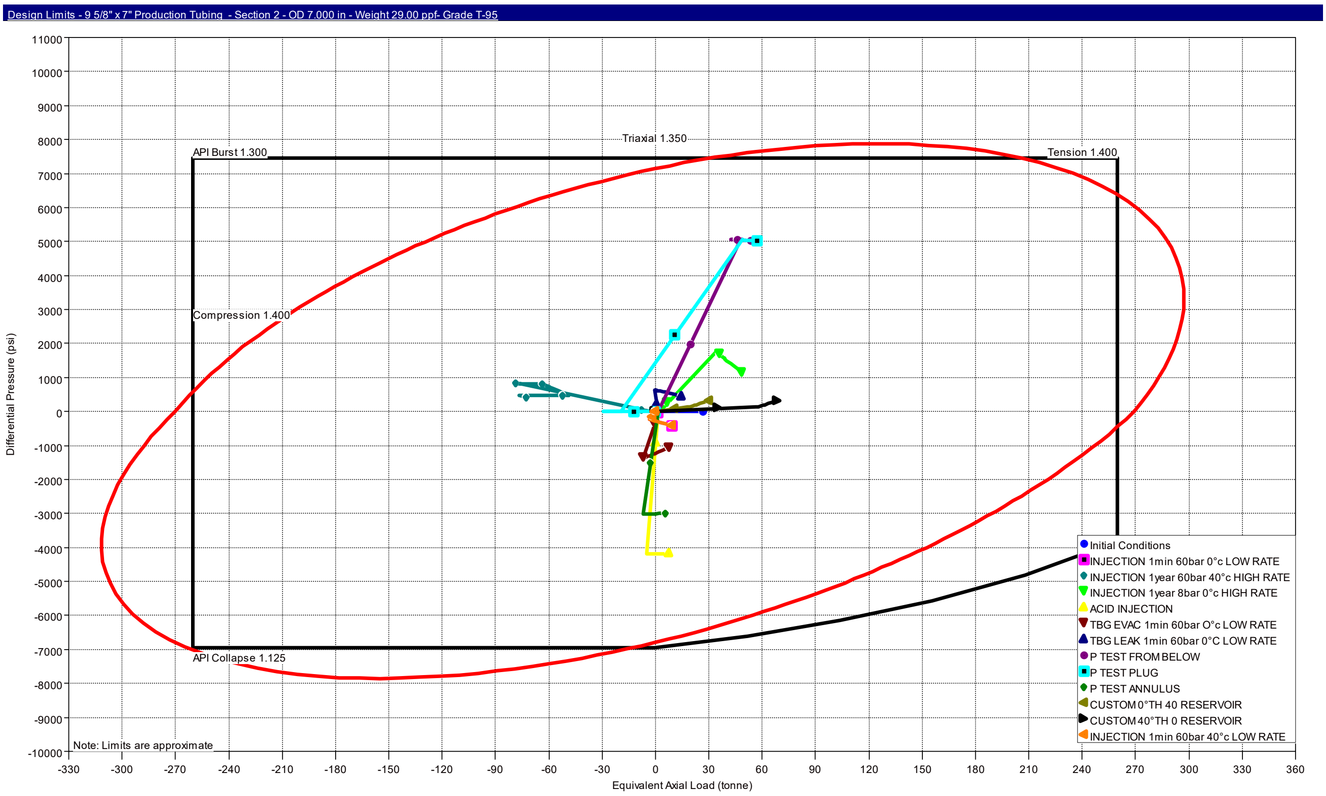

Figure 8.7 - Design Limit Plot for 9 5/8” x 7” tapered string case

Packer Loads - 9 5/8" x 7" Production Tubing - Packer #1 (Packer @ 1550.00 m MD)

	Load	Tubing-to-Packer Force (tonne)	Axial Load		Annulus Pressure		Temperature (°C)	Latching Force (tonne)	Packer-to-Casing Force (tonne)
			Above (tonne)	Below (tonne)	Above (psi)	Below (psi)			
1	Initial Conditions	-12.3926	5.7806	-6.6124	2206.49	2206.59	35.256	---	-12.3926
2	INJECTION 1min 60bar 0°c LOW RATE	5.2269	-10.9276	-5.7011	2209.01	2006.24	45.080	---	6.9494
3	INJECTION 1year 60bar 40°c HIGH RATE	58.9441	-64.6449	-5.7011	1136.64	2037.86	62.166	---	51.2880
4	INJECTION 1year 8bar 0°c HIGH RATE	-39.0357	33.3349	-5.7011	227.04	2048.14	6.186	---	-54.5064
5	ACID INJECTION	6.5830	-12.2838	-5.7011	6186.53	1973.40	16.467	---	42.3745
6	TBG EVAC 1min 60bar O°c LOW RATE	8.5154	-6.3669	2.1485	1361.90	0.00	45.080	---	20.0851
7	TBG LEAK 1min 60bar 0°C LOW RATE	-1.8247	-3.8760	-5.7011	1361.90	2005.82	45.080	---	-7.2950
8	P TEST FROM BELOW	-58.3876	32.6126	-25.7754	2206.41	7206.59	35.256	---	-100.8652
9	P TEST PLUG	25.1265	-31.7385	-6.6124	2206.41	2206.59	35.256	---	25.1265
10	P TEST ANNULUS	8.3840	-14.9961	-6.6124	5206.41	2206.59	35.256	---	33.8682
11	CUSTOM 0°TH 40 RESERVOIR	-16.6684	9.5716	-7.0972	2206.48	2333.07	35.256	---	-17.7438
12	CUSTOM 40°TH 0 RESERVOIR	-55.3046	48.2078	-7.0972	2206.48	2333.07	0.002	---	-56.3800
13	INJECTION 1min 60bar 40°c LOW RATE	5.2269	-10.9276	-5.7011	2209.01	2006.24	45.080	---	6.9494
14									
15	**Negative forces are in the upward direction.**								

Table 8.2 - Packer envelope table for 9 5/8” x 7” tapered string case

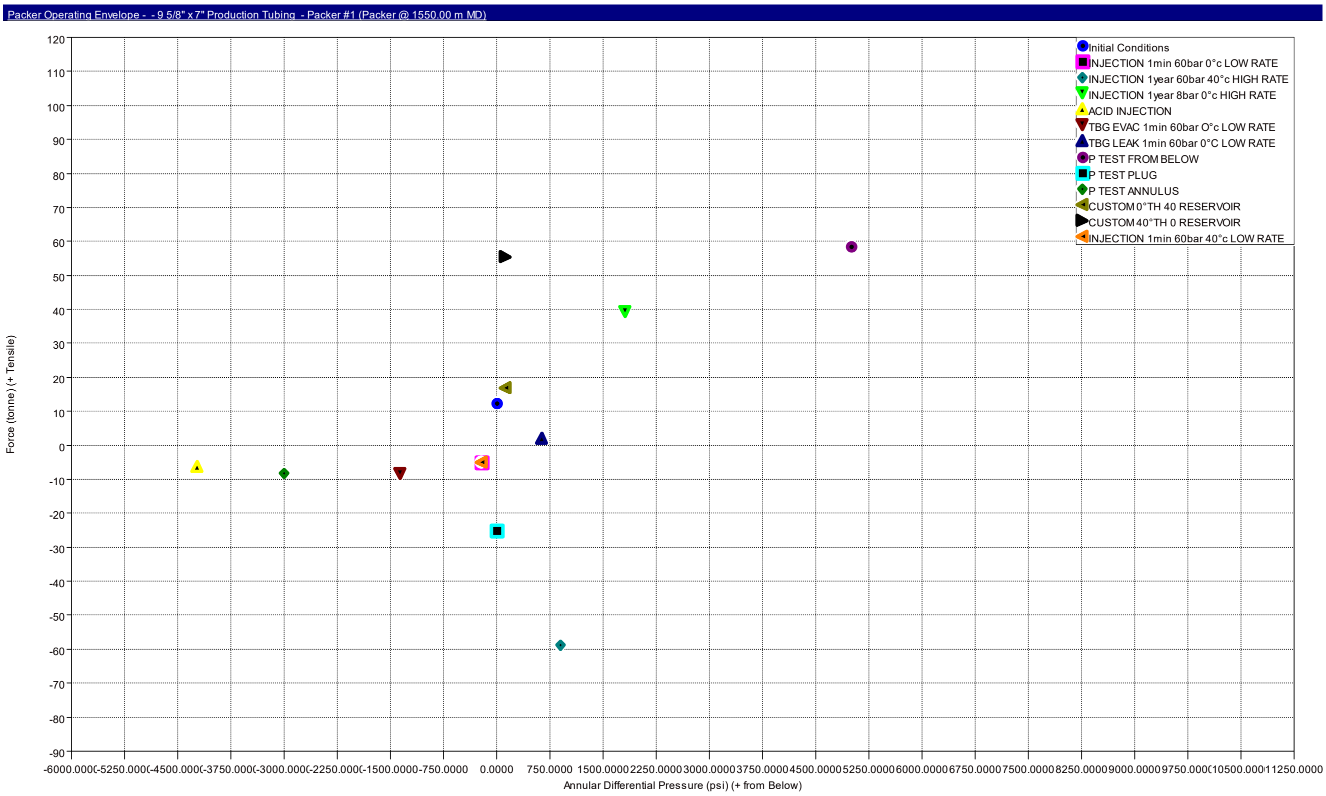

Figure 8.8 - Packer envelope for 9 5/8” x 7” tapered string case

8.12.3 9”5/8 OD PRODUCTION TUBING STRING DOWN TO THE UPPER BUNTER RESERVOIR

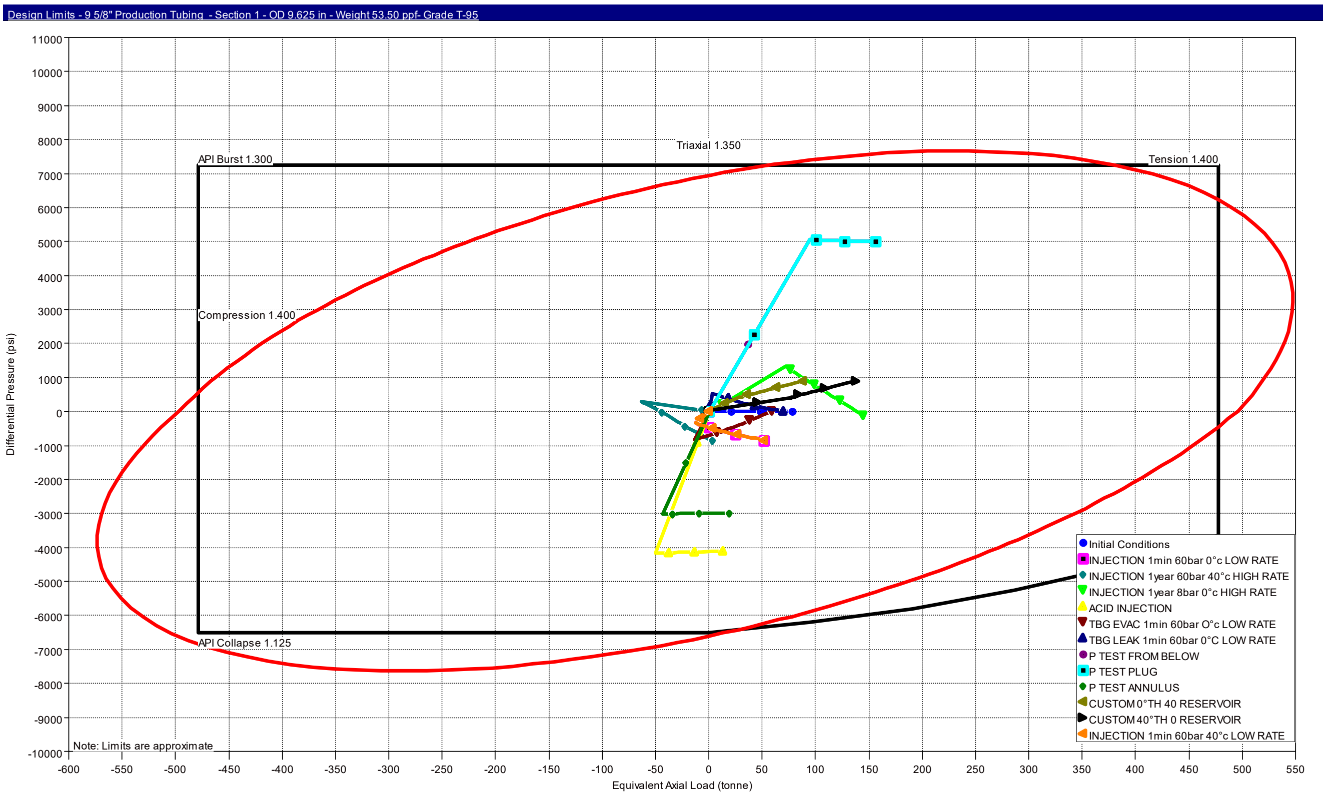

Figure 8.9 - Design Limit Plot for 9 5/8” string case

Packer Loads - 9 5/8" Production Tubing - Packer #1 (Packer @ 960.00 m MD)

	Load	Tubing-to-Packer Force (tonne)	Axial Load		Annulus Pressure		Temperature (°C)	Latching Force (tonne)	Packer-to-Casing Force (tonne)
			Above (tonne)	Below (tonne)	Above (psi)	Below (psi)			
1	Initial Conditions	-15.5684	6.0597	-9.5129	1494.86	1494.94	39.239	---	-15.5684
2	INJECTION 1min 60bar 0°c LOW RATE	13.2049	-21.6002	-8.3994	1689.80	1352.82	50.086	---	20.8861
3	INJECTION 1year 60bar 40°c HIGH RATE	61.0408	-69.4360	-8.3994	1065.20	1358.07	56.376	---	54.3649
4	INJECTION 1year 8bar 0°c HIGH RATE	-80.6290	72.2337	-8.3994	28.20	1361.65	-12.477	---	-111.0243
5	ACID INJECTION	50.7932	-59.1885	-8.3994	5520.95	1338.47	16.088	---	146.1309
6	TBG EVAC 1min 60bar O°c LOW RATE	14.2611	-13.0654	1.1921	830.60	0.00	50.086	---	33.1942
7	TBG LEAK 1min 60bar 0°C LOW RATE	-6.0097	-2.3855	-8.3994	830.60	1352.45	50.086	---	-17.9053
8	P TEST FROM BELOW	-128.6822	83.9146	-44.7717	1494.84	6494.94	39.239	---	-242.6572
9	P TEST PLUG	-128.6822	83.9146	-44.7717	1494.84	6494.94	39.239	---	-242.6572
10	P TEST ANNULUS	43.8371	-53.3458	-9.5129	4494.84	1494.94	39.239	---	112.2186
11	CUSTOM 0°TH 40 RESERVOIR	-27.8577	15.7904	-12.0713	1494.86	1857.74	39.239	---	-36.1293
12	CUSTOM 40°TH 0 RESERVOIR	-76.4647	64.3975	-12.0713	1494.86	1857.74	1.196	---	-84.7363
13	INJECTION 1min 60bar 40°c LOW RATE	13.2049	-21.6002	-8.3994	1689.80	1352.82	50.086	---	20.8861
14									
15	**Negative forces are in the upward direction.**								

Table 8.3 - Packer envelope table for 9 5/8” string case

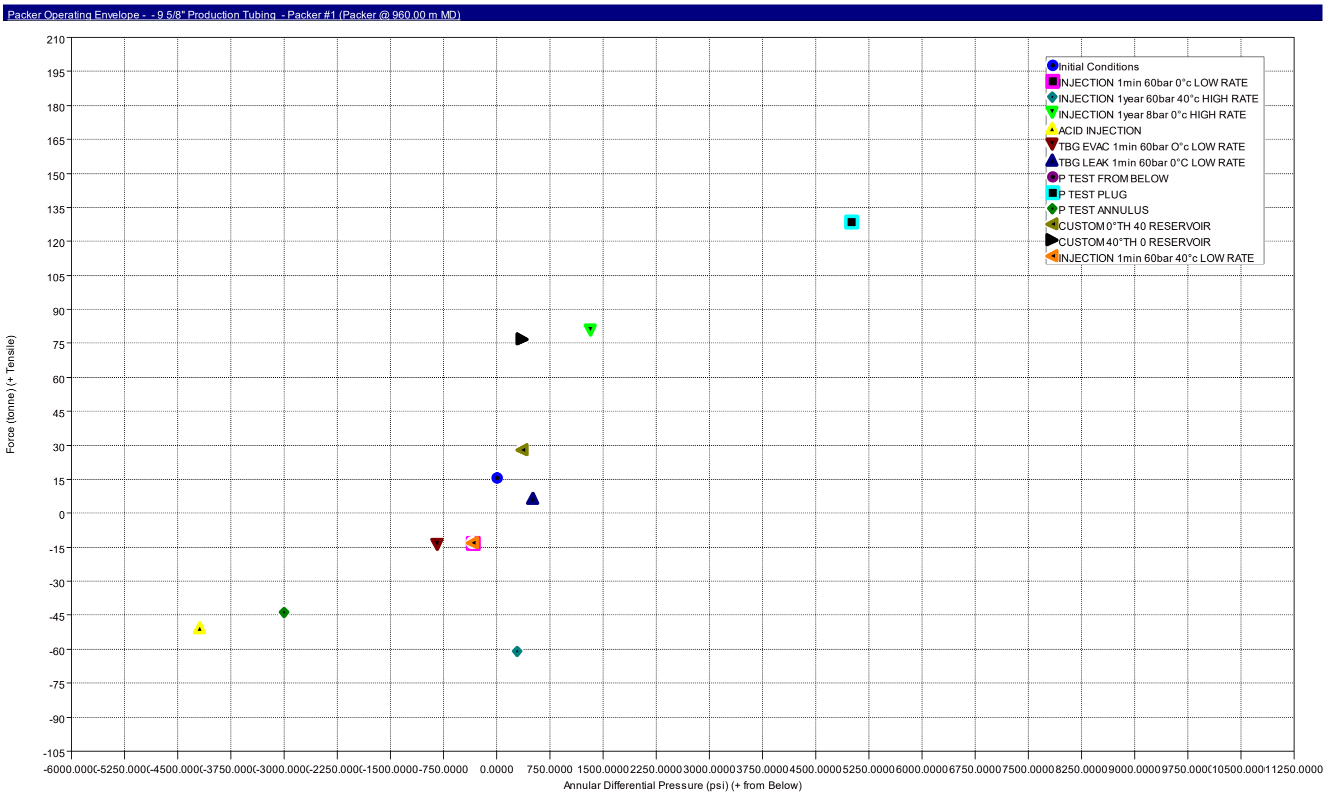

Figure 8.10 - Packer envelope for 9 5/8" string case

9. SUMMARY OF THE OPERATIONAL SEQUENCE

The operative sequence considered for the time and cost estimation are reported in the following paragraphs.

The reference wells considered for the study are:

- Appraisal well
- Upper Bunter injection well
- Lower Bunter Injection well

9.1 APPRAISAL WELL

The well shall be equipped with Mud Line Suspension System (included in the time and cost estimation).

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Rig preparation and M/U DP stands
- Install CP
- Install diverter
- Drill 24” phase
- RIH and cement 20” casing
- Install BOP and test
- Drill 17 1/2” phase
- RIH and cement 16 liner
- Drill 14 3/4” phase
- RIH and cement 13 3/8” casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼” phase
- RIH and cement 9 5/8” liner
- Drill 8 ½” phase at TD
- Logs
- Run 7” slotted liner
- Temporary P&A

For future well re-entry

- Rig preparation and M/U DP stands
- Install BOP
- Well re-entry
- Upper completion installation
- Remove BOP
- Install Xtree

9.2 UPPER BUNTER INJECTION WELL

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Install CP
- Install diverter
- Drill 24” phase
- RIH and cement 20” casing
- Install BOP and test
- Drill 17 1/2” phase
- RIH and cement 13 3/8” casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼” phase
- Run 9 5/8” slotted liner
- Well cleaning operations and brine displacement
- RIH upper completion
- Install Xmas Tree
- Close well

9.3 LOWER BUNTER INJECTION WELL

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Install CP
- Install diverter
- Drill 24” phase
- RIH and cement 20” casing
- Install BOP and test
- Drill 17 1/2” phase
- RIH and cement 16 liner
- Drill 14 3/4” phase
- RIH and cement 13 3/8” casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼” phase
- RIH and cement 9 5/8” liner
- Drill 8 ½” phase at TD
- Run 7” slotted liner
- Well cleaning operations and brine displacement
- RIH upper completion
- Install Xmas Tree
- Close well

APPENDIX A – ENI P&A CAMPAIGN OF HEWETT EXISTING WELLS

Eni has already planned to P&A the Hewett wells considering its low productivity. Therefore, as the Bunter Sandstones, both Lower and Upper level, are gas-bearing and depleted, they have been evaluated suitable for CO2 storage and segregation.

All existing wells will be abandoned, providing that the CO2 injection will be carried out throughout new dedicated wells.

Eni is currently starting a decommissioning campaign of all the subsurface and surface infrastructures that includes the Plugging & Abandoning of all the existing 40 wells; it will be used a Jack-Up rig to plug the wells with cement plugs, cut and recover the conductors and casings from approximately 1.5 – 3 m below the sea bed.

Abandonments will be planned and executed with the best technologies and method currently available to achieve the well integrity during all the CCS field life. The well's plugging will be carried out in such a way to avoid any future remedial job due to a downhole failure and minimizing the need of seabed monitoring.

This appendix briefly summarizes the additional activities that are required to the already scheduled abandonments plans to make the wells compliance with CO2 injection.

The existing plans for well abandonment take into account Eni procedure "STAP 26521" and Oil & Gas UK Guidelines, Issue 6. Oil & Gas UK guidelines specify that wells lying in fields which could be used for CO2 injection and storage should be abandoned to be CO2 resistant in terms of injection pressures and storage concentration.

28 out of the 40 wells on the main field (Platforms A, B and 52/5A) are Bunter or Zechstein producers and require to be abandoned to be CO2 resistant. The Zechstein wells pass through the Bunter Sandstones and are not directly perforated in those zones, but in any case will be in contact with the injected CO2. Therefore, they need to be CO2 proof abandoned.

The wells were predominantly drilled in the late 60's and early 70's and production casing strings have been cemented with Class B cement, which is not resistant to the concentration of CO2 foreseen in the CCS project.

To upgrade the abandonment plan such that the main field wells would be entirely CO_2 resistant and capable of withstanding CO_2 at the concentration and pressures of injection, the following additional activities will be required:

- All the cement that will be used to isolate the Bunter reservoirs will be CO_2 resistant;
- All new cement barriers above the Upper and Lower Bunter will be set in casing milled windows. The currently present annular cement, even if in acceptable condition, is class B and it is not design to resist to the CO_2 that will be injected in the reservoir. For this reason, a window will be milled in the production casing, above each Bunter reservoirs, removing the old cement currently present beyond the casing. A new cement plug barrier will be placed instead rock to rock, sealing directly and recreating the original cap rock.

Eni S.p.A.	ORGANIZING DEPARTMENT	TYPE OF ACTIVITY'	ISSUING DEPT.	DOC. TYPE	REF. N.	PAG. 1
	COAP/ESA	P	1	P	28047	OF 31

HEWETT GAS FIELD CONVERSION INTO CARBON SEQUESTRATION SITE - DRILLING AND COMPLETION TIME & COST ESTIMATE

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INDEX

1. SCOPE OF WORK

The present document refers to the "HEWETT GAS FIELD CONVERSION INTO CARBON SEQUESTRATION SITE - DRILLING AND COMPLETION FEASIBILLITY STUDY" and includes and implement the Time & Cost estimates for the Drilling and Completion activities.

All the Well engineering and design details are only briefly summarized in this document.

The time/cost analysis has been obtained from a risk analysis approach as indicated in the Eni D&C procedure STAP-P-1-MG-26505 - rev.01 (Cost Estimating, Budgeting and Controlling Handbook for Drilling, Completion and Workover Activities), with an accuracy within +/-40%.

All data used for this study are the most updated and available during the document preparation.

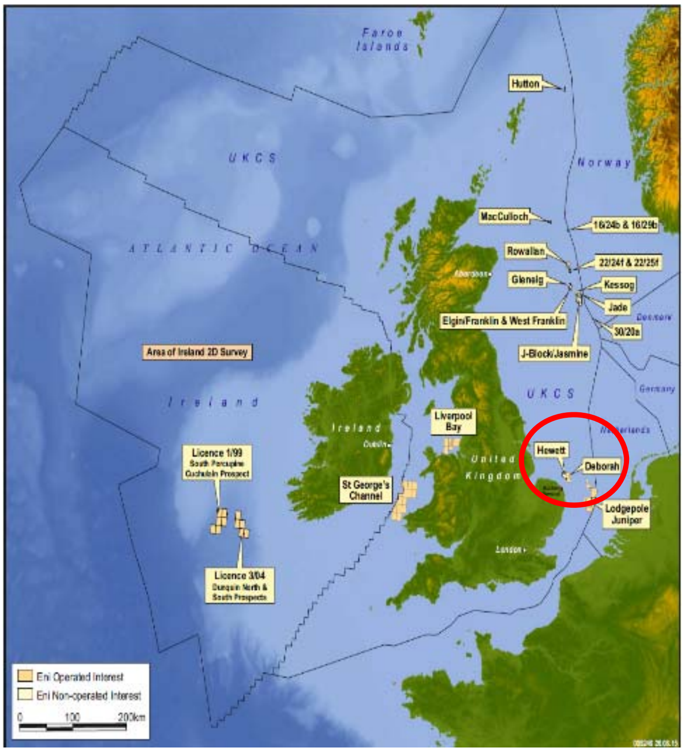
Any change from the original data received could affect the future estimation.

2. DEFINITION, ACRONYMS & ABBREVIATIONS

Acronym	Definition
BHST	Bottom Hole Static Temperature
BOP	Blow Out Preventer
CAPEX	Capital Expenditure
CCS	CO2 Capture Storage
CP	Conductor Pipe
CRA	Corrosion Resistant Alloy
D&C	Drilling and Completion
DHE	DownHole Equipment
DLS	Dog Leg Severity
DP	Drill Pipe
ECD	Equivalent Circulating Density
FG	Fracture Gradient
FW-PO-KC	Fresh Water – Polimer – Potassium Chloride
GRE	Glassfiber Reinforced Epoxy
KOP	Kick-Off Point
LB	Lower Bunter
MAASP	Maximum Allowable Annular Surface Pressure
MADF	Minimum Acceptable Design Factor
MAWHP	Maximum Anticipated Wellhead Pressure
MD	Measured Depth
MLS	Mud Line Suspension
MSL	Mean Sea Level
MW	Mud Weight
OPD	Opportunity & Project Development
P&A	Plugging & Abandonment
PPG	Pore Pressure Gradient
PPFG	Pore Pressure and Fracture Gradient
RKB	Rotary Kelly Bushing
SCSSV	Surface Controlled – Sub-surface Safety Valve
SG	Specific Gravity
TD	Total Depth
THP	Tubing Head Pressure
THT	Tubing Head Temperature
TOC	Top Of Cement
TOL	Top Of Liner
TVD	True Vertical Depth
TVDss	True Vertical Depth Sub Sea
UB	Upper Bunter
WBM	Water Base Mud
WBS	Wellbore Stability
WD	Water Depth
WPR	Working Pressure Rating
XT	Christmas (Production) Tree

3. PROJECT DESCRIPTION

Hewett is a mature field, been on production for over 40 years. It was discovered in 1966 with first production in 1969. Eni took ownership of the Hewett installation and infrastructure in 2008.
The field has a length of approx 29 km and lies in a water depth ranging between 20 and 40 m, at about 16 km from the coastline.



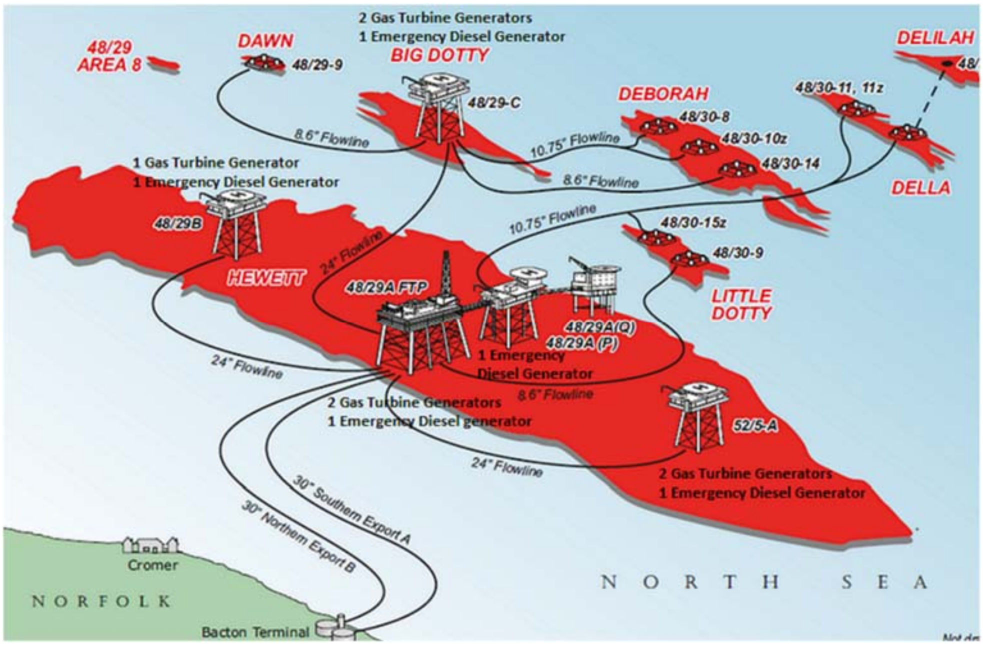


Figure 3.1: Location map and evidence of blocks and permits

The asset has 32 platform wells spread over 4 platforms plus 8 subsea production wells and one suspended subsea P&A well. All wells were drilled between 1967 and 2008 by a different operator.

The reservoir includes 5 separate stacked layers:

- Upper Bunter (shallowest)
- Lower Bunter
- Plattendolomit
- Zechsteinkalk
- Rotliegend (deepest)

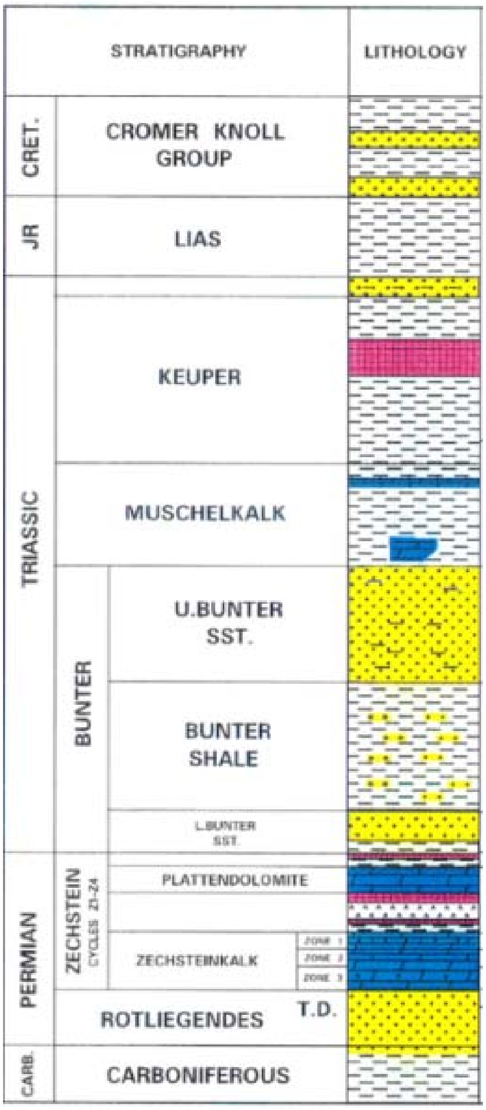


Figure 3.2: Typical lithological sequence of the field

Only two layers are selected for the purpose of CO_2 injection and storage:

- Upper Bunter, secondary target (827 – 964 m TVD MSL)
- Lower Bunter, primary target (1200 – 1268 m TVD MSL)

Both formations are highly depleted, PPG values are around 0.1 $kg/cm^2/10m$.

Eni is now on starting a decommissioning campaign of all the subsurface and surface infrastructures. The campaign will include the Plugging & Abandoning of all the 40 wells, the isolation of the subsea well flowlines and umbilicals to make the platforms hydrocarbon free and the dismantling of all the platforms.

In the preliminary phases of the project to convert Hewett field into a CO_2 sequestration site, different options have been considered and they included also the possibilities to utilize the existing wells.

Reusing or sidetracking the existing wells has been considered in the first instance but has been rejected as it showed elevated risk mainly related to well integrity issues but also to directional plan limitation.

The current well integrity status has been verified and found in poor condition both for casing condition both for cement reliability in respect of newest CO_2 reservoir fluid.

Moreover the sidetracking strategy foresees to perform cased hole side track inside the 9 5/8" casing and completing the well with a 7" production liner. This appeared to be not in line with the requirement of displacement distance and minimum rate of injection.

Therefore Eni approached the life extension of the field considering only new appraisal and new injector wells to be drilled.

Drilling and completion activities are intended to be carried on through a Jack-Up rig. A water depth of 33 m and an RKB elevation of 40 m have been considered during the design of the wells.

The development scenario foresees five wells to be drilled from a unique new platform:

- One appraisal vertical well with 7" production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7" production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8" production liner

For all the deviated wells, inclination was limited to 45°, as per preliminary output of Eni geomechanical study.

All data used for this study are the most updated provided by Reservoir Department at the time of document preparation. In addition to that, also information gathered from offset well already drilled in the Field have been considered.

Any variation on the current input data could affect the proposed drilling strategy.

4. EXECUTIVE SUMMARY

Time & Cost estimates, related to Drilling and Completion activities to convert and reutilize Hewett Gas Producer Field as a Carbon Sequestration Site, are here below summarized, together with a brief activities summary and main well's features description.

Five wells will be drilled from a unique new platform with a conventional jack up rig:

- One appraisal vertical well with 7” production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7” production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8” production liner

No specific surface location was requested to be considered for the time being.
The wells have been designed with a slant profile, a maximum inclination of 45° and KOP short below surface casing seat.

The main features of the three proposed well profiles are presented in the table below:

Well type	Profile	Wells number	TVD [m MSL]	MD [m RKB]	KOP [m RKB]	Max Incl. [°]	Max DLS [°/30 m]	Casings number	Prod. lnr size [in]
Appraisal	S-shape	1	1268	1308	-	0	0	5	7
Injection Upper Bunter	Slanted	1	1004	1117	330	45	2	3	9 5/8
Injection Lower Bunter	Slanted	3	1268	1535	330	45	2	5	7

Table 4.1: Well profiles features

For the trajectories design, a water depth of 33 m and a RKB elevation of 40 m have been considered.

Based on the operating strategy selected (drilling activities carried on by a Jack-Up rig), the following tables summarizes time and cost estimates for each well type.

Well type	Drilling Time (Days)			Completion Time (Days)			Total Time (days)		
	P10	P50	P90	P10	P50	P90	P10	P50	P90
Appraisal well Drilling + Temp P&A	31,9	**33,8**	37,5						
Appraisal Well Re-entry and Completion				14,0	**14,6**	14,8	45,9	**48,4**	52,3
Upper Bunter Well	12,6	**15,1**	22,1	6,8	**7,6**	8,5	19,4	**22,7**	30,6
Lower Bunter Well	22,9	**24,7**	28,3	8.1	**8.6**	8.7	31,0	**33,2**	37,1

Table 4.2: Wells Time estimate

Well type	Drilling Cost (MM£)			Completion Cost (MM£)			Total Cost (MM£)		
	P10	P50	P90	P10	P50	P90	P10	P50	P90
Appraisal well Drilling + Temp P&A	12,2	**12,9**	14,0						
Appraisal Well Re-entry and Completion				5,4	**5,6**	5,6	17,6	**18,4**	19,6
Upper Bunter Well	6.4	**7.2**	9.2	3.5	**3.7**	3.7	10.0	**11.0**	12.8
Lower Bunter Well	9,7	**10,3**	11,2	3,4	**3,6**	3,5	13,2	**13,8**	14,8

Table 4.3: Wells Cost estimate

The following table summarizes the overall schedule time and cost:

- Rig mobilization (appraisal campaign)
- Drilling Appraisal well + log + P&A and Rig demobilization
- Rig re-mobilization (development campaign)
- Re-entry Appraisal well and Completion
- Drilling and Completion Upper Bunter Injection well
- Drilling and Completion 3 Lower Bunter Injection wells

Phase	Total time (Days)			Total cost (MM£)		
	P10	P50	P90	P10	P50	P90
Rig mobilization	3	**3**	3	0,75	**0,75**	0,75
Drilling Appraisal well + log + P&A and Rig demobilization	31,9	**33,8**	37,5	12,2	**12,9**	14
Rig mobilization	3	**3**	3	0,75	**0,75**	0,75
Re-entry and Completion Appraisal well	14	**14,6**	14,8	45,9	**48,4**	52,3
Drilling and Completion Upper Bunter Injection well	19,4	**22,7**	30,6	10	**11**	12,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Total	164,3	**176,7**	200,2	109,2	**115,2**	125

Table 4.4: Total D&C time and cost estimate

5. WELL DESIGN

Five wells will be drilled from a unique new platform with a conventional jack up rig:

- One appraisal vertical well with 7" production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7" production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8" production liner

No specific surface location was requested to be considered for the time being.
The wells have been designed with a slant profile, a maximum inclination of 45° and KOP short below surface casing seat.

The main features of the three proposed well profiles are presented in the table below:

Well type	Profile	Wells number	TVD [m MSL]	MD [m RKB]	KOP [m RKB]	Max Incl. [°]	Max DLS [°/30 m]	Casings number	Prod. lnr size [in]
Appraisal	S-shape	1	1268	1308	-	0	0	5	7
Injection Upper Bunter	Slanted	1	1004	1117	330	45	2	3	9 5/8
Injection Lower Bunter	Slanted	3	1268	1535	330	45	2	5	7

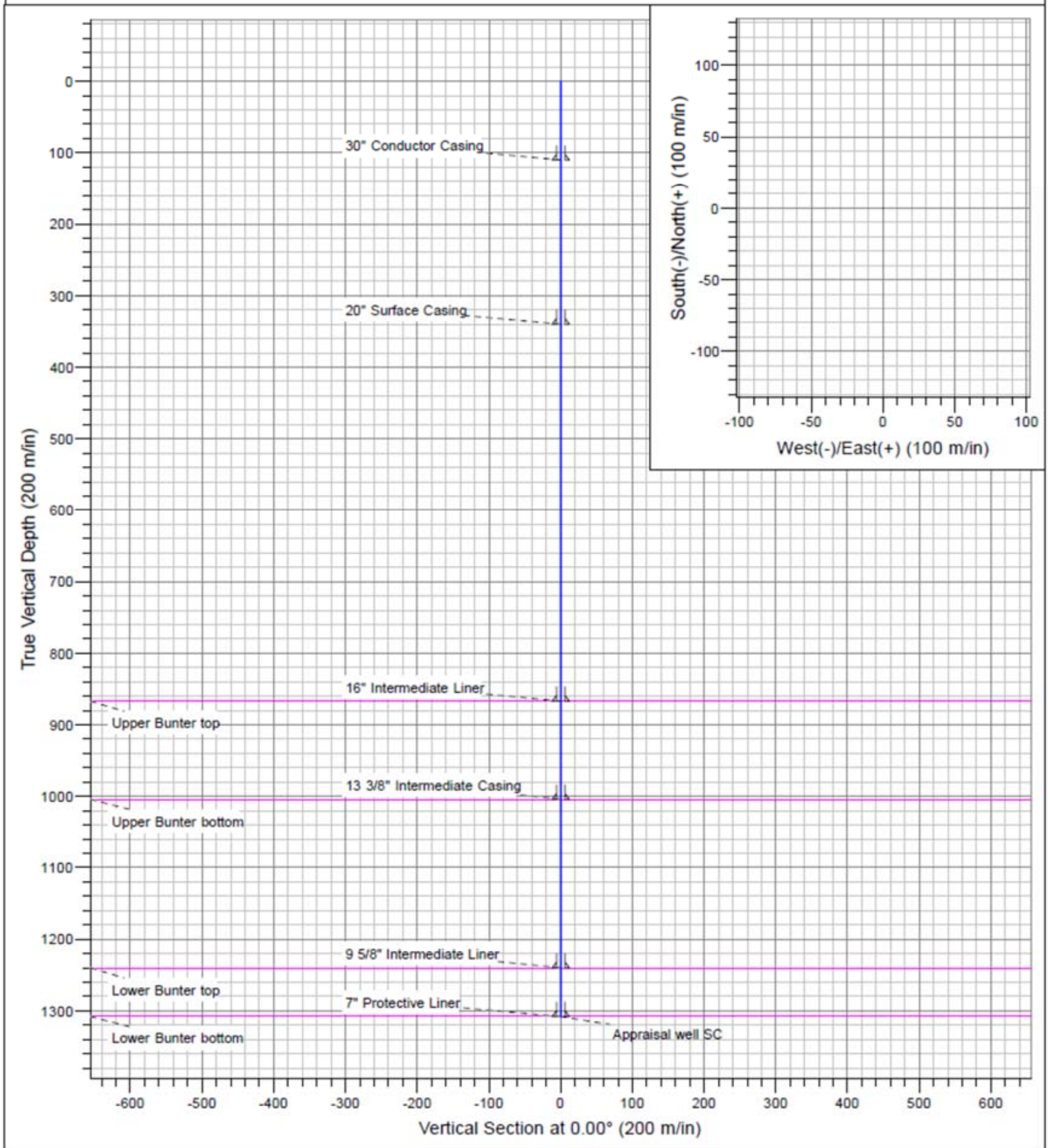
Table 5.1: Well profiles features

For the trajectories design, a water depth of 33 m and a RKB elevation of 40 m have been considered.

WELL DETAILS: Appraisal well

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	1308.00	0.00	0.00	1308.00	0.00	0.00	0.00	0.00	0.00	

CASING DETAILS

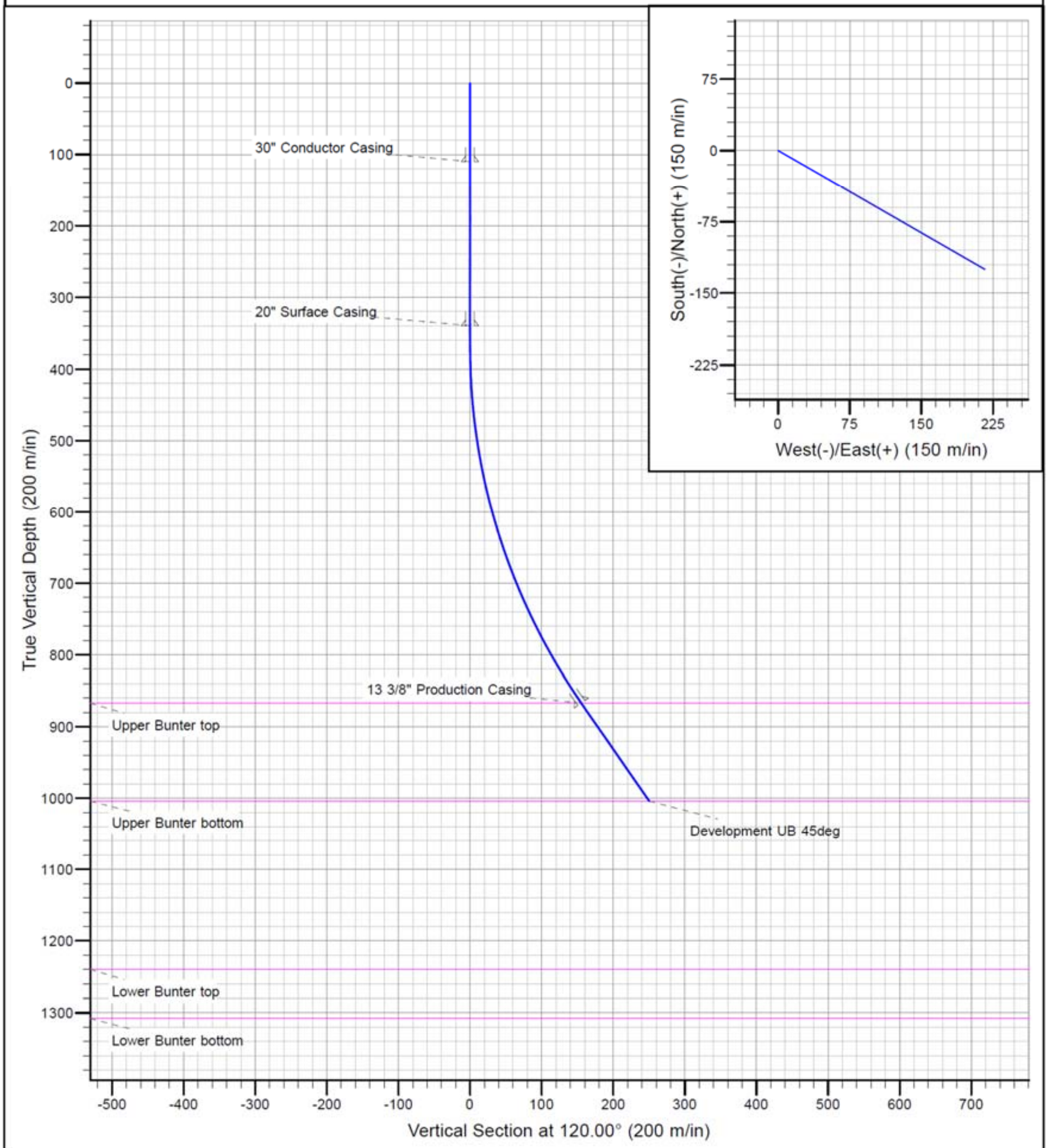
TVD	MD	Name	Size
110.10	110.10	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	867.00	16" Intermediate Liner	16.000
1004.00	1004.00	13 3/8" Intermediate Casing	13.375
1240.00	1240.00	9 5/8" Intermediate Liner	9.625
1308.00	1308.00	7" Protective Liner	7.000

Figure 5.1: Appraisal well trajectory

WELL DETAILS: Development well upper Bunter

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	370.00	0.00	120.00	370.00	0.00	0.00	0.00	120.00	0.00	
3	898.72	34.69	120.00	867.00	-77.62	134.44	2.00	120.00	155.24	
4	1065.34	34.69	120.00	1004.00	-125.04	216.58	0.00	0.00	250.08	

CASING DETAILS

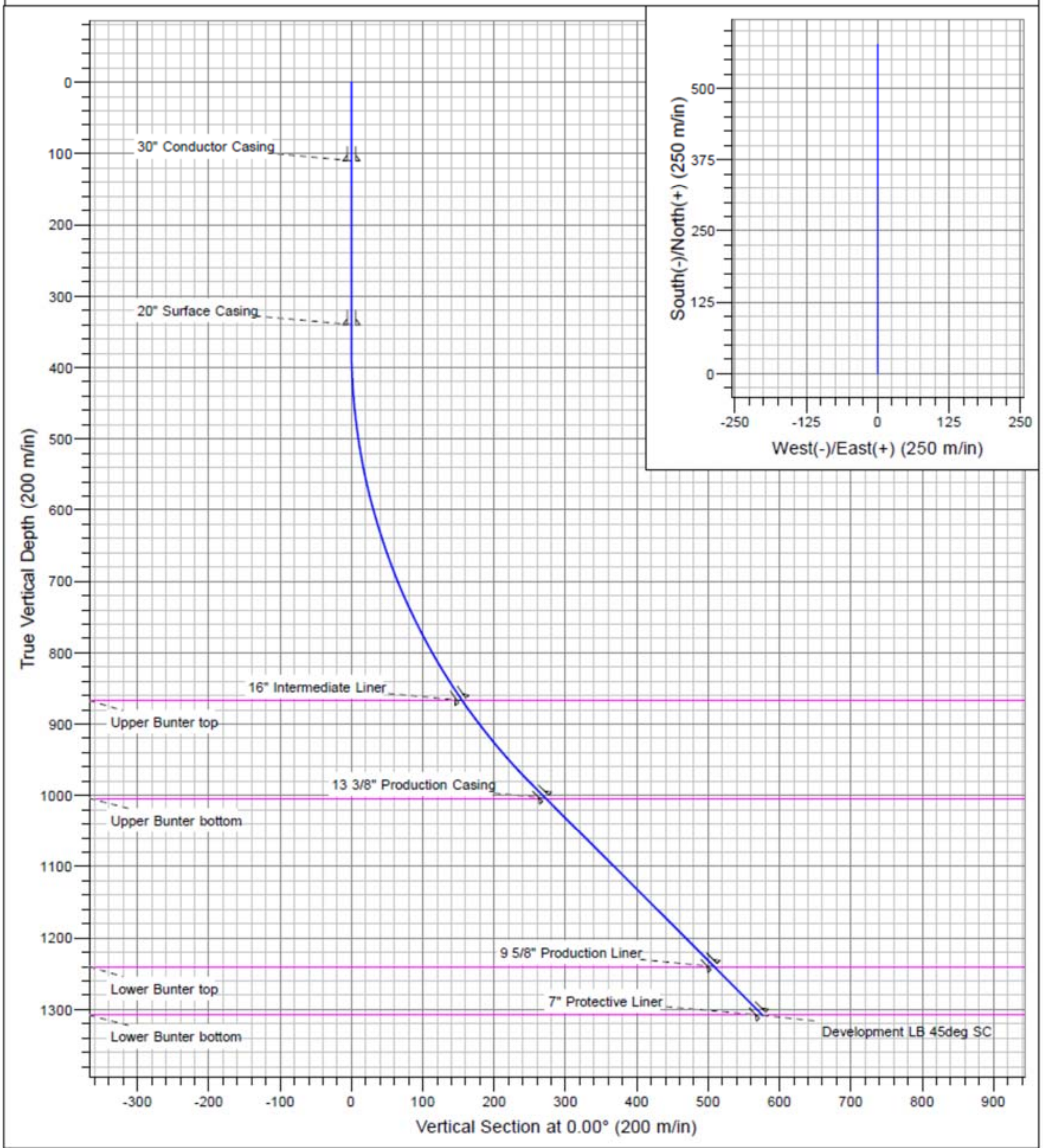
TVD	MD	Name	Size
110.00	110.00	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	898.72	13 3/8" Production Casing	13.375
	1079.22	9 5/8" Production Liner	9.625

Figure 5.2: Upper Bunter injection well trajectory

WELL DETAILS: Development well Lower Bunter

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	370.00	0.00	0.00	370.00	0.00	0.00	0.00	0.00	0.00	
3	1055.80	45.00	0.00	987.44	255.75	0.00	2.00	0.00	255.75	
4	1509.14	45.00	0.00	1308.00	576.31	0.00	0.00	0.00	576.31	

CASING DETAILS

TVD	MD	Name	Size
110.00	110.00	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	898.72	16" Intermediate Liner	16.000
1004.00	1079.22	13 3/8" Production Casing	13.375
1240.00	1412.98	9 5/8" Production Liner	9.625
1308.00	1509.14	7" Protective Liner	7.000

Figure 5.3: Lower Bunter injection wells trajectory

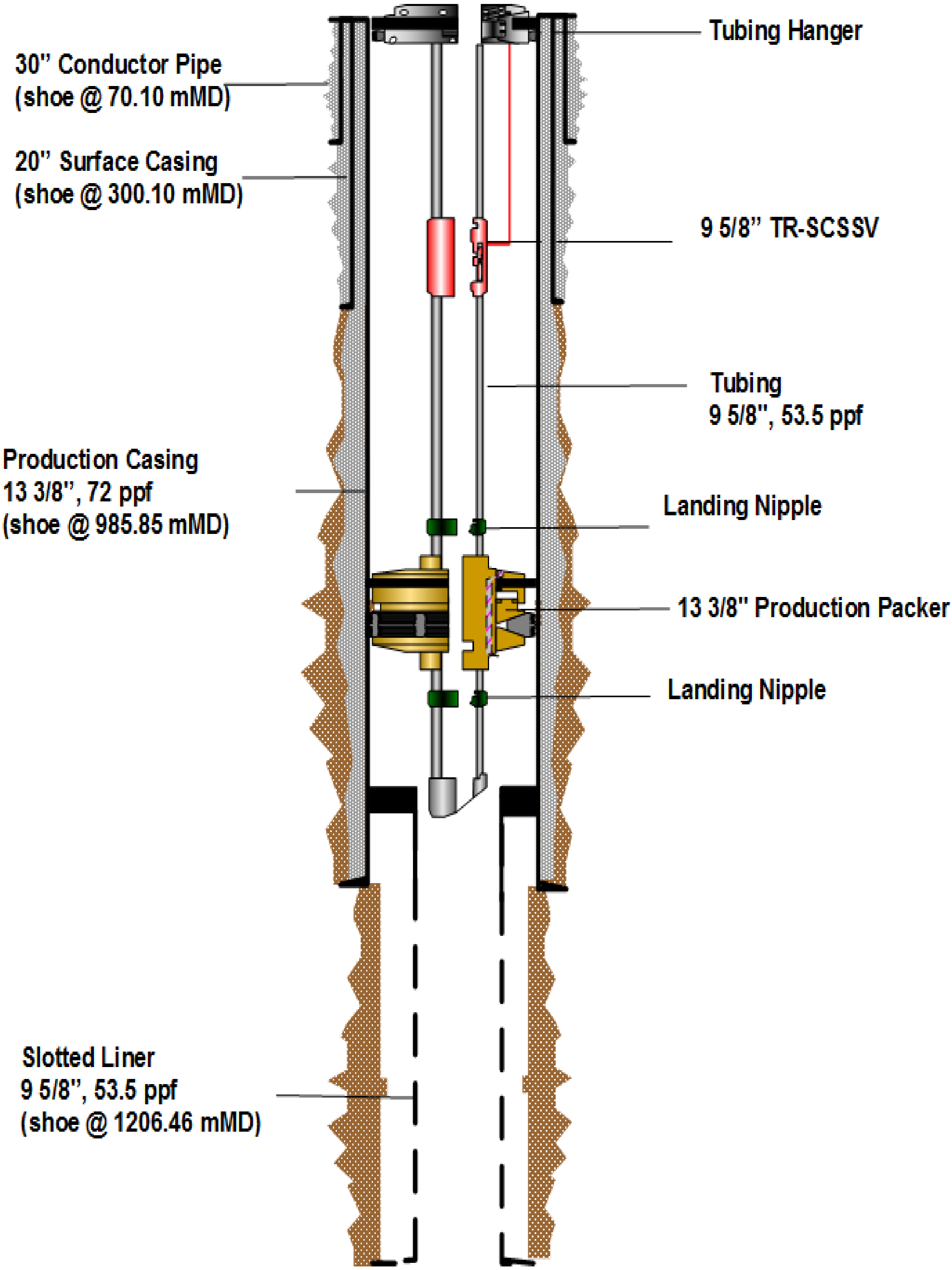


Figure 5.4: Preliminary Completion Scheme for Upper Bunter Wells

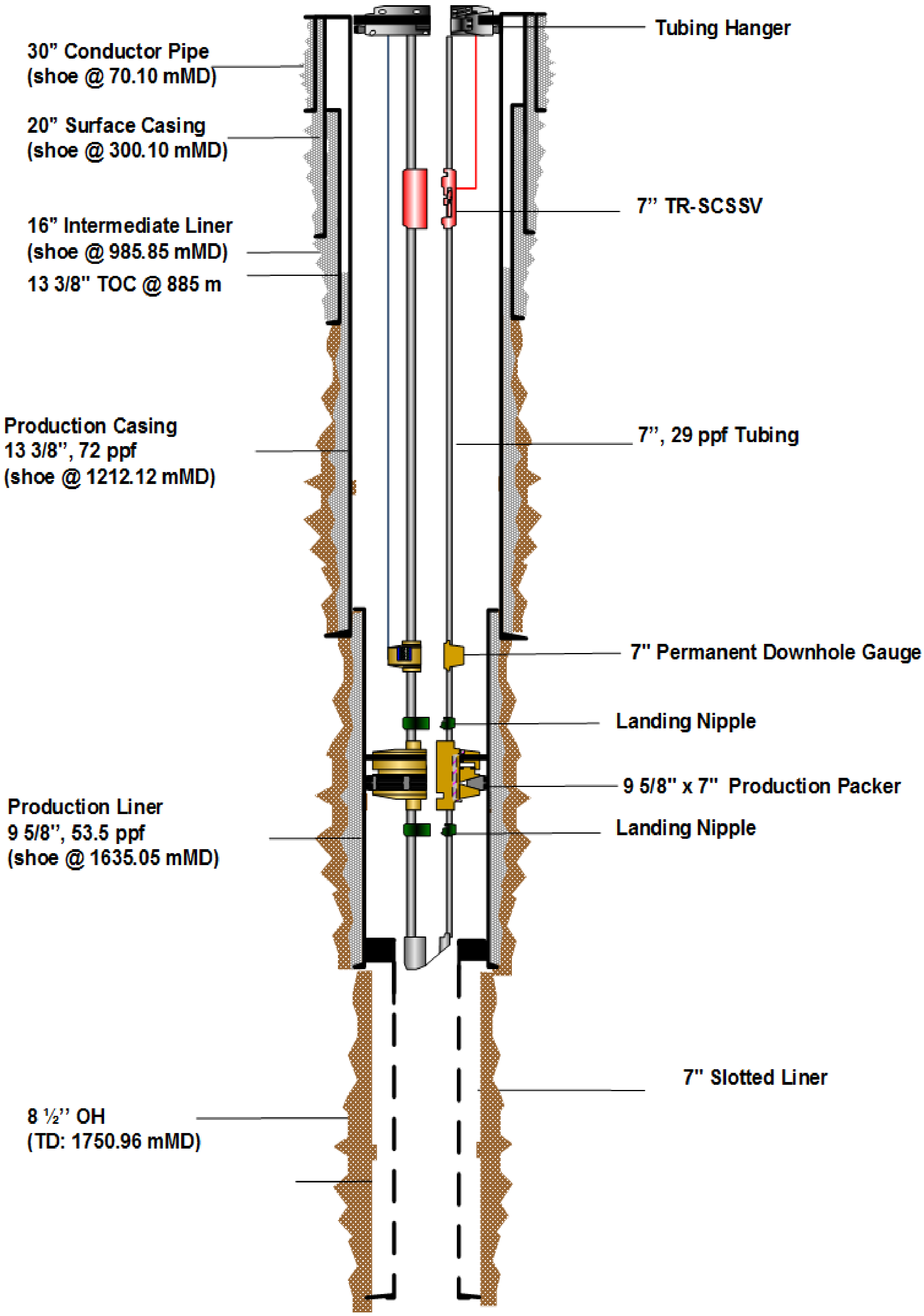


Figure 5.5: Preliminary Completion Scheme for Lower Bunter Wells

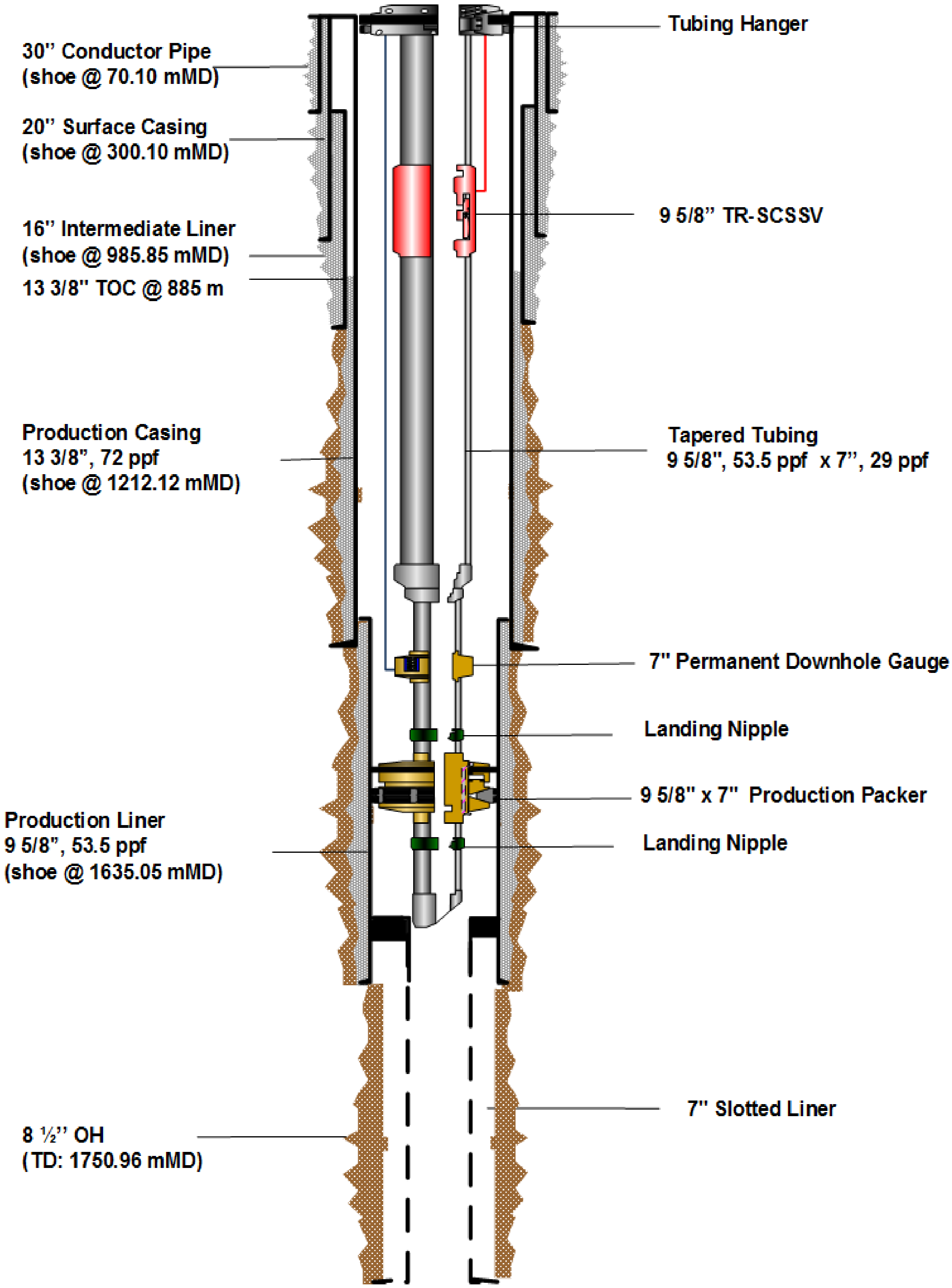


Figure 5.6: Preliminary Tapered Completion Scheme for Lower Bunter Wells

6. TIME AND COST

Time and cost estimates for drilling and completion activity have been evaluated with a probabilistic approach, applying Eni Risk Management evaluation as provided in the following documents:

- SVI.VMS.GL.0004.000 - Best Practice for Risk Management
- STAP-P-1-N-20913 - Project Risk Management for Drilling, Completion & Production Optimization Activities

All the results and activities summarized in this document are based on the workflow provided by the AWARE system (Advised Workflow for Accurate Risk Estimates) that is the Eni proprietary system and process dedicated to support drilling and completion engineers in the identification, evaluation and control of project risks. In addition, it allows to perform risk based time and cost evaluation maximizing the accuracy of projects AFE.

The cost and time probabilistic calculations are performed by using the Landmark Well cost software.

The input data are based on previous Eni's experience in similar project, taking into account the performances of the wells drilled in the area.

6.1 RISK REGISTER

The following picture summarizes all the drilling risks evaluated in AWARE with the risk matrix approach.

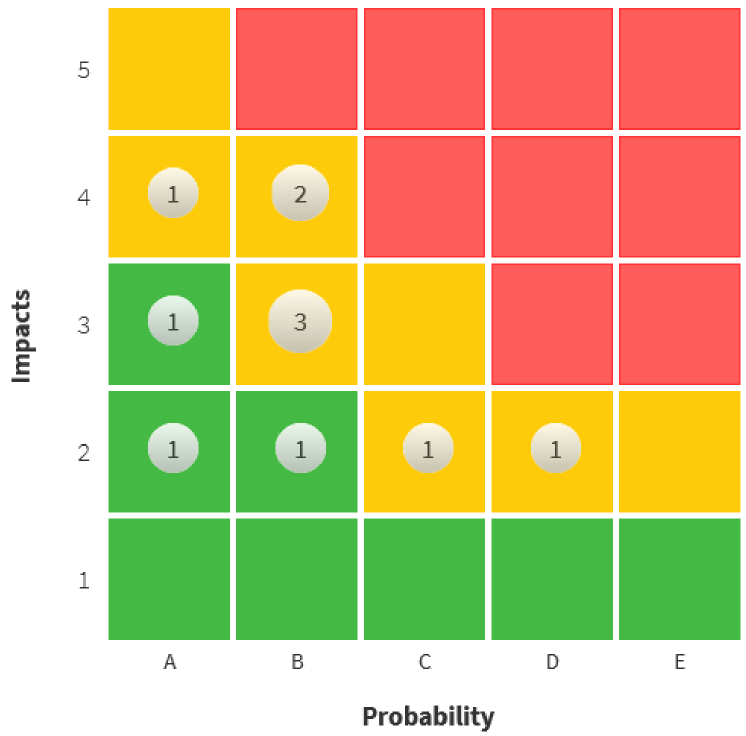


Table 6.1: Risk Register (post-mitigation evaluation)

All the reported risks are described in the following table. For each risk it is reported the pre-mitigation evaluation (first row) and the post-mitigation evaluation (second row).

RISK NAME / RISK DESCRIPTION	CATEGORY / AREA	PROBABILITY	PEOPLE	ENVIROINMENT	COST	QUALITY	SCHEDULE	BUSINESS LOSS	CORPORATE IMAGE	3RD PARTY	MANAGEABILITY	RISK LEVEL	RISK OWNER	STRATEGY	STATUS	DUE DATE
			IMPACT										CONTROL STRATEGY DESCRIPTION			
1. Borehole instability (loss hole, stuck pipes, casing running & cementing difficulties,.)	Well Condition	B	-	-	3	-	3	-	-	-	L	M	-	-	Planned	
	Lithology	B	-	-	3	-	3	-	-	-	L	M	-			
Differential sticking																
2. Integrity of cementing (TOC,...)	Drilling	C	-	-	4	-	4	-	-	-	M	H	-	-	Planned	
	Cementing	B	-	-	4	-	4	-	-	-	M	M	Cement slurries design optimization			
Casing not properly cemented, cement job not performed as per plan																
3. Lack of offset wells info	Organization	A	-	-	2	2	2	-	2	2	L	L	-	-	Planned	
	Engineering	A	-	-	2	2	2	-	2	2	L	L	-			
Assumption based on development wells drilled in 60-70s by other operators. Not updated data																

RISK NAME / RISK DESCRIPTION	CATEGORY / AREA	PROBABILITY	PEOPLE	ENVIROINMENT	COST	QUALITY	SCHEDULE	BUSINESS LOSS	CORPORATE IMAGE	3RD PARTY	MANAGEABILITY	RISK LEVEL	RISK OWNER	STRATEGY	STATUS	DUE DATE
			IMPACT										CONTROL STRATEGY DESCRIPTION			
4. Logging / test operations duration (stuck,)	Drilling	C	-	-	3	-	3	-	-	-	M	M	-	-	Planned	
	Control / Tests	B	-	-	3	-	2	-	-	-	M	M	Possible log acquisition in TLC			
Logging / test operations duration (stuck,)																
5. Mud losses	Drilling	C	-	-	3	-	3	-	-	-	M	M	-	-	Planned	
	D&C Fluids	B	-	-	3	-	3	-	-	-	M	M	Mud weight formulation shall include carbonate/bridging agent			
Mud losses in the depleted reservoirs																

RISK NAME / RISK DESCRIPTION	CATEGORY / AREA	PROBABILITY	PEOPLE	ENVIROINMENT	COST	QUALITY	SCHEDULE	BUSINESS LOSS	CORPORATE IMAGE	3RD PARTY	MANAGEABILITY	RISK LEVEL	RISK OWNER / CONTROL STRATEGY DESCRIPTION	STRATEGY	STATUS	DUE DATE
6. Borehole instability (loss hole, stuck pipes, casing running & cementing difficulties,.)	Well Condition	C	-	-	2	2	-	-	-	-	L	M	-	-	Planned	
	Lithology	C	-	-	2	2	-	-	-	-	L	M	-			
WBS study never performed - Mud weight definition to be revised (very old data available)																
7. Availability of current drilling services contracts / uncertainty on market prices for new contracts or potential late changes	Organization	A	-	-	3	3	-	-	-	-	L	L	-	-	Planned	
	Contracts	A	-	-	3	3	-	-	-	-	L	L	-			
Specific tool availablity, back-up strategy																
8. Casing capability to reach target depth (casing stuck)	Drilling	B	-	-	4	-	4	-	-	-	L	M	-	-	Planned	
	Casing	B	-	-	4	-	4	-	-	-	L	M	-			
Casing capability to reach target depth due to differential sticking, most likely referred to 13-3/8" csg in wells reaching LB formation																
9. Reliability (NPT records, mechanical conditions, consistent in QA, HSE and maintenance)	Rig	B	-	-	2	2	2	-	-	-	L	L	-	-	Planned	
	Performance	B	-	-	2	2	2	-	-	-	L	L	-			
Rig and Downhole Equipment Reliability (NPT records, mechanical conditions, consistent in QA, HSE and maintenance)																
10. Availability of equipment and services contracts	Completion	D	-	-	4	5	-	-	-	-	M	H	-	-	Planned	
	Running completion	D	-	0	2	2	-	-	-	-	M	M	Design change to 7" completion or require to manufacturer additional qualification tests (impact on costs)			
Availability of equipment and services contracts for 9 5/8" TR SCSSV and 13 3/8" x 9 5/8" production packer																
11. Slotted liner RIH	Completion	A	-	-	4	-	4	-	-	-	L	M	-	-	Planned	
	Running completion	A	-	-	4	-	4	-	-	-	L	M	-			
Slotted liner capability to reach target depth due to differential sticking																

Table 6.2: Risk Register detail

6.2 SUMMARY OF THE OPERATIONAL SEQUENCE

The operative sequence considered for the time and cost estimation are reported in the following paragraphs.

The reference wells considered for the study are:

- Appraisal well
- Upper Bunter injection well
- Lower Bunter Injection well

6.2.1 APPRAISAL WELL

The well shall be equipped with Mud Line Suspension System (included in the time and cost estimation).

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Rig preparation and M/U DP stands
- Install CP
- Install diverter
- Drill 24” phase
- RIH and cement 20” casing
- Install BOP and test
- Drill 17 1/2” phase
- RIH and cement 16 liner
- Drill 14 3/4” phase
- RIH and cement 13 3/8” casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼” phase
- RIH and cement 9 5/8” liner
- Drill 8 ½” phase at TD
- Logs
- Run 7” slotted liner
- Temporary P&A

For future well re-entry

- Rig preparation and M/U DP stands
- Install BOP
- Well re-entry
- Upper completion installation
- Remove BOP
- Install Xtree

6.2.2 UPPER BUNTER INJECTION WELL

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Install CP
- Install diverter
- Drill 24” phase
- RIH and cement 20” casing
- Install BOP and test
- Drill 17 1/2” phase
- RIH and cement 13 3/8” casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼” phase
- Run 9 5/8” slotted liner
- Well cleaning operations and brine displacement
- RIH upper completion
- Install Xmas Tree
- Close well

6.2.3 LOWER BUNTER INJECTION WELL

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Install CP
- Install diverter
- Drill 24” phase
- RIH and cement 20” casing
- Install BOP and test
- Drill 17 1/2” phase
- RIH and cement 16 liner
- Drill 14 3/4” phase
- RIH and cement 13 3/8” casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼” phase
- RIH and cement 9 5/8” liner
- Drill 8 ½” phase at TD
- Run 7” slotted liner
- Well cleaning operations and brine displacement
- RIH upper completion
- Install Xmas Tree
- Close well

6.3 TIME ESTIMATES

Time estimate has been enhanced by ID3 software tool.

ID3 (Integrated Drilling Data Discovery) is an analytical platform dedicated to evaluate the performance of the drilling and completion operations. The system is consolidating daily drilling reports and surface logging data in order to provide accurate and objective KPI. The application of ID3 on multiple wells allows to identify the Statistical Technical Limit and highlight the Invisible Lost Time.

An analysis was performed on the comparable wells currently stored in the database, drilled by jack up rigs in shallow water and with same sections and casings diameters: primarily Rowallan 22/19C-G (drilled in 2019, UK North Sea), plus 18 wells drilled in Italy.

The job focused on tripping speed and casing running speed (none of the above is comparable as per ROP).

- ***Tripping speed analysis:*** the reported values refer to the performance during Running In Hole and Pulling Out Of Hole of the drilling string for each section.

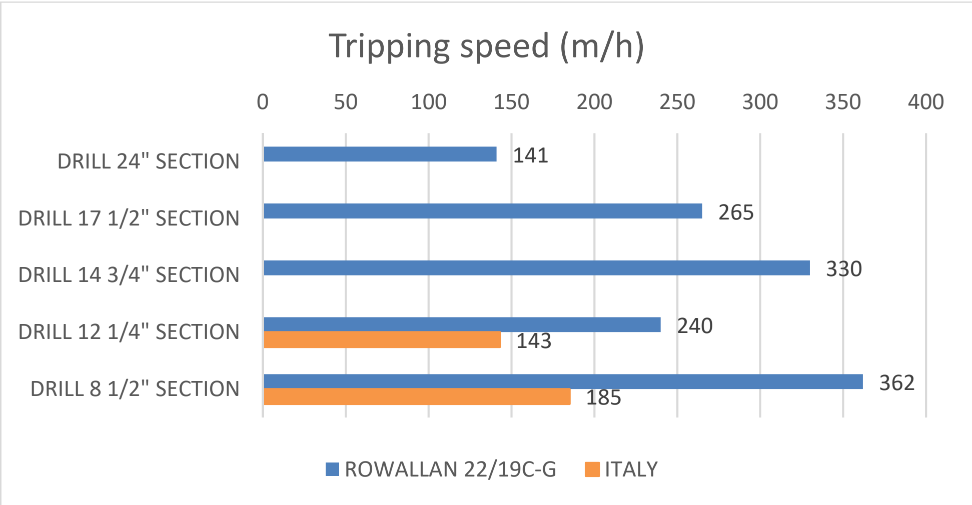


Table 6.3: Tripping speed

- ***Casing running speed analysis:*** the reported values refer to the performance during Make Up and Running In Hole of each casing or liner string (different values are considered for liner running with DP).

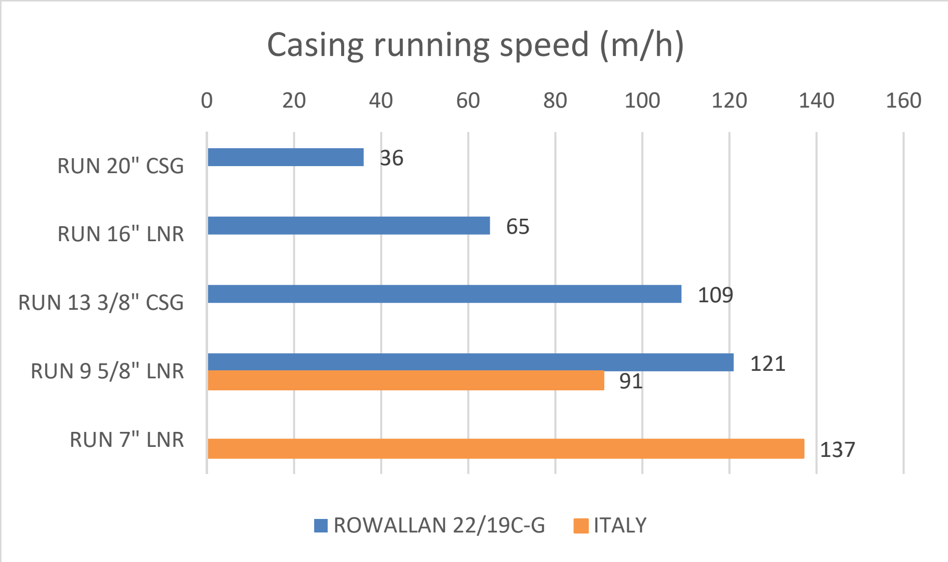


Table 6.4: Casing running speed

The following main input data have been used in WellCost model for drilling operations:

Phase	Tripping speed (m/h)	ROP (m/h)	Csg running speed (m/h)
24”	-	12-20	30 - 100
17 ½ ”	200-280	12-20	100 - 150
14 ¾ “	200-280	12-20	100 - 180
12 ¼ ”	200-280	12-20	100 - 180
8 ½”	200-280	12-20	100 - 180

Table 6.5: WellCost model main input

The above values are derived from considerations including both ID3 results and previous similar fields experience.

The time vs depth results obtained with the Well cost probabilistic model are reported in the next page.

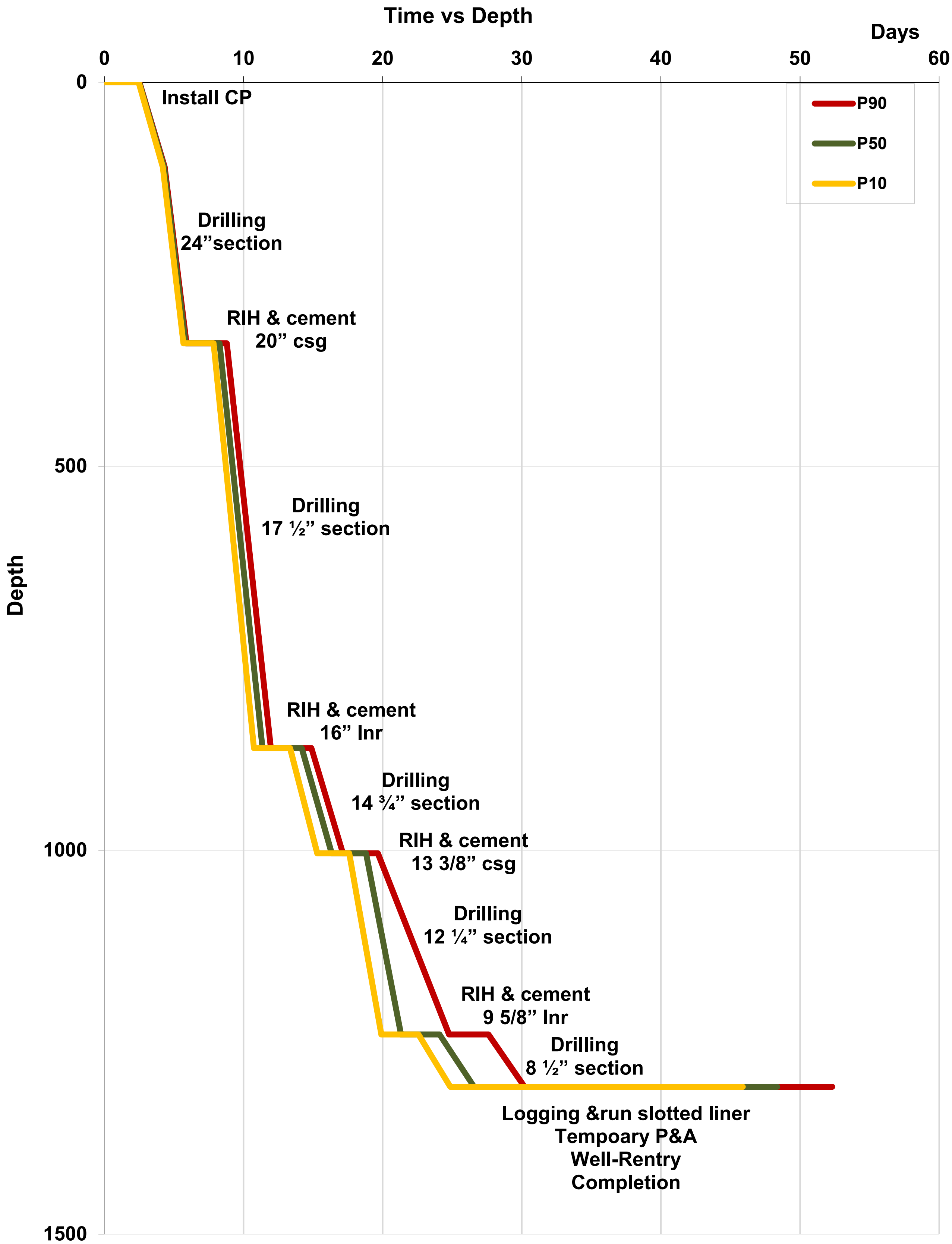


Figure 6.1: Appraisal well - Time vs depth

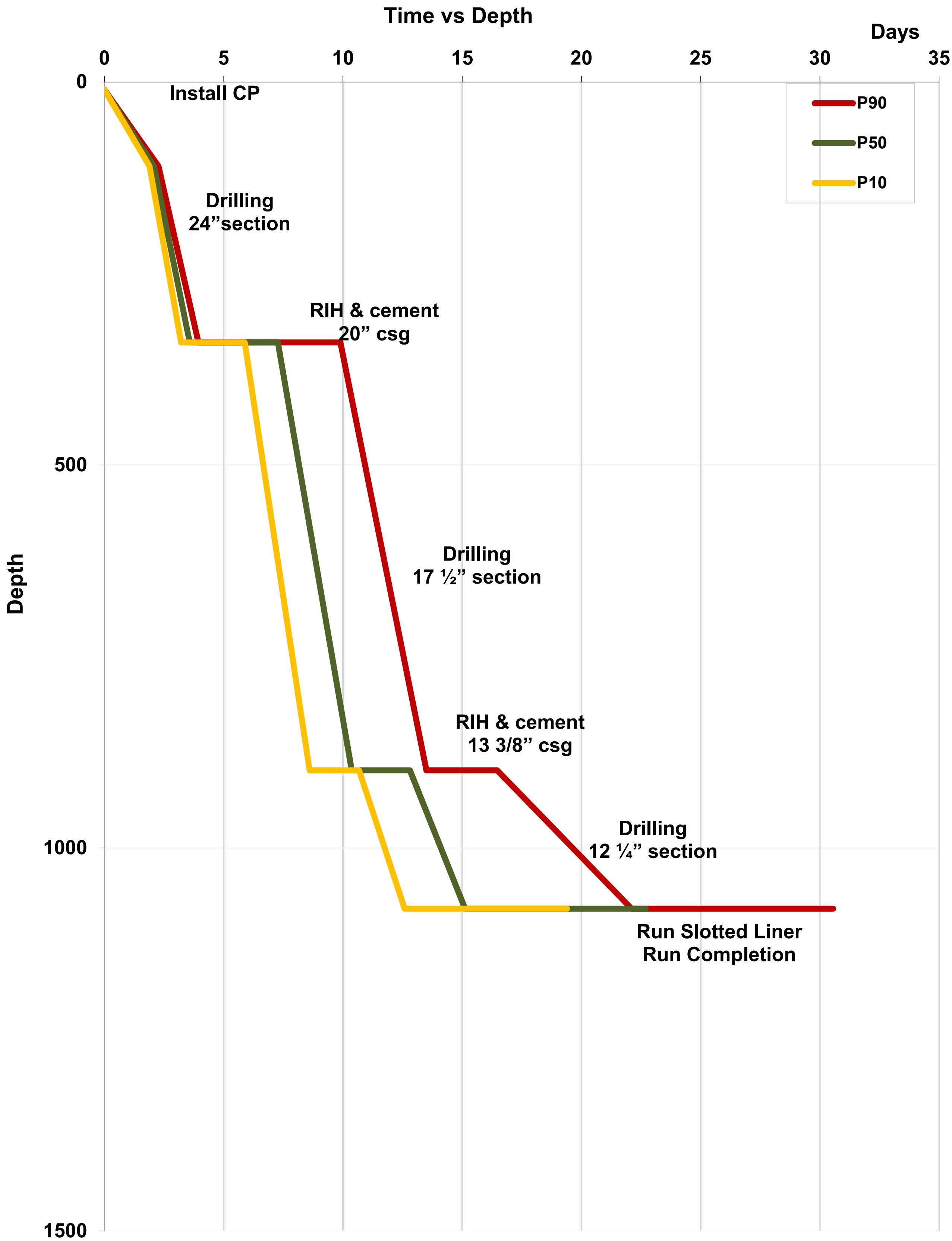


Figure 6.2: Upper Bunter Injection well - Time vs depth

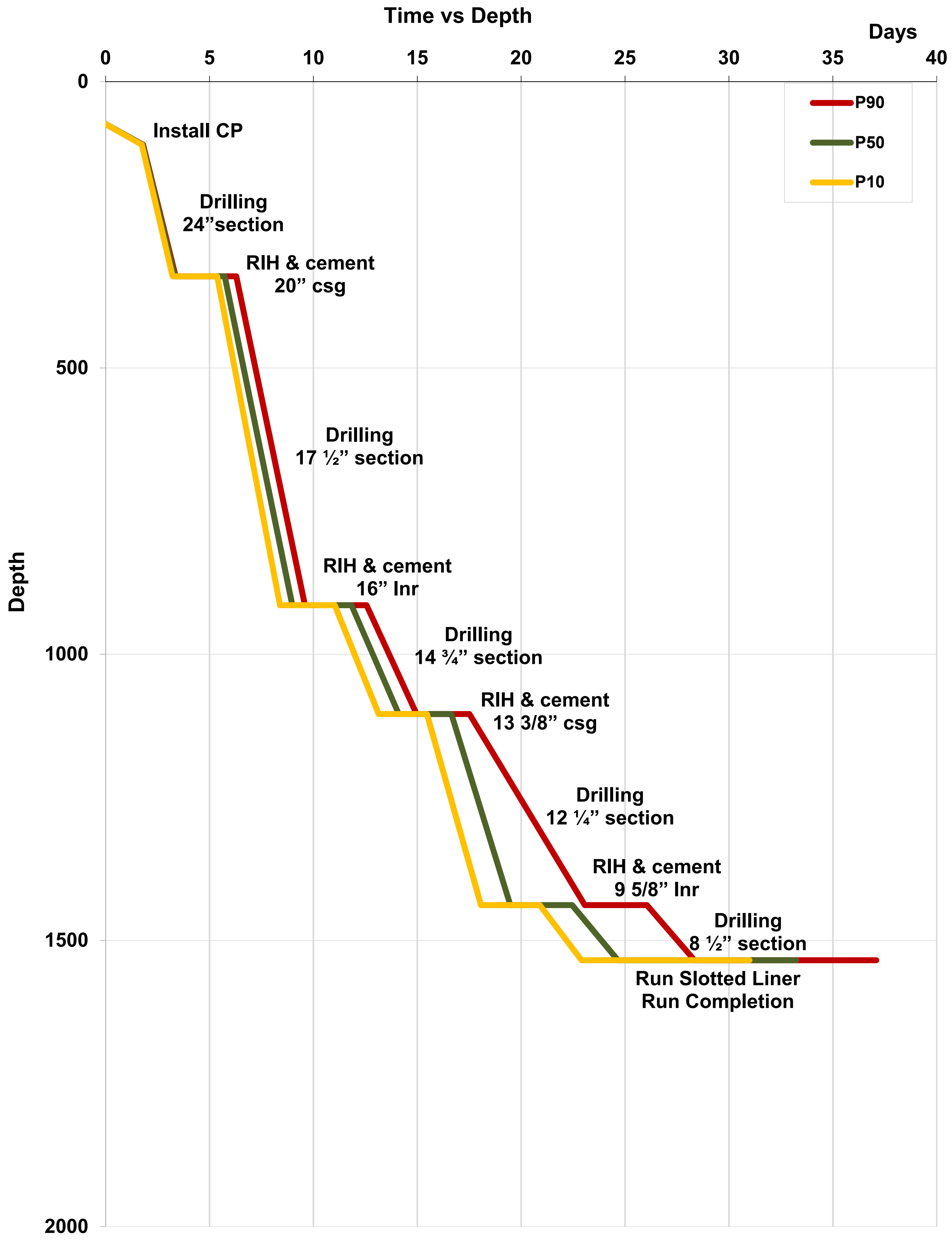


Figure 6.3: Lower Bunter Injection well - Time vs depth

The here below table reports all the results:

Well type	Drilling Time (Days)			Completion Time (Days)			Total Time (days)		
	P10	P50	P90	P10	P50	P90	P10	P50	P90
Appraisal well Drilling + Temp P&A	31,9	**33,8**	37,5						
Appraisal Well re-entry and completion				14,0	**14,6**	14,8	45,9	**48,4**	52,3
Upper Bunter well	12,6	**15,1**	22,1	6,8	**7,6**	8,5	19,4	**22,7**	30,6
Lower Bunter well	22,9	**24,7**	28,3	8.1	**8.6**	8.7	31,0	**33,2**	37,1

Table 6.6: Well duration

The mobilization (MOB) times are not included.

6.4 COST ESTIMATES

Based on the previously given time estimates from reference wells, cost estimates are provided.

The input costs are reported in GBP and US$. The change is fixed to 1GBP =1.23 US$

It is to be specified that:

- Daily Rig rate and services are based on the present contracts value of the wells ongoing in the UK offshore.

DAILY RATES	Min value [£/day] [US$/Day]	Average value [£/day] [US$/Day]	Max value [£/day] [US$/Day]
Rig Rate (including fuel)	98.000 120.540	115.000 141.450	132.000 162.360
Services*	60.000 73.800	70.000 86.100	81.000 99.630
Logistic	34.000 41.820	40.000 49.200	46.000 56.580
Total Rate	**192.000 236.160**	**225.000 276.750**	**259.000 318.570**

Table 6.7: Daily rates

*Services daily rates include: cementing services, geological assistance, mud technical assistance, solid control, casing running, deviation and waste treatment.

- Materials costs (for each well):
  For casing materials, cost per meter values have been calculated in compliance with the existing Tenaris Framework Agreement. A lump sum for tubular materials is considered for each well typology (including also conductor, hangers and floating equipment).

TUBULAR COSTS			
Well Type	**Min value [£] [US$]**	**Average value [£] [US$]**	**Max value [£] [US$]**
Appraisal well	1.080.000 1.329.400	1.200.000 1.476.000	1.320.000 1.623.600
Upper Bunter well	900.000 1.107.000	1.000.000 1.230.000	1.100.000 1.353.000
Lower Bunter well	1.350.000 1.660.500	1.500.000 1.845.000	1.650.000 2.029.500

Table 6.8: Tubular costs

At least 150-200 m of CRA casing for production string section below packer is considered. For LB case, 13 3/8” casing is also considered as CRA in front of UB formation.

Contingency 11 3/4” material is included as risk cost (200.000 £/246.00USD)

    - For appraisal well, the MLSS is assumed 81300 £/100.000US$.
    - Well head: 250.000 £/307.500US$
    - For cementing, mud and consumable 2 MM£/2.46 MMUS$.

- A lump sum of 1.500.000 £/1.845.000 US$ has been considered for logging operation of the Appraisal well, meanwhile 100.000 £/123.000 US$ is assumed for the other wells.
- The completion input data considered:
    - Completion equipment (Packer, nipples and SCSSV): 975.600 £/1.200.000 US$
    - The tubing (28Cr) is evaluated in 1.057.000£/1.300.000 US$ for all well configuration
    - The Xtree cost is assumed 406.500£/500.000 US$

All here above material cost could be evaluated in Well cost with a ±10% distribution ratio.

Tax cost are not included in the estimation.

Here below are reported the final results for cost estimate, performed using a probabilistic approach on reference well profiles.

Well type	Drilling Cost (MM£)			Completion Cost (MM£)			Total Cost (MM£)		
	P10	**P50**	**P90**	**P10**	**P50**	**P90**	**P10**	**P50**	**P90**
Appraisal well Drilling + Temp P&A	12,2	**12,9**	14,0						
Appraisal Well re-entry and completion				5,4	**5,6**	5,6	17,6	**18,4**	19,6
Upper Bunter well	6.4	**7.2**	9.2	3.5	**3.7**	3.7	10.0	**11.0**	12.8
Lower Bunter well	9,7	**10,3**	11,2	3,4	**3,6**	3,5	13,2	**13,8**	14,8

Table 6.9: Costs Evaluation

The mobilization (MOB) cost are not included.

6.5 FINAL SUMMARY FOR TIME & COST

The following table summarizes the overall time and cost with the proposed schedule:

- MOB
- Drilling Appraisal well + log + P&A
- MOB
- Re-entry Appraisal well and Completion
- Drilling and Completion Upper Bunter Injection well
- Drilling and Completion 3 Lower Bunter Injection well

Full Project Total Time and Cost	**Total time (Days)**			**Total cost (MM£)**		
	P10	**P50**	P90	P10	**P50**	P90
MOB	3	**3**	3	0,75	**0,75**	0,75
Drilling Appraisal +log+ P&A	31,9	**33,8**	37,5	12,2	**12,9**	14
MOB	3	**3**	3	0,75	**0,75**	0,75
Re-entry Appraisal and Completion	14	**14,6**	14,8	45,9	**48,4**	52,3
Drilling and Completion Upper Bunter Injection well	19,4	**22,7**	30,6	10	**11**	12,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Total	164,3	**176,7**	200,2	109,2	**115,2**	125

Table 6.10: Time & Cost Evaluation

Time and cost for MOB have been here included.

Eni S.p.A.	ORGANIZING DEPARTMENT	TYPE OF ACTIVITY'	ISSUING DEPT.	DOC. TYPE	REF. N.	PAG. 1 OF 31
	COAP/ESA	P	1	P	28047	

HEWETT GAS FIELD CONVERSION INTO CARBON SEQUESTRATION SITE - DRILLING AND COMPLETION TIME & COST ESTIMATE

DISTRIBUTION LIST

Date of issue: October 2019

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INDEX

1. SCOPE OF WORK

The present document refers to the "HEWETT GAS FIELD CONVERSION INTO CARBON SEQUESTRATION SITE - DRILLING AND COMPLETION FEASIBILLITY STUDY" and includes and implement the Time & Cost estimates for the Drilling and Completion activities.

All the Well engineering and design details are only briefly summarized in this document.

The time/cost analysis has been obtained from a risk analysis approach as indicated in the Eni D&C procedure STAP-P-1-MG-26505 - rev.01 (Cost Estimating, Budgeting and Controlling Handbook for Drilling, Completion and Workover Activities), with an accuracy within +/-40%.

All data used for this study are the most updated and available during the document preparation.

Any change from the original data received could affect the future estimation.

2. DEFINITION, ACRONYMS & ABBREVIATIONS

Acronym	Definition
BHST	Bottom Hole Static Temperature
BOP	Blow Out Preventer
CAPEX	Capital Expenditure
CCS	CO2 Capture Storage
CP	Conductor Pipe
CRA	Corrosion Resistant Alloy
D&C	Drilling and Completion
DHE	DownHole Equipment
DLS	Dog Leg Severity
DP	Drill Pipe
ECD	Equivalent Circulating Density
FG	Fracture Gradient
FW-PO-KC	Fresh Water – Polimer – Potassium Chloride
GRE	Glassfiber Reinforced Epoxy
KOP	Kick-Off Point
LB	Lower Bunter
MAASP	Maximum Allowable Annular Surface Pressure
MADF	Minimum Acceptable Design Factor
MAWHP	Maximum Anticipated Wellhead Pressure
MD	Measured Depth
MLS	Mud Line Suspension
MSL	Mean Sea Level
MW	Mud Weight
OPD	Opportunity & Project Development
P&A	Plugging & Abandonment
PPG	Pore Pressure Gradient
PPFG	Pore Pressure and Fracture Gradient
RKB	Rotary Kelly Bushing
SCSSV	Surface Controlled – Sub-surface Safety Valve
SG	Specific Gravity
TD	Total Depth
THP	Tubing Head Pressure
THT	Tubing Head Temperature
TOC	Top Of Cement
TOL	Top Of Liner
TVD	True Vertical Depth
TVDss	True Vertical Depth Sub Sea
UB	Upper Bunter
WBM	Water Base Mud
WBS	Wellbore Stability
WD	Water Depth
WPR	Working Pressure Rating
XT	Christmas (Production) Tree

3. PROJECT DESCRIPTION

Hewett is a mature field, been on production for over 40 years. It was discovered in 1966 with first production in 1969. Eni took ownership of the Hewett installation and infrastructure in 2008.
The field has a length of approx 29 km and lies in a water depth ranging between 20 and 40 m, at about 16 km from the coastline.

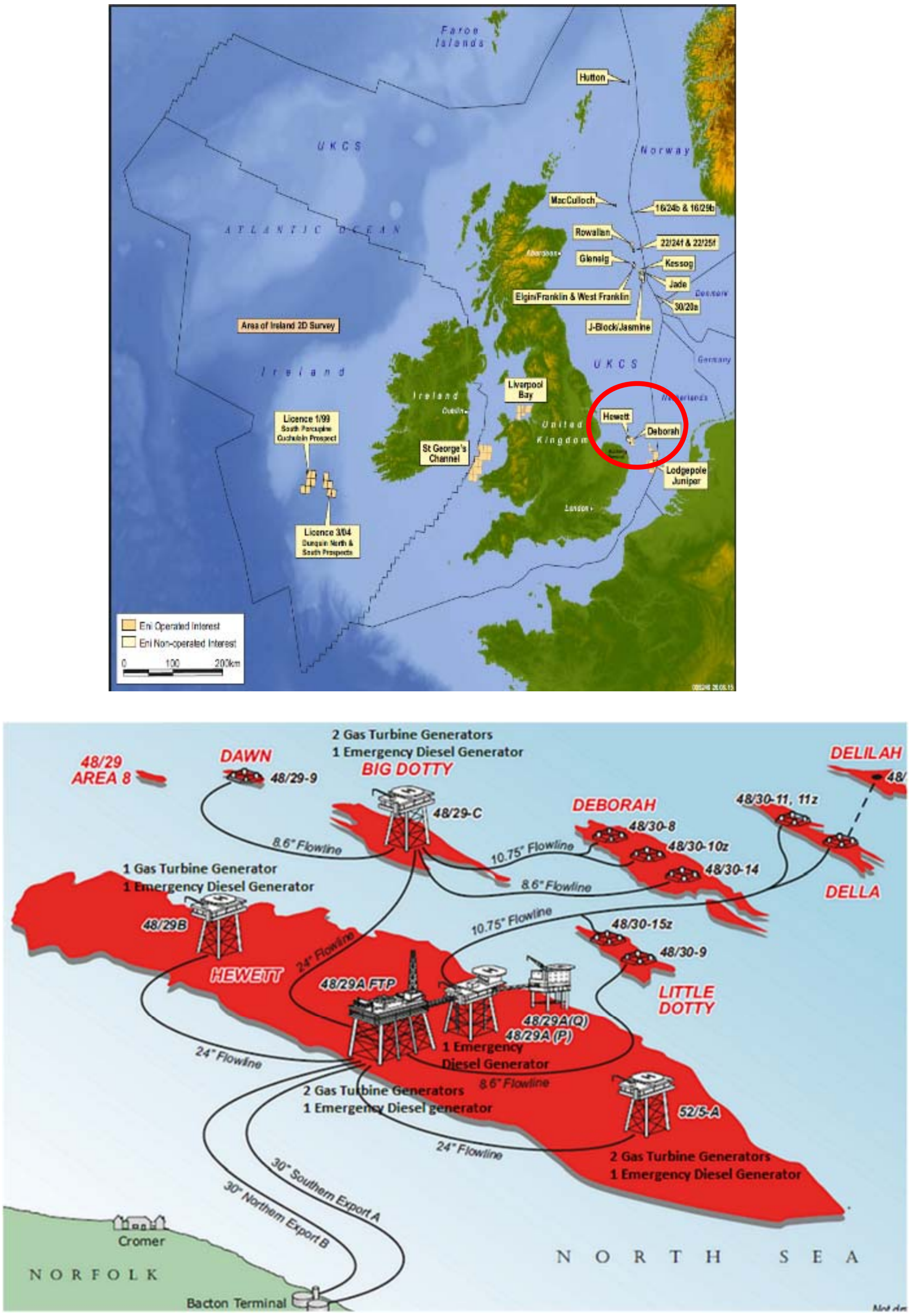


Figure 3.1: Location map and evidence of blocks and permits

The asset has 32 platform wells spread over 4 platforms plus 8 subsea production wells and one suspended subsea P&A well. All wells were drilled between 1967 and 2008 by a different operator.

The reservoir includes 5 separate stacked layers:

- Upper Bunter (shallowest)
- Lower Bunter
- Plattendolomit
- Zechsteinkalk
- Rotliegend (deepest)

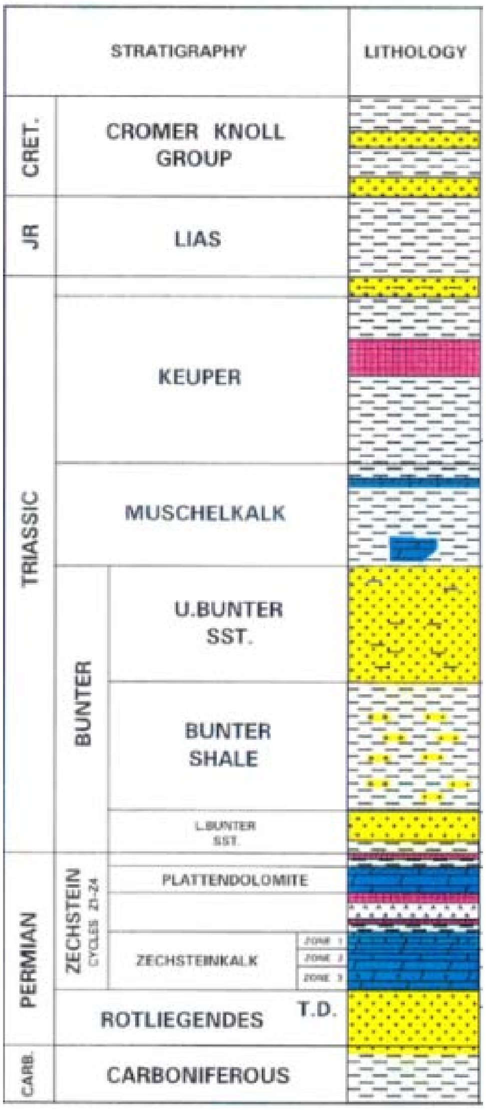


Figure 3.2: Typical lithological sequence of the field

Only two layers are selected for the purpose of CO2 injection and storage:

- Upper Bunter, secondary target (827 – 964 m TVD MSL)
- Lower Bunter, primary target (1200 – 1268 m TVD MSL)

Both formations are highly depleted, PPG values are around 0.1 kg/cm^2/10m.

Eni is now on starting a decommissioning campaign of all the subsurface and surface infrastructures. The campaign will include the Plugging & Abandoning of all the 40 wells, the isolation of the subsea well flowlines and umbilicals to make the platforms hydrocarbon free and the dismantling of all the platforms.

In the preliminary phases of the project to convert Hewett field into a CO_2 sequestration site, different options have been considered and they included also the possibilities to utilize the existing wells.

Reusing or sidetracking the existing wells has been considered in the first instance but has been rejected as it showed elevated risk mainly related to well integrity issues but also to directional plan limitation.

The current well integrity status has been verified and found in poor condition both for casing condition both for cement reliability in respect of newest CO_2 reservoir fluid.

Moreover the sidetracking strategy foresees to perform cased hole side track inside the 9 5/8" casing and completing the well with a 7" production liner. This appeared to be not in line with the requirement of displacement distance and minimum rate of injection.

Therefore Eni approached the life extension of the field considering only new appraisal and new injector wells to be drilled.

Drilling and completion activities are intended to be carried on through a Jack-Up rig. A water depth of 33 m and an RKB elevation of 40 m have been considered during the design of the wells.

The development scenario foresees five wells to be drilled from a unique new platform:

- One appraisal vertical well with 7" production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7" production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8" production liner

For all the deviated wells, inclination was limited to 45°, as per preliminary output of Eni geomechanical study.

All data used for this study are the most updated provided by Reservoir Department at the time of document preparation. In addition to that, also information gathered from offset well already drilled in the Field have been considered.

Any variation on the current input data could affect the proposed drilling strategy.

4. EXECUTIVE SUMMARY

Time & Cost estimates, related to Drilling and Completion activities to convert and reutilize Hewett Gas Producer Field as a Carbon Sequestration Site, are here below summarized, together with a brief activities summary and main well's features description.

Five wells will be drilled from a unique new platform with a conventional jack up rig:

- One appraisal vertical well with 7” production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7” production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8” production liner

No specific surface location was requested to be considered for the time being.
The wells have been designed with a slant profile, a maximum inclination of 45° and KOP short below surface casing seat.

The main features of the three proposed well profiles are presented in the table below:

Well type	Profile	Wells number	TVD [m MSL]	MD [m RKB]	KOP [m RKB]	Max Incl. [°]	Max DLS [°/30 m]	Casings number	Prod. lnr size [in]
Appraisal	S-shape	1	1268	1308	-	0	0	5	7
Injection Upper Bunter	Slanted	1	1004	1117	330	45	2	3	9 5/8
Injection Lower Bunter	Slanted	3	1268	1535	330	45	2	5	7

Table 4.1: Well profiles features

For the trajectories design, a water depth of 33 m and a RKB elevation of 40 m have been considered.

Based on the operating strategy selected (drilling activities carried on by a Jack-Up rig), the following tables summarizes time and cost estimates for each well type.

Well type	**Drilling Time (Days)**			**Completion Time (Days)**			**Total Time (days)**		
	P10	**P50**	**P90**	**P10**	**P50**	**P90**	**P10**	**P50**	**P90**
Appraisal well Drilling + Temp P&A	31,9	**33,8**	37,5						
Appraisal Well Re-entry and Completion				14,0	**14,6**	14,8	45,9	**48,4**	52,3
Upper Bunter Well	12,6	**15,1**	22,1	6,8	**7,6**	8,5	19,4	**22,7**	30,6
Lower Bunter Well	22,9	**24,7**	28,3	8.1	**8.6**	8.7	31,0	**33,2**	37,1

Table 4.2: Wells Time estimate

Well type	**Drilling Cost (MM£)**			**Completion Cost (MM£)**			**Total Cost (MM£)**		
	P10	**P50**	**P90**	**P10**	**P50**	**P90**	**P10**	**P50**	**P90**
Appraisal well Drilling + Temp P&A	12,2	**12,9**	14,0						
Appraisal Well Re-entry and Completion				5,4	**5,6**	5,6	17,6	**18,4**	19,6
Upper Bunter Well	6.4	**7.2**	9.2	3.5	**3.7**	3.7	10.0	**11.0**	12.8
Lower Bunter Well	9,7	**10,3**	11,2	3,4	**3,6**	3,5	13,2	**13,8**	14,8

Table 4.3: Wells Cost estimate

The following table summarizes the overall schedule time and cost:

- Rig mobilization (appraisal campaign)
- Drilling Appraisal well + log + P&A and Rig demobilization
- Rig re-mobilization (development campaign)
- Re-entry Appraisal well and Completion
- Drilling and Completion Upper Bunter Injection well
- Drilling and Completion 3 Lower Bunter Injection wells

Phase	Total time (Days)			Total cost (MM£)		
	P10	**P50**	**P90**	**P10**	**P50**	**P90**
Rig mobilization	3	**3**	3	0,75	**0,75**	0,75
Drilling Appraisal well + log + P&A and Rig demobilization	31,9	**33,8**	37,5	12,2	**12,9**	14
Rig mobilization	3	**3**	3	0,75	**0,75**	0,75
Re-entry and Completion Appraisal well	14	**14,6**	14,8	45,9	**48,4**	52,3
Drilling and Completion Upper Bunter Injection well	19,4	**22,7**	30,6	10	**11**	12,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Total	164,3	**176,7**	200,2	109,2	**115,2**	125

Table 4.4: Total D&C time and cost estimate

5. WELL DESIGN

Five wells will be drilled from a unique new platform with a conventional jack up rig:

- One appraisal vertical well with 7” production liner
- Three slanted Injector wells dedicated to the Lower Bunter with 7” production liner
- One slanted Injector well dedicated to the Upper Bunter with 9 5/8” production liner

No specific surface location was requested to be considered for the time being.
The wells have been designed with a slant profile, a maximum inclination of 45° and KOP short below surface casing seat.

The main features of the three proposed well profiles are presented in the table below:

Well type	Profile	Wells number	TVD [m MSL]	MD [m RKB]	KOP [m RKB]	Max Incl. [°]	Max DLS [°/30 m]	Casings number	Prod. lnr size [in]
Appraisal	S-shape	1	1268	1308	-	0	0	5	7
Injection Upper Bunter	Slanted	1	1004	1117	330	45	2	3	9 5/8
Injection Lower Bunter	Slanted	3	1268	1535	330	45	2	5	7

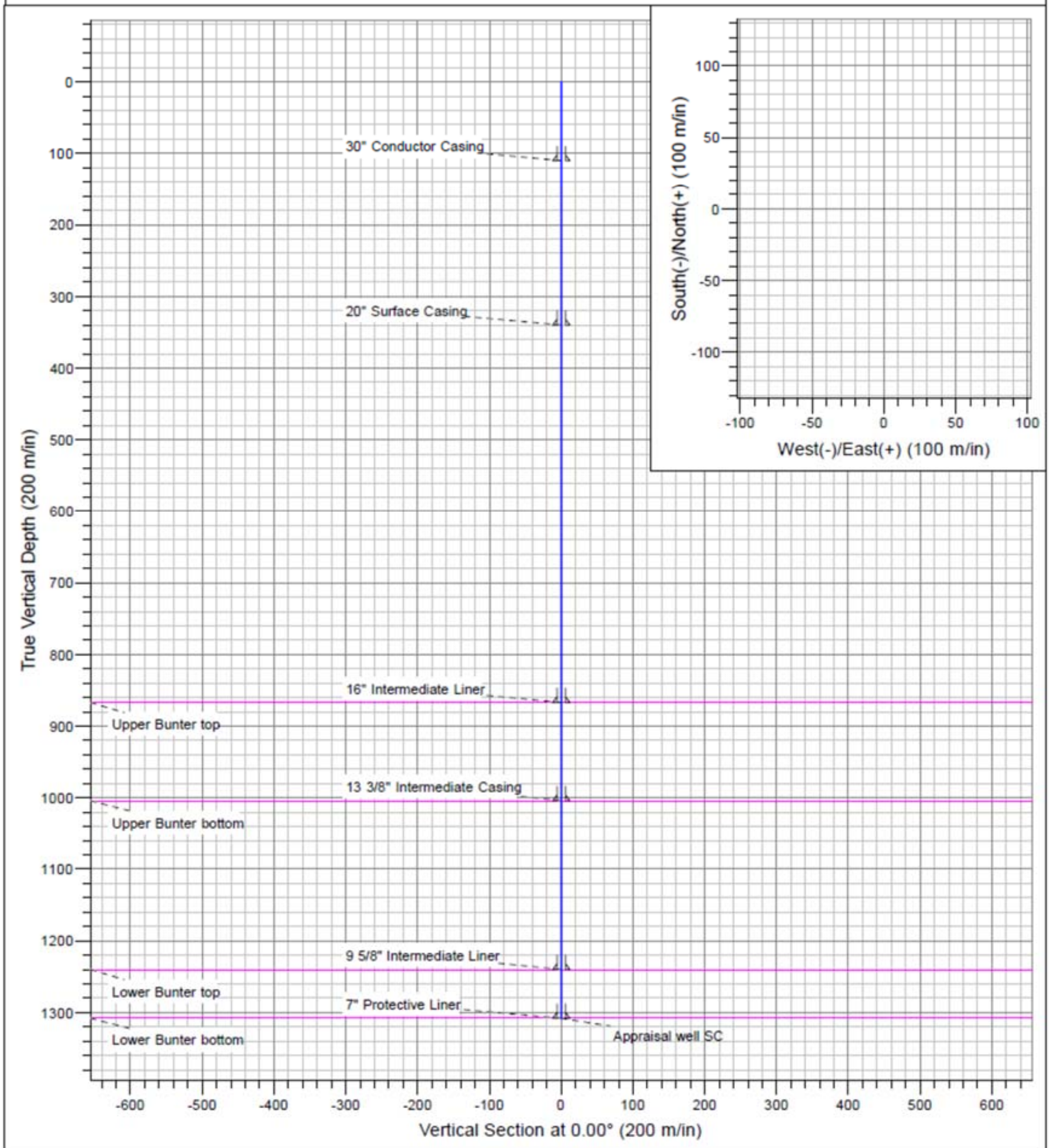
Table 5.1: Well profiles features

For the trajectories design, a water depth of 33 m and a RKB elevation of 40 m have been considered.

WELL DETAILS: Appraisal well

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	1308.00	0.00	0.00	1308.00	0.00	0.00	0.00	0.00	0.00	

CASING DETAILS

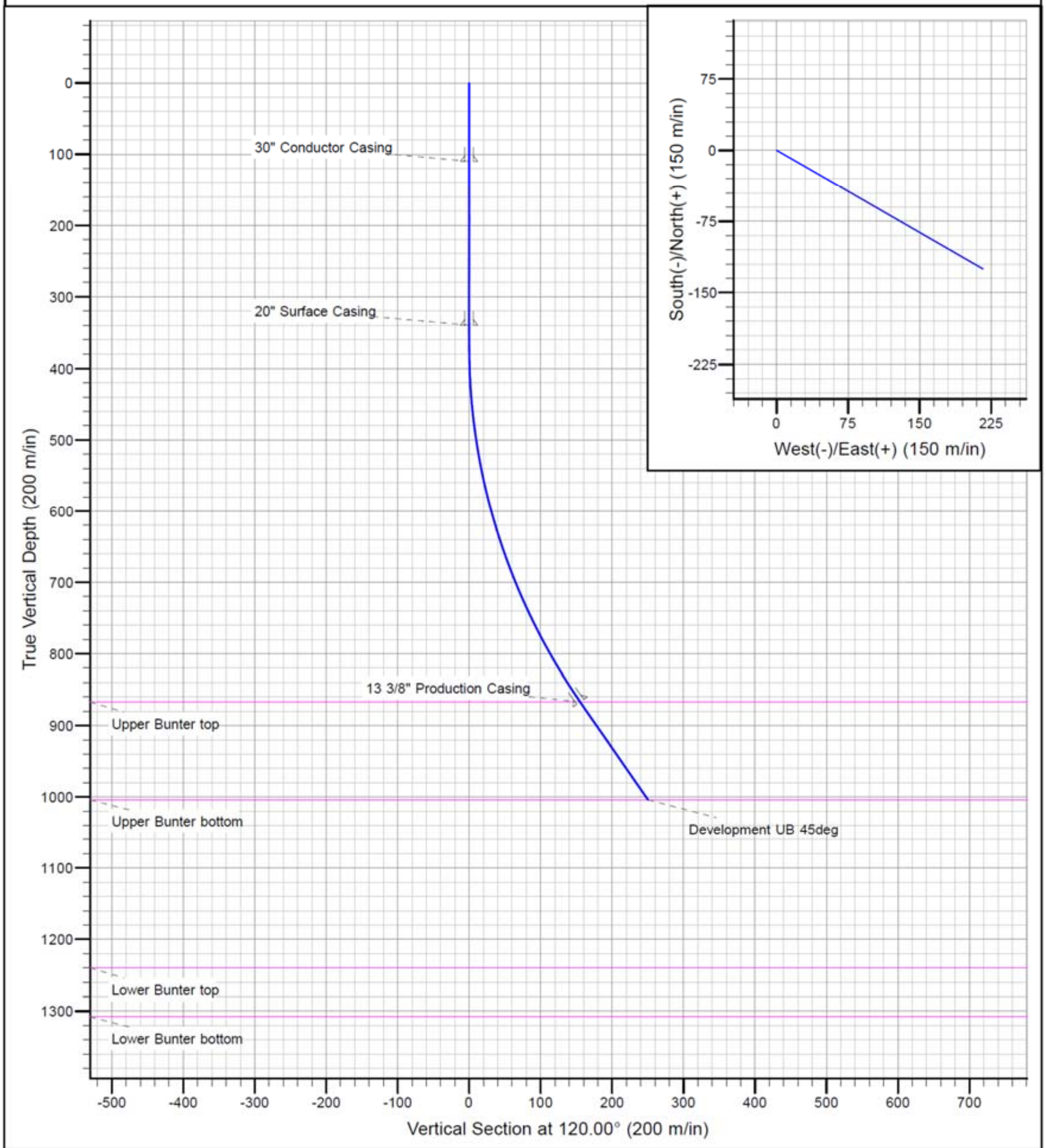
TVD	MD	Name	Size
110.10	110.10	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	867.00	16" Intermediate Liner	16.000
1004.00	1004.00	13 3/8" Intermediate Casing	13.375
1240.00	1240.00	9 5/8" Intermediate Liner	9.625
1308.00	1308.00	7" Protective Liner	7.000

Figure 5.1: Appraisal well trajectory

WELL DETAILS: Development well upper Bunter

Water Depth: 34.00

Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	370.00	0.00	120.00	370.00	0.00	0.00	0.00	120.00	0.00	
3	898.72	34.69	120.00	867.00	-77.62	134.44	2.00	120.00	155.24	
4	1065.34	34.69	120.00	1004.00	-125.04	216.58	0.00	0.00	250.08	

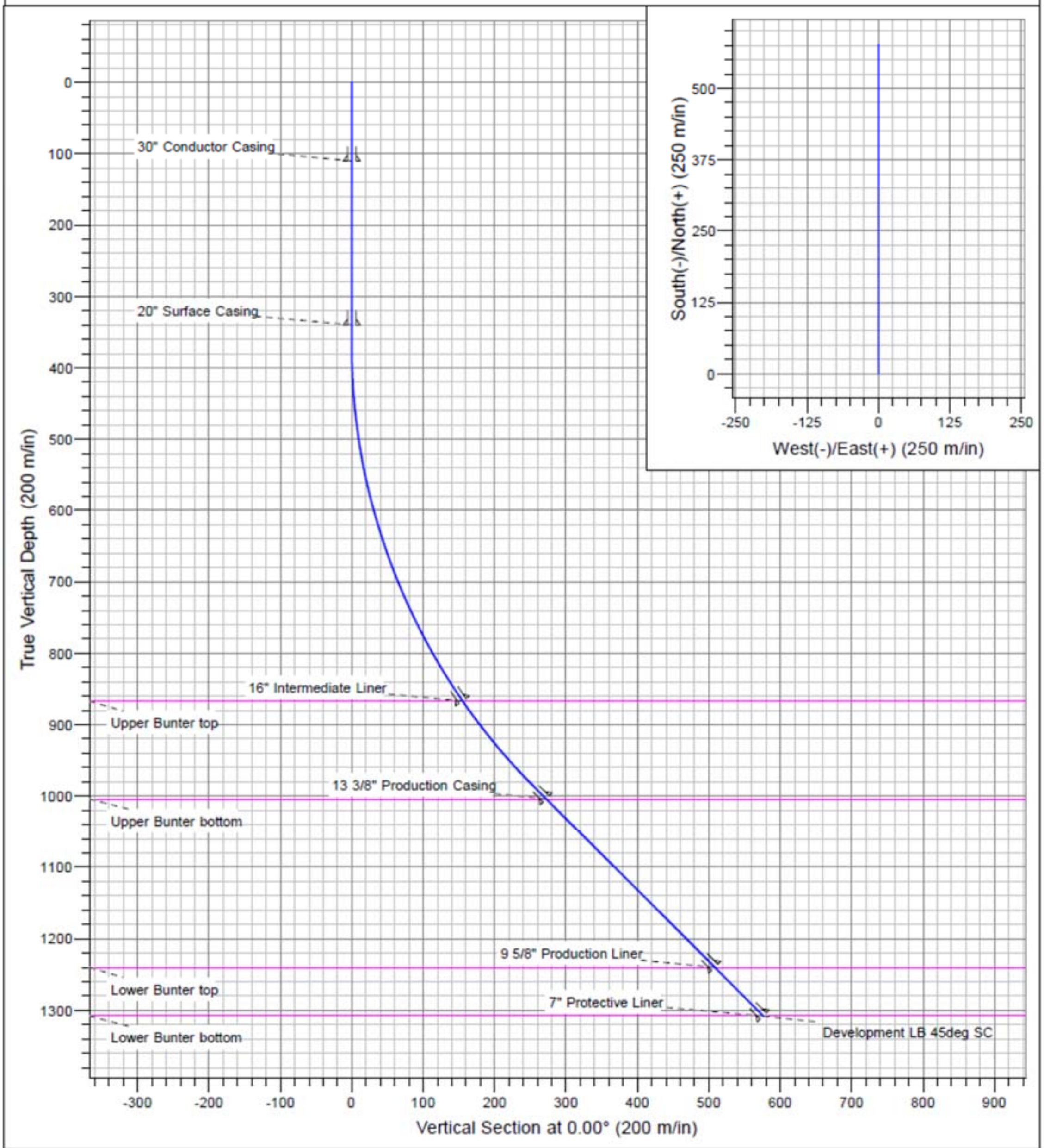
CASING DETAILS

TVD	MD	Name	Size
110.00	110.00	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	898.72	13 3/8" Production Casing	13.375
	1079.22	9 5/8" Production Liner	9.625

Figure 5.2: Upper Bunter injection well trajectory

WELL DETAILS: Development well Lower Bunter

Water Depth:	34.00
Northing	Easting
5873807.00	421234.00



SECTION DETAILS

Sec	MD	Inc	Azi	TVD	+N/-S	+E/-W	Dleg	TFace	VSect	Target
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	370.00	0.00	0.00	370.00	0.00	0.00	0.00	0.00	0.00	
3	1055.80	45.00	0.00	987.44	255.75	0.00	2.00	0.00	255.75	
4	1509.14	45.00	0.00	1308.00	576.31	0.00	0.00	0.00	576.31	

CASING DETAILS

TVD	MD	Name	Size
110.00	110.00	30" Conductor Casing	30.000
340.00	340.00	20" Surface Casing	20.000
867.00	898.72	16" Intermediate Liner	16.000
1004.00	1079.22	13 3/8" Production Casing	13.375
1240.00	1412.98	9 5/8" Production Liner	9.625
1308.00	1509.14	7" Protective Liner	7.000

Figure 5.3: Lower Bunter injection wells trajectory

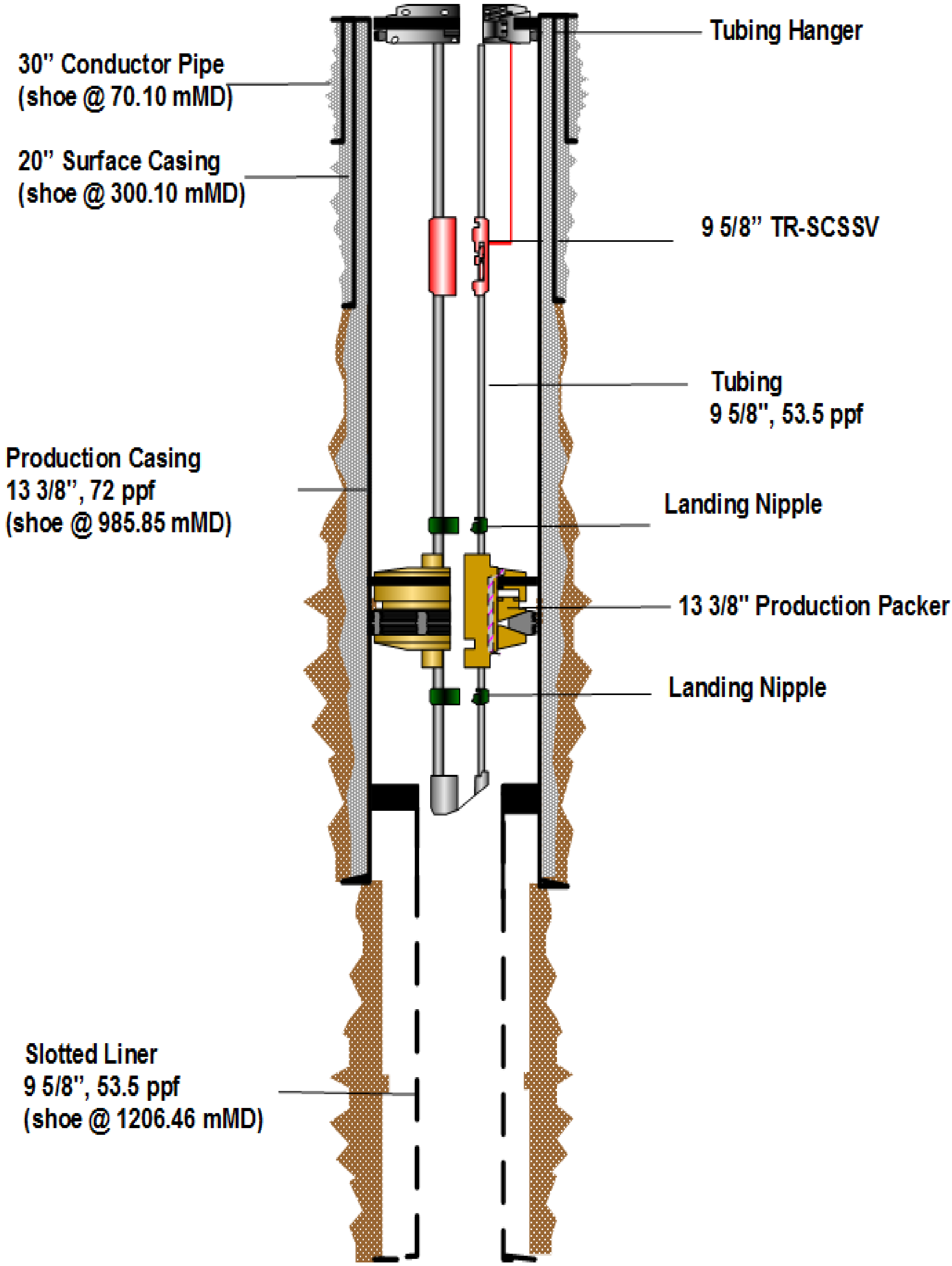


Figure 5.4: Preliminary Completion Scheme for Upper Bunter Wells

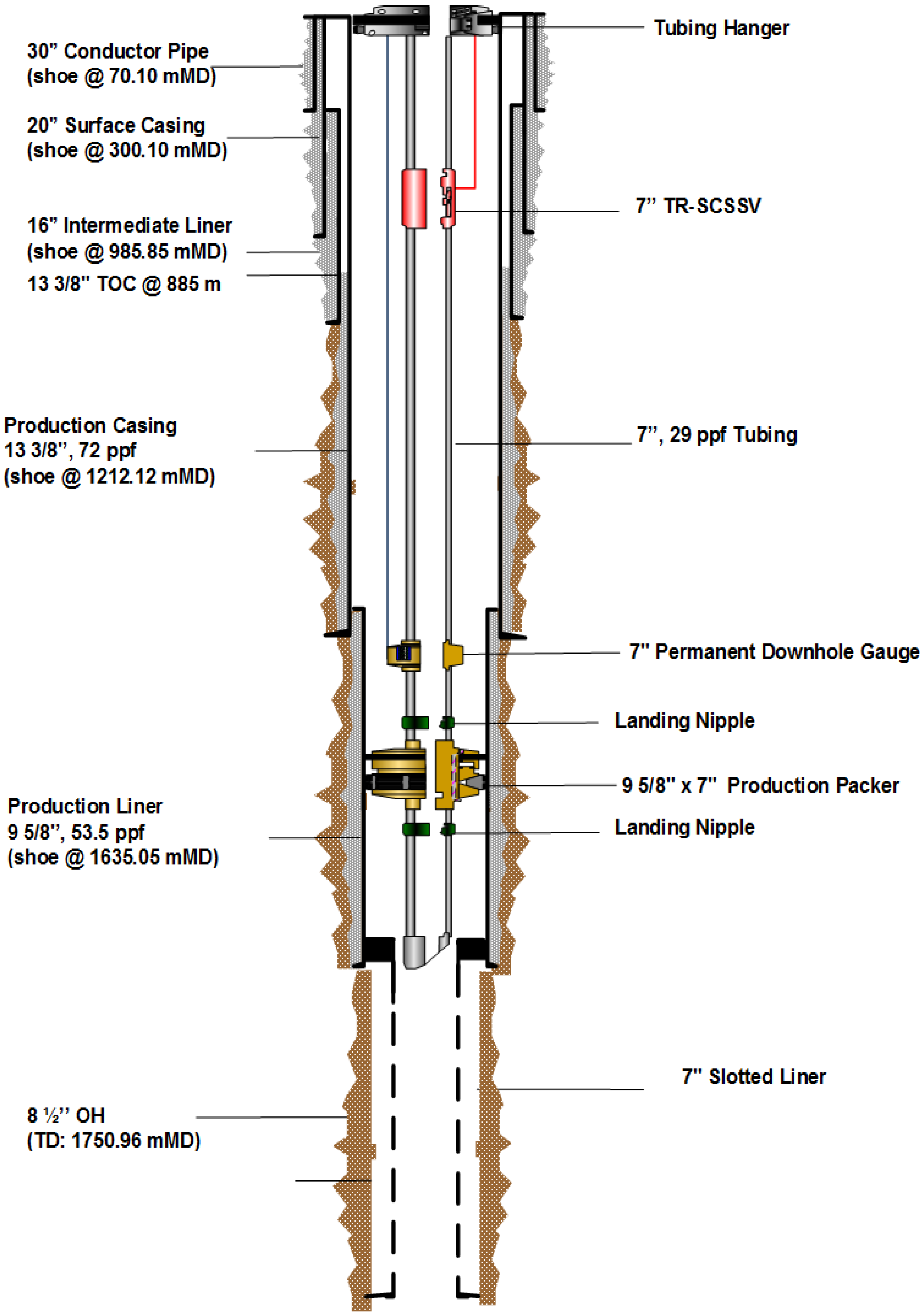


Figure 5.5: Preliminary Completion Scheme for Lower Bunter Wells

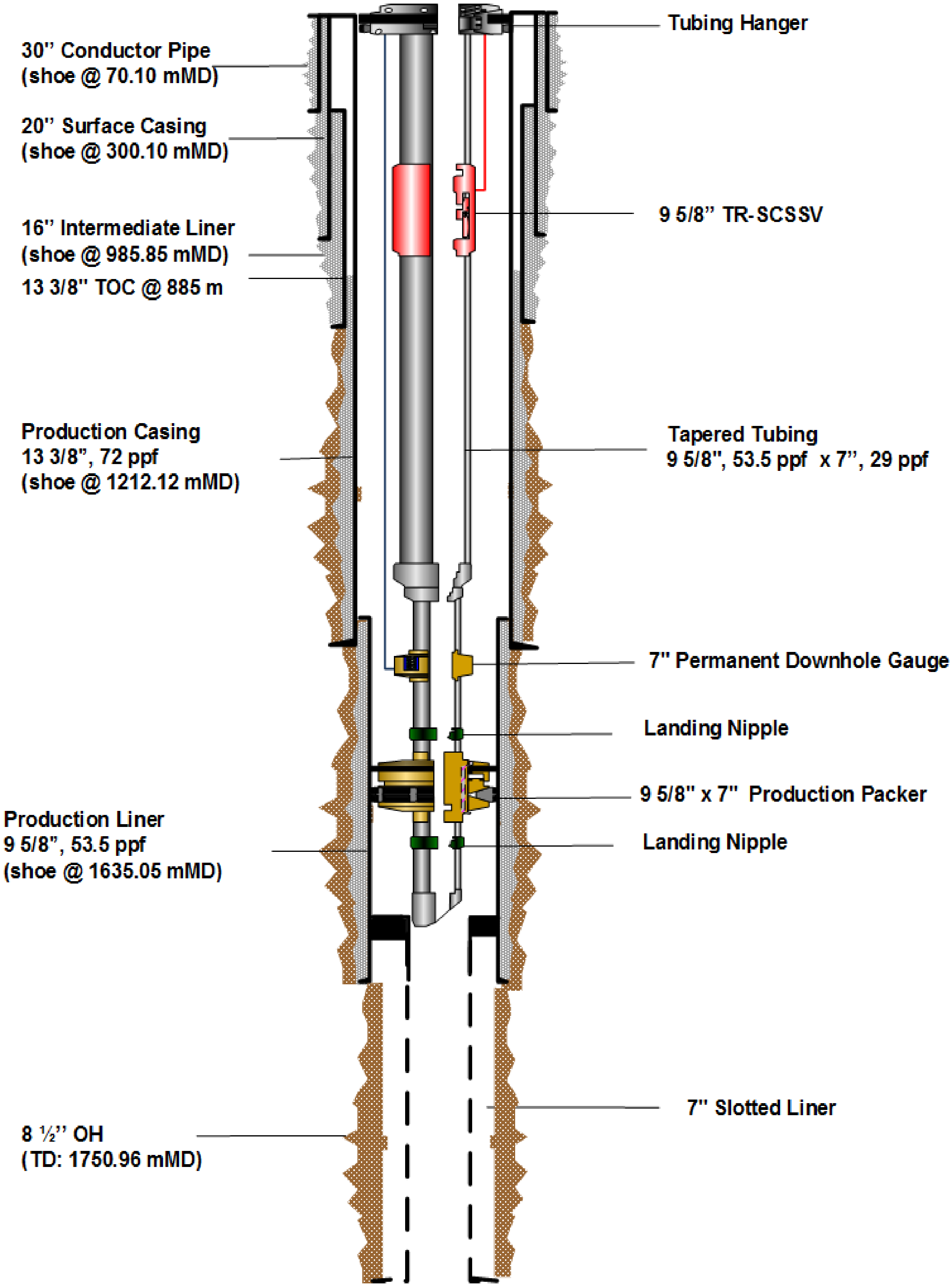


Figure 5.6: Preliminary Tapered Completion Scheme for Lower Bunter Wells

6. TIME AND COST

Time and cost estimates for drilling and completion activity have been evaluated with a probabilistic approach, applying Eni Risk Management evaluation as provided in the following documents:

- SVI.VMS.GL.0004.000 - Best Practice for Risk Management
- STAP-P-1-N-20913 - Project Risk Management for Drilling, Completion & Production Optimization Activities

All the results and activities summarized in this document are based on the workflow provided by the AWARE system (Advised Workflow for Accurate Risk Estimates) that is the Eni proprietary system and process dedicated to support drilling and completion engineers in the identification, evaluation and control of project risks. In addition, it allows to perform risk based time and cost evaluation maximizing the accuracy of projects AFE.

The cost and time probabilistic calculations are performed by using the Landmark Well cost software.

The input data are based on previous Eni's experience in similar project, taking into account the performances of the wells drilled in the area.

6.1 RISK REGISTER

The following picture summarizes all the drilling risks evaluated in AWARE with the risk matrix approach.

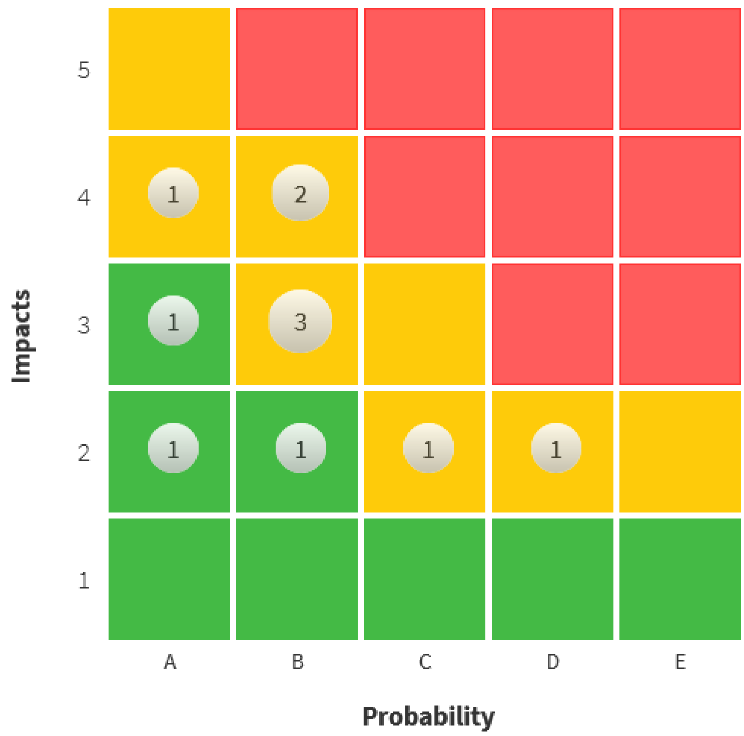


Table 6.1: Risk Register (post-mitigation evaluation)

All the reported risks are described in the following table. For each risk it is reported the pre-mitigation evaluation (first row) and the post-mitigation evaluation (second row).

RISK NAME / RISK DESCRIPTION	CATEGORY / AREA	PROBABILITY	IMPACT: PEOPLE	ENVIROINMENT	COST	QUALITY	SCHEDULE	BUSINESS LOSS	CORPORATE IMAGE	3RD PARTY	MANAGEABILITY	RISK LEVEL	RISK OWNER / CONTROL STRATEGY DESCRIPTION	STRATEGY	STATUS	DUE DATE
1. Borehole instability (loss hole, stuck pipes, casing running & cementing difficulties,.)	Well Condition	B	-	-	3	-	3	-	-	-	L	M	-	-	Planned	
	Lithology	B	-	-	3	-	3	-	-	-	L	M	-			
Differential sticking																
2. Integrity of cementing (TOC,...)	Drilling	C	-	-	4	-	4	-	-	-	M	H	-	-	Planned	
	Cementing	B	-	-	4	-	4	-	-	-	M	M	Cement slurries design optimization			
Casing not properly cemented, cement job not performed as per plan																
3. Lack of offset wells info	Organization	A	-	-	2	2	2	-	2	2	L	L	-	-	Planned	
	Engineering	A	-	-	2	2	2	-	2	2	L	L	-			
Assumption based on development wells drilled in 60-70s by other operators. Not updated data																
4. Logging / test operations duration (stuck,)	Drilling	C	-	-	3	-	3	-	-	-	M	M	-	-	Planned	
	Control / Tests	B	-	-	3	-	2	-	-	-	M	M	Possible log acquisition in TLC			
Logging / test operations duration (stuck,)																
5. Mud losses	Drilling	C	-	-	3	-	3	-	-	-	M	M	-	-	Planned	
	D&C Fluids	B	-	-	3	-	3	-	-	-	M	M	Mud weight formulation shall include carbonate/bridging agent			
Mud losses in the depleted reservoirs																

RISK NAME / RISK DESCRIPTION	CATEGORY / AREA	PROBABILITY	PEOPLE	ENVIROINMENT	COST	QUALITY	SCHEDULE	BUSINESS LOSS	CORPORATE IMAGE	3RD PARTY	MANAGEABILITY	RISK LEVEL	RISK OWNER	STRATEGY	STATUS	DUE DATE
6. Borehole instability (loss hole, stuck pipes, casing running & cementing difficulties,.)	Well Condition	C	-	-	2	2	-	-	-	-	L	M	-	-	Planned	
	Lithology	C	-	-	2	2	-	-	-	-	L	M	-			
WBS study never performed - Mud weight definition to be revised (very old data available)																
7. Availability of current drilling services contracts / uncertainty on market prices for new contracts or potential late changes	Organization	A	-	-	3	3	-	-	-	-	L	L	-	-	Planned	
	Contracts	A	-	-	3	3	-	-	-	-	L	L	-			
Specific tool availablity, back-up strategy																

RISK NAME	CATEGORY	PROBABILITY	IMPACT									RISK LEVEL	RISK OWNER	STRATEGY	STATUS	DUE DATE
	AREA		PEOPLE	ENVIROINMENT	COST	QUALITY	SCHEDULE	BUSINESS LOSS	CORPORATE IMAGE	3RD PARTY	MANAGEABILITY		CONTROL STRATEGY DESCRIPTION			
RISK DESCRIPTION																
8. Casing capability to reach target depth (casing stuck)	Drilling	B	-	-	4	-	4	-	-	-	L	M	-	-	Planned	
	Casing	B	-	-	4	-	4	-	-	-	L	M	-			
Casing capability to reach target depth due to differential sticking, most likely referred to 13-3/8" csg in wells reaching LB formation																
9. Reliability (NPT records, mechanical conditions, consistent in QA, HSE and maintenance)	Rig	B	-	-	2	2	2	-	-	-	L	L	-	-	Planned	
	Performance	B	-	-	2	2	2	-	-	-	L	L	-			
Rig and Downhole Equipment Reliability (NPT records, mechanical conditions, consistent in QA, HSE and maintenance)																
10. Availability of equipment and services contracts	Completion	D	-	-	4	5	-	-	-	-	M	H	-	-	Planned	
	Running completion	D	-	0	2	2	-	-	-	-	M	M	Design change to 7" completion or require to manufacturer additional qualification tests (impact on costs)			
Availability of equipment and services contracts for 9 5/8" TR SCSSV and 13 3/8" x 9 5/8" production packer																
11. Slotted liner RIH	Completion	A	-	-	4	-	4	-	-	-	L	M	-	-	Planned	
	Running completion	A	-	-	4	-	4	-	-	-	L	M	-			
Slotted liner capability to reach target depth due to differential sticking																

Table 6.2: Risk Register detail

6.2 SUMMARY OF THE OPERATIONAL SEQUENCE

The operative sequence considered for the time and cost estimation are reported in the following paragraphs.

The reference wells considered for the study are:

- Appraisal well
- Upper Bunter injection well
- Lower Bunter Injection well

6.2.1 APPRAISAL WELL

The well shall be equipped with Mud Line Suspension System (included in the time and cost estimation).

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Rig preparation and M/U DP stands
- Install CP
- Install diverter
- Drill 24" phase
- RIH and cement 20" casing
- Install BOP and test
- Drill 17 1/2" phase
- RIH and cement 16 liner
- Drill 14 3/4" phase
- RIH and cement 13 3/8" casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼" phase
- RIH and cement 9 5/8" liner
- Drill 8 ½" phase at TD
- Logs
- Run 7" slotted liner
- Temporary P&A

For future well re-entry

- Rig preparation and M/U DP stands
- Install BOP
- Well re-entry
- Upper completion installation
- Remove BOP
- Install Xtree

6.2.2 UPPER BUNTER INJECTION WELL

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Install CP
- Install diverter
- Drill 24" phase
- RIH and cement 20" casing
- Install BOP and test
- Drill 17 1/2" phase
- RIH and cement 13 3/8" casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼" phase
- Run 9 5/8" slotted liner
- Well cleaning operations and brine displacement
- RIH upper completion
- Install Xmas Tree
- Close well

6.2.3 LOWER BUNTER INJECTION WELL

The drilling activity time estimation for this well includes the following main operations (some operations may change due to BOP stack configuration):

- Install CP
- Install diverter
- Drill 24" phase
- RIH and cement 20" casing
- Install BOP and test
- Drill 17 1/2" phase
- RIH and cement 16 liner
- Drill 14 3/4" phase
- RIH and cement 13 3/8" casing
- Remove and Install new BOP stack. BOP test
- Drill 12 ¼" phase
- RIH and cement 9 5/8" liner
- Drill 8 ½" phase at TD
- Run 7" slotted liner
- Well cleaning operations and brine displacement
- RIH upper completion
- Install Xmas Tree
- Close well

6.3 TIME ESTIMATES

Time estimate has been enhanced by ID3 software tool.

ID3 (Integrated Drilling Data Discovery) is an analytical platform dedicated to evaluate the performance of the drilling and completion operations. The system is consolidating daily drilling reports and surface logging data in order to provide accurate and objective KPI. The application of ID3 on multiple wells allows to identify the Statistical Technical Limit and highlight the Invisible Lost Time.

An analysis was performed on the comparable wells currently stored in the database, drilled by jack up rigs in shallow water and with same sections and casings diameters: primarily Rowallan 22/19C-G (drilled in 2019, UK North Sea), plus 18 wells drilled in Italy.

The job focused on tripping speed and casing running speed (none of the above is comparable as per ROP).

- ***Tripping speed analysis:*** the reported values refer to the performance during Running In Hole and Pulling Out Of Hole of the drilling string for each section.

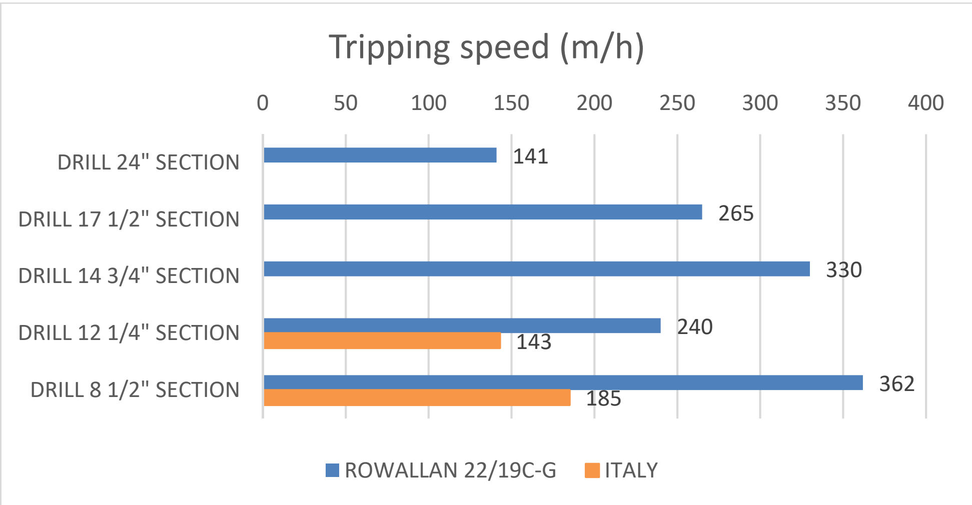


Table 6.3: Tripping speed

- ***Casing running speed analysis:*** the reported values refer to the performance during Make Up and Running In Hole of each casing or liner string (different values are considered for liner running with DP).

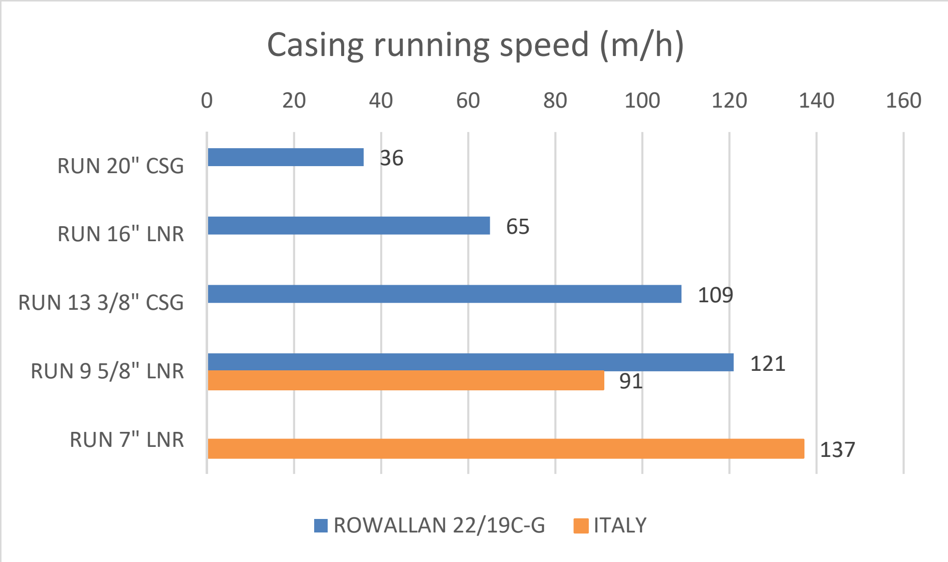


Table 6.4: Casing running speed

The following main input data have been used in WellCost model for drilling operations:

Phase	Tripping speed (m/h)	ROP (m/h)	Csg running speed (m/h)
24”	-	12-20	30 - 100
17 ½ ”	200-280	12-20	100 - 150
14 ¾ “	200-280	12-20	100 - 180
12 ¼ ”	200-280	12-20	100 - 180
8 ½”	200-280	12-20	100 - 180

Table 6.5: WellCost model main input

The above values are derived from considerations including both ID3 results and previous similar fields experience.

The time vs depth results obtained with the Well cost probabilistic model are reported in the next page.

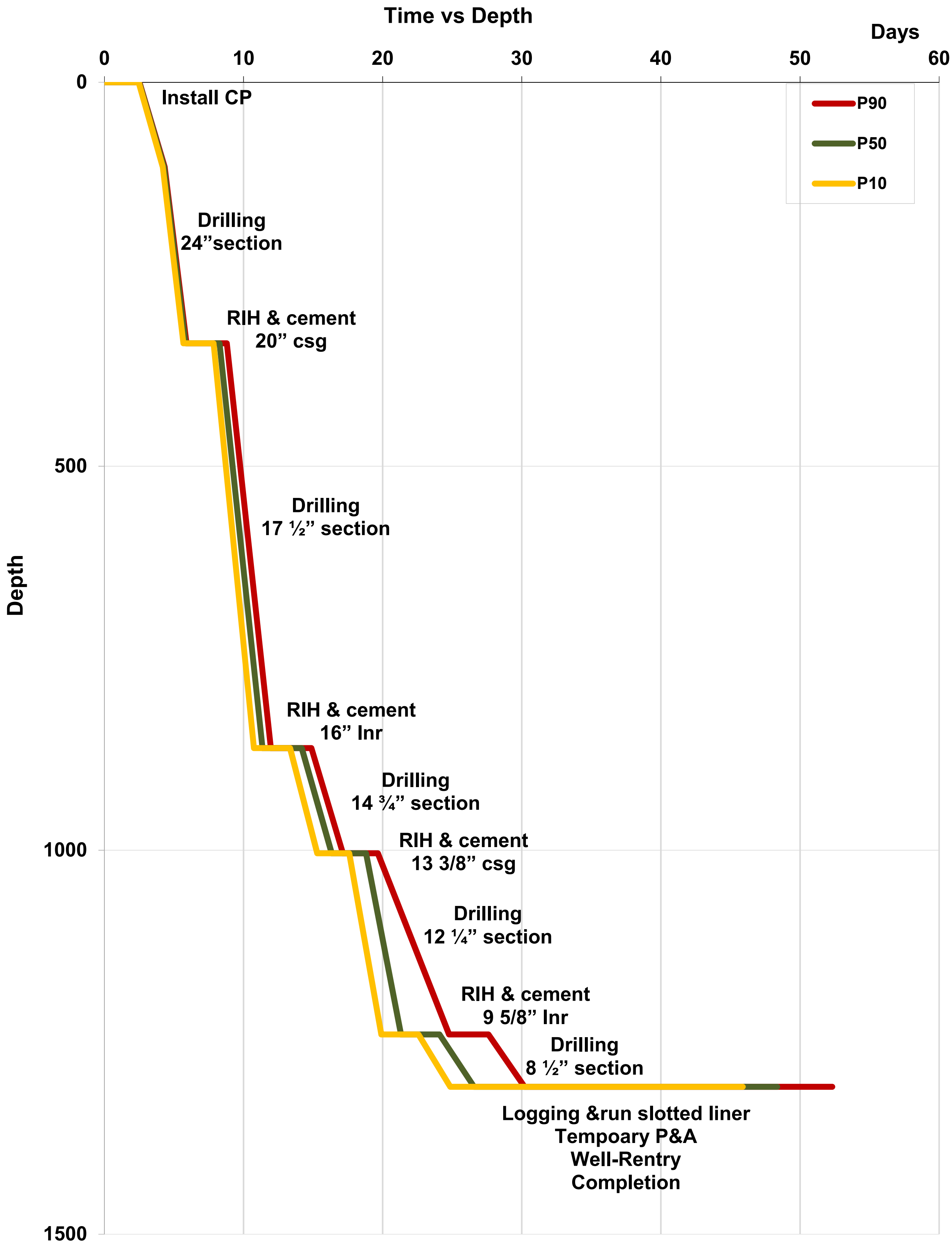


Figure 6.1: Appraisal well - Time vs depth

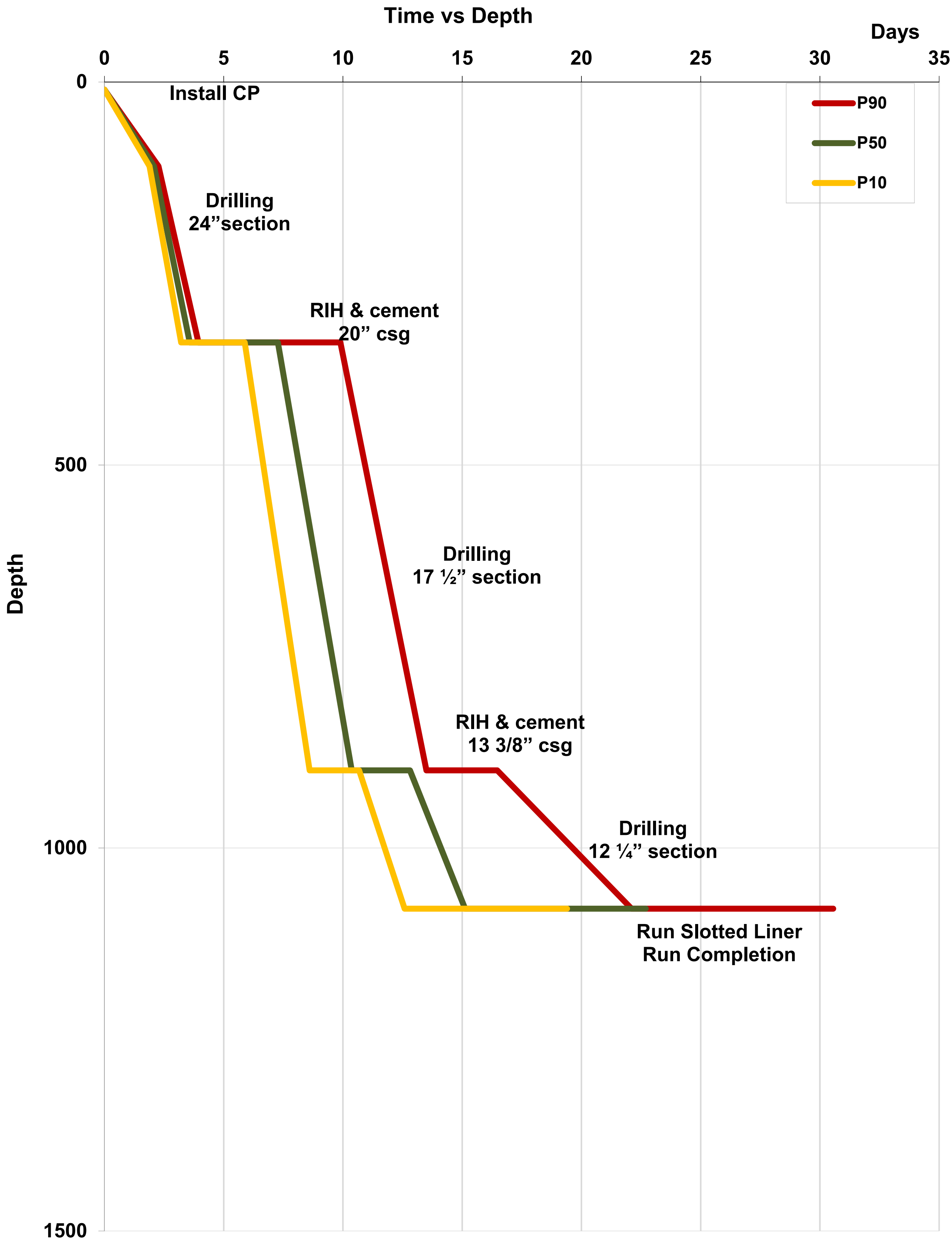


Figure 6.2: Upper Bunter Injection well - Time vs depth

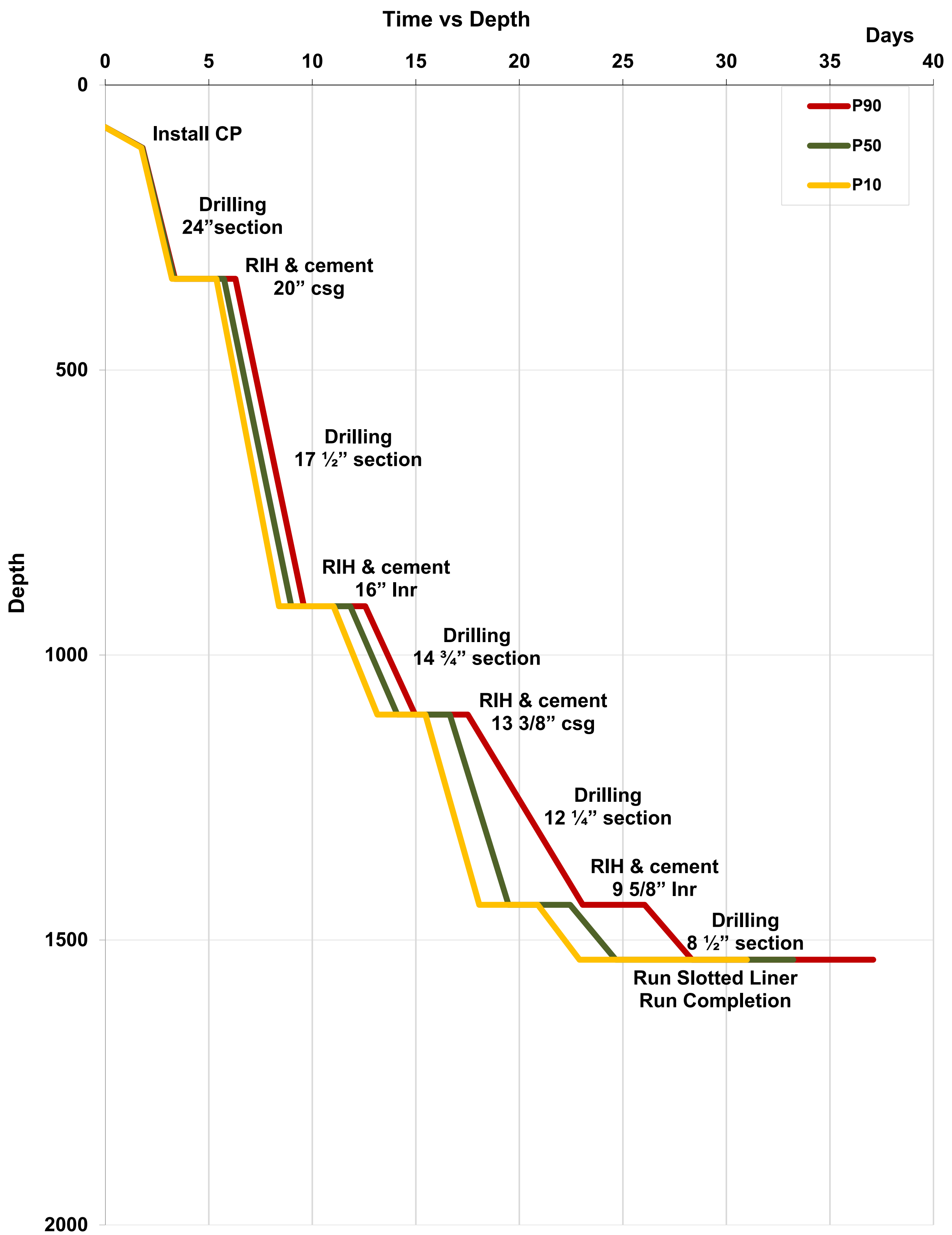


Figure 6.3: Lower Bunter Injection well - Time vs depth

The here below table reports all the results:

Well type	Drilling Time (Days)			Completion Time (Days)			Total Time (days)		
	P10	**P50**	**P90**	**P10**	**P50**	**P90**	**P10**	**P50**	**P90**
Appraisal well Drilling + Temp P&A	31,9	**33,8**	37,5						
Appraisal Well re-entry and completion				14,0	**14,6**	14,8	45,9	**48,4**	52,3
Upper Bunter well	12,6	**15,1**	22,1	6,8	**7,6**	8,5	19,4	**22,7**	30,6
Lower Bunter well	22,9	**24,7**	28,3	8.1	**8.6**	8.7	31,0	**33,2**	37,1

Table 6.6: Well duration

The mobilization (MOB) times are not included.

6.4 COST ESTIMATES

Based on the previously given time estimates from reference wells, cost estimates are provided.

The input costs are reported in GBP and US$. The change is fixed to 1GBP =1.23 US$

It is to be specified that:

- Daily Rig rate and services are based on the present contracts value of the wells ongoing in the UK offshore.

DAILY RATES	Min value [£/day] [US$/Day]	Average value [£/day] [US$/Day]	Max value [£/day] [US$/Day]
Rig Rate (including fuel)	98.000 120.540	115.000 141.450	132.000 162.360
Services*	60.000 73.800	70.000 86.100	81.000 99.630
Logistic	34.000 41.820	40.000 49.200	46.000 56.580
Total Rate	**192.000** **236.160**	**225.000** **276.750**	**259.000** **318.570**

Table 6.7: Daily rates

*Services daily rates include: cementing services, geological assistance, mud technical assistance, solid control, casing running, deviation and waste treatment.

- Materials costs (for each well):
  For casing materials, cost per meter values have been calculated in compliance with the existing Tenaris Framework Agreement. A lump sum for tubular materials is considered for each well typology (including also conductor, hangers and floating equipment).

TUBULAR COSTS			
Well Type	**Min value [£] [US$]**	**Average value [£] [US$]**	**Max value [£] [US$]**
Appraisal well	1.080.000 1.329.400	1.200.000 1.476.000	1.320.000 1.623.600
Upper Bunter well	900.000 1.107.000	1.000.000 1.230.000	1.100.000 1.353.000
Lower Bunter well	1.350.000 1.660.500	1.500.000 1.845.000	1.650.000 2.029.500

Table 6.8: Tubular costs

At least 150-200 m of CRA casing for production string section below packer is considered. For LB case, 13 3/8” casing is also considered as CRA in front of UB formation.
Contingency 11 3/4” material is included as risk cost (200.000 £/246.00USD)

- For appraisal well, the MLSS is assumed 81300 £/100.000US$.
- Well head: 250.000 £/307.500US$
- For cementing, mud and consumable 2 MM£/2.46 MMUS$.

- A lump sum of 1.500.000 £/1.845.000 US$ has been considered for logging operation of the Appraisal well, meanwhile 100.000 £/123.000 US$ is assumed for the other wells.
- The completion input data considered:
  - Completion equipment (Packer, nipples and SCSSV): 975.600 £/1.200.000 US$
  - The tubing (28Cr) is evaluated in 1.057.000£/1.300.000 US$ for all well configuration
  - The Xtree cost is assumed 406.500£/500.000 US$

All here above material cost could be evaluated in Well cost with a ±10% distribution ratio.

Tax cost are not included in the estimation.

Here below are reported the final results for cost estimate, performed using a probabilistic approach on reference well profiles.

Well type	**Drilling Cost (MM£)**			**Completion Cost (MM£)**			**Total Cost (MM£)**		
	P10	**P50**	**P90**	**P10**	**P50**	**P90**	**P10**	**P50**	**P90**
Appraisal well Drilling + Temp P&A	12,2	**12,9**	14,0						
Appraisal Well re-entry and completion				5,4	**5,6**	5,6	17,6	**18,4**	19,6
Upper Bunter well	6.4	**7.2**	9.2	3.5	**3.7**	3.7	10.0	**11.0**	12.8
Lower Bunter well	9,7	**10,3**	11,2	3,4	**3,6**	3,5	13,2	**13,8**	14,8

Table 6.9: Costs Evaluation

The mobilization (MOB) cost are not included.

6.5 FINAL SUMMARY FOR TIME & COST

The following table summarizes the overall time and cost with the proposed schedule:

- MOB
- Drilling Appraisal well + log + P&A
- MOB
- Re-entry Appraisal well and Completion
- Drilling and Completion Upper Bunter Injection well
- Drilling and Completion 3 Lower Bunter Injection well

Full Project Total Time and Cost	Total time (Days)			Total cost (MM£)		
	P10	**P50**	P90	P10	**P50**	P90
MOB	3	**3**	3	0,75	**0,75**	0,75
Drilling Appraisal +log+ P&A	31,9	**33,8**	37,5	12,2	**12,9**	14
MOB	3	**3**	3	0,75	**0,75**	0,75
Re-entry Appraisal and Completion	14	**14,6**	14,8	45,9	**48,4**	52,3
Drilling and Completion Upper Bunter Injection well	19,4	**22,7**	30,6	10	**11**	12,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Drilling and Completion Lower Bunter Injection well	31	**33,2**	37,1	13,2	**13,8**	14,8
Total	164,3	**176,7**	200,2	109,2	**115,2**	125

Table 6.10: Time & Cost Evaluation

Time and cost for MOB have been here included.

Global Projects Organization

Global Concept Development

Hewett Flow Assurance, Topside Facilities & Stuctures

Applicability:	Net Zero Teesside
Approver:	Ben Kek
Approval Date:	
Author:	Eni
Checker:	Philippe Legrand / A. Mooney
Security Classification:	General
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Third Party Revision	01

Revision history

Rev	Reason for Issue	Originator	Checker	Checker Date	Approver	Approval Date
B01	Issued for Use	Eni	P. Legrand / A. Mooney		B. Kek	

UK – Hewett

Hewett CCS
Flow Assurance, Topside Facilities and Structures Study

December 20th 2019

REVISION DESCRIPTION SHEET

STUDY TITLE

Hewett CCS Facilities & Flow Assurance Study

DISTRIBUTION LIST:

SUMMARY:

Hewett is an off-shore dry gas field whose production started in 1968 (Lower Bunter Sandstone reservoir) and 1973 (Upper Bunter Sandstone reservoir).

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The current document reports flow assurance analyses (CO_2 transport and injection), platform structures, technical topside layout and safety studies centered on such CO_2 transport and injection solution.

AUTHORS

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EniProgetti: Francesco Bertelli, Attilio Bertolotti, Costantino Zappino, Stefano Pelucchini, Stefano Sartirana

Date: 20/12/2029

A		Alberto Di Lullo (signature) Francesco Bertelli (signature)	Lodovico Paoli (signature)
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A		Alberto Di Lullo Francesco Bertelli	Lodovico Paoli
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TABLE OF CONTENT

1 INTRODUCTION

The scope of this document is to describe the outcome of the Concept Definition Study for a CO2 Injection Platform to be located in the Hewett Off-Shore dry gas field, in order to ensure the correct functionality of the equipment as well as the protection of the personnel and the environment.

All the equipment will be designed according with the criteria described in the next paragraphs in order to meet the following targets:

- gas processing
- injection of processed gas into Hewett Reservoir
- ensure all necessary utilities for a safe and complete operation.

1.1 General information

In order to process and inject gas into the Hewett Reservoir a four leg unmanned platform, four wells single completion type will be installed and one slot spare.

The Hewett Platform will be located inside Hewett Field, a depleted gas off-shore field located in the United Kingdom's Southern North Sea (30 m water depth). It is located in Block 48/28, 48/29, 48/30, 52/4a, 52/5a.

Within Hewett field, CO2 storage capacity has been estimated corresponding to 206 MMt (Lower Bunter) and 120 MMt (Upper Bunter).

The Hewett Injection Platform geographical coordinates at platform location are the following:

Platform	Longitude	Latitude
Hewett Injection Platform (water depth: 30m)	1.584389 deg EAST (TBC)	53.112556 deg NORTH (TBC)

The platform will be designed to handle CO2 coming from by the Teesside Bay industries (East UK coast) through a specific pipeline in order to be injected inside Hewett depleted field.
More in detail Hewett platform is composed by:

- Four legs platform in 30m (TBC) water depth connected to the ground by foundation piles;
- wellhead module to perform wells drilling;

- 6 Single Completion wells;
- deck including process and utilities plants, deck structure will be designed in order to minimize hook-up works.

The Hewett CO_2 Injection platform facilities shall be designed to meet the following targets:

- CO_2 processing;
- supply of all necessary utilities for a safe and complete operation.

A monoethylenglycol (MEG) injection system is foreseen to prevent hydrate formation in the gas stream lines.

MEG injection will be used, where necessary, for occasional operations (start up, workover etc).
Fixed MEG injection point has been envisaged before each wellhead.

Indirect oil-bath gas heater is used to guarantee optimal CO2 injection temperature during normal operation. The oil-bath heater will be equipped with an electrical heater.

The normally unmanned platform is linked with onshore facilities by mean of a radio communication system and is designed to perform safe and complete operations also during the manned period (only for maintenance purpose).

1.2 Design service life

Design life is 30 years of continuous operation (365 days per year).

1.3 Attending philosophy

The Hewett CO2 Injection platform shall be normally unmanned; for this reason, a self-regulating configuration shall be foreseen through the installation of high reliability and low maintenance equipment and apparatus.

It will be a self-regulating platform (by means of a RTU system and hydro/pneumatic WHCP), monitored by redundant radio link through Telecom System; only routine maintenance activities will be performed on the platform.

Electrical power shall be ensured by mean of dedicated electrical cable coming from onshore. The dedicated electrical supply system shall be designed to cover the 100% of the electrical loads and at the same time to charge the battery system (unit 720).

Production or maintenance personnel shall perform only routine maintenance activities periodically. During these activities the platform is temporary manned and the electrical power, in case of emergency/shutdown shall be ensured by mean of service diesel generator (unit 480) located on the platform.

During manned period, the supply vessel (or helicopter) shall be continuously present at the boat landing (helideck).

1.4 Abbreviations

AC	Alternating Current
ACO	Automatic Change Over
ASD	Abandonment Platform push button
BDV	Blowdown Valve
CCTV	Closed Circuit TV
CPU	Central Processing Unit
CR	Control Room
DC	Direct Current
DI	Digital Input
DO	Digital Output
DPDT	Double Pole Double Throw
SDG	Stand-by Diesel Generator
ESD	Emergency Shut Down system
EWS	Engineering Work Station
FAT	Factory Acceptance Test
F&G	Fire and Gas system
FO	Flow Orifice
HCIP	Hewett CO2 Injection Platform
HMI	Human Machine Interface
HP VENT	High Pressure vent
HW	Hardware
IP	Mechanical protection
LAN	Local Area Network
LCP	Local Control Panel
LED	Light Emitting Diode
LP VENT	Low Pressure vent
LSS	Load Shedding System
LV	Low Voltage
MSP	Manual Shut-down Panel
MFA	Manual Fire Alarm push button
MOB	Man Overboard push button
OCS	Operator Control Station
PA/GA	Public Address General Alarm System
P&ID	Piping and Instrumentation Diagram
PC	Personal Computer
PCS	Process Control System
PLC	Programmable Logic Controller
PSD	Process Shutdown
PSV	Pressure Safety Valve
RTD	Resistance Temperature Detector
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition System
SDV	Shut-Down Valves
SLD	Single Line Diagram
SOE	Sequence Of Event System
SPDT	Single Pole Double Throw
SSV	Surface Safety Valve
SSSV	Sub Surface Safety Valve
VDU	Video Display Unit
WHCP	Wellhead Control Panel

2 NORMS, CODES / STANDARD, RULES

This project shall be developed in compliance with all locally applicable laws and regulations, with emphasis on safety and environment, and responsible standards in the absence of regulations.

The platform shall be designed, fabricated, inspected and certified in conformity with the Codes and Eni Standards listed in "Part D of Appendix D": Section 7 – List of Company's Standard and Specifications.

In case of conflict arising from the multiplicity of applicable documents, the following priority applies:

- UK National, Regional and Local Laws
- National and International Codes, Standards, Rules, Regulations
- Project Technical Documents with Company's approval
- Company's General Specifications and Standards

Should any conflict arise between the requirements of applicable National Legislation as well as applicable National and International Codes, Standards, Rules and Regulations, then the most stringent requirement applies.

3 REFERENCE DOCUMENTS

3.1 Documents supply by Company

[1] UK and International Laws, rules and regulations

[2] List of Company's Standard and Specifications

[3] Contract HSE Requirements for Abroad Activities

[4] Assessment of Meteo-Marine Design Parameters

3.2 Attachments

[1] http://www.hse.gov.uk/carboncapture/assets/docs/major-hazard-potential-carbon-dioxide.pdf

[2] COSHER RuptureTest1_Report13_Aug13

[3] PLOT PLAN +16500.pdf
[4] PLOT PLAN +22500.pdf
[5] PLOT PLAN +29500.pdf
[6] PLOT PLAN +35500.pdf
[7] PLOT PLAN +41500 plus Hldk.pdf

[8] Olga 2018 sample input file for Teesside-Hewett transportation
[9] Olga 2018 sample input file for Humberside-Hewett transportation
[10] Olga 2018 sample input file for Bacton-Hewett transportation

4 DESIGN CRITERIA

4.1 Language and System of Units

The official language of the Project is English.
The units of measurement to be used within the Project will be as per the following table.
Concerning the system of units, in principle the SI measurement system will be applied.
All derived units (multiple, sub-multiple or combination) may also be used.

However the following reference conditions and specific selections will be used.

Reference	Temperature °C	Pressure bara
Standard Conditions	15,56	1,013
Normal Conditions	0	1,013

Quantity	Name of Unit	Symbol	Notes
Piping standardisation	ASME		
Piping nominal diameter	inches		
Piping thickness	schedule		
Insulation thickness	millimiters	mm	
Length	meters	m	
" "	millimiters	mm	
Temperature	degree Celsius	° C	
" "	Kelvin	K	
Pressure	Bar	bar	
" "	Pound square inch	Psi	
Capacity	cubic metres	m^3	
Current	ampere	A	
Liquid flowrate (volume)	litres per hour	l/h	
" " (volume)	cubic metres per hour	m^3/h	
" " (volume)	Standard cubic metres per hour	S m^3/h	@15.5 ° C
" " (mass)	kilograms per hour	kg/h	
Gas and vapour flowrate (vol.)	Standard cubic metres per hour	S m^3/h	@ 15.5 ° C and 1.013 bar
Surfaces	square metres	m^2	
" "	square centimetres	cm^2	
" "	square millimetres	mm^2	
Mass	kilogram	kg	
Density	Kilograms per cubic metre	kg/m^3	
" "	API Gravity	° API	
" "	Specific Gravity	Sp.Gr.	
Energy	Kilojoule Kilowatt/hour	kj kWh	
Power	kilowatt	kW	
Plane angle	degree	deg	
" "	minute	'	

" "	second	"	
Time	second	s	
“ “	minute	min	
" "	hour	h	
Frequency	hertz	Hz	
Speed – linear	metres per second	m/s	
Speed - angular	degrees per second	deg/s	
Speed - rotating	revolutions per minute	rpm	
Amount of substance	kilogram mole	kmol	
Molecular weight	kilogram per kilogram mole	kg/kmol	
Concentration, mass	parts per million, mass	ppm w	
Concentration, volume	parts per million, volume	ppm v	
Force	Newton	N	
Stress	Newton per square millimetre	N/mm^2	
Viscosity - dynamic	centi-Poise	cP	
Viscosity - kinematic	centi-Stocks	cSt	
Voltage	volts	V	
Surface tension	dyne per centimetre	dyne/cm	
Heat	kilocalorie	kcal	
Heat flow rate	kilocalories per hour	kcal/h	
Specific heat	kilocalories per kilogram degree Celsius	kcal/kg °C	
Thermal conductivity	kilocalories per metre degree C hour	kcal/h m °C	
Heat transfer coefficient	kilocalories per square metre degree C hour	kcal/h m^2 °C	
Enthalpy/Entropy	kilocalorie per kilogram / kilocalorie per kilogram degree C	kcal/kg/ kcal/kg °C	
Electric power	Volt Ampère / Watt	VA / W	
Radiation intensity	Watt per square metre	W/m^2	
Electric current	Ampère	A	
Electric potential	Volt	V	
Illuminance	lux	lx	
Resistence	Ohm	[illegible]	
Resistivity	Ohm metre	[illegible]m	
Noise	decibel	dB(a)	

4.2 Design Pressure / Design Temperature

4.2.1 Equipment and Lines

Design pressure for equipment and lines shall be defined according to the following process rules:

Max. Operating Pressure MOP	Design Pressure
Atmospheric Pressure	Max. Hydrostatic pressure +35000/-250 mm H_2O
Vacuum	Full vacuum/+3.5 barg
0 < MOP < 1.5 barg	3.5 barg (except Open Drain)
1.5 < MOP ≤ 18 barg	MOP +2 barg
18 < MOP ≤ 40 barg	MOP + 10% min.
40 < MOP ≤ 80 barg	MOP + 4 barg
MOP > 80 barg	MOP + 5% min.

Design Pressure for equipment shall be the Maximum pipeline pressure.

Design pressure injection header (*) shall be:
- Upstream pressure control valve: 150 barg
- Downstream pressure control valve: 70 barg

Vent and Purge Burner Design Pressure shall be 3.5 barg; selected thickness shall resist for an internal mechanical pressure (internal explosion), of 8 barg.

Design temperature for equipment and lines shall be defined according to the following process rules:

Max. Operating Temperature MOT	Design Temperature (Min/Max)
MOT < -29°C	Minimum calculated temperature and 60°C
-29 ≤ MOT < 313°C	Minimum calculated temperature/MOT+30°C or 60°C (whichever is greater)
MOT ≥ 313°C	Shall be specified according to selected material and process requirements

The minimum design temperature will be based on depressurization/blowdown calculations.

4.2.2 Equipment downstream of pumps

For equipment downstream of pumps the following design pressure shall be applied:

A. For centrifugal type the design pressure shall be as follows:

Design pressure shall be equal (or greater) than design pressure of centrifugal pump.

B. For volumetric type the design pressure shall be as follow:

$P_d = 1.15\ P_{max\ discharge}$, barg or

$P_d = P_{max\ discharge} + 1.8$, barg whichever is greater

Downstream equipment shall have adequate protection unless pump's driver can't supply sufficient power to overcome pump design pressure.

4.3 Nozzles diameter

For vertical separators nozzle's diameter calculation, the following criteria shall be applied:

	ρv^2 Criteria, (kg/m^3 (m/sec)^2)
Inlet Separator Nozzles	
- nozzle with no fittings	1500
- nozzle with simple fittings to aid separation	3750
Gas Outlet Separator Nozzles	3750
- Inlet/Outlet Heat Exchanger nozzle	6000

4.4 Piping design

4.4.1 Introduction

All platform piping shall be designed in accordance to ASME B31.3 Process Piping. However, the Pig Trap and pipe systems to the Riser for both platforms will be designed as primary piping in accordance with pipeline code ISO 13623.

4.4.2 Current Piping design parameters

	ρv^2 Criteria, (kg/m^3 (m/sec)^2)
Gas piping design (without limitations on allowed pressure drop)	$\rho V^2 < 15000$;
Gas piping design (with limitations on allowed pressure drop)	$\rho V^2 < 6500$;
Blow-down header piping design	V < 0.5 Mach
Blow-down sub-header piping design	V < 0.5 Mach
Blow-down discharge line	V < 0.7 Mach
Blow-down stack design	Pressure drop < 0.5bar; V < 0.7 Mach
PSV discharge piping design	DP<10% set pressure @ PSV rated Capacity V < 0.7 Mach
PSV inlet piping design	DP<3% set pressure @ PSV rated Capacity

4.5 Overdesign

The following overdesign shall be considered:

- Gas system 20% on flowrate
- Liquid/Water system 10 % on flowrate

4.6 Wellheads movements

A possible vertical movement of +/- (TBD) mm shall be considered for the wellheads, due to pressure effects or soil settlement. Piping flexibility will be guaranteed accordingly.

5 BASIC DATA

5.1 Location

The well site is located offshore of Bacton premises.

The preliminary well site coordinates are displayed in the following table.

LOCATION	CENTRAL WELL COORDINATES			WATER DEPTH
Hewett	Type	East	North	30m
	Geographical	TBC	TBC	
	Metrical	TBC	TBC	

5.2 Well Head Data

The platform design will be based on the following basic data:

Drilling configuration	6 Well Single completion Configuration Wellhead Cameron Dual X-Mas Tree API 5000

5.3 Reservoir Data

According to reservoir study, the platform design shall be based on the following data:

Description	
Maximum static wellhead pressure (barg)	130
Operating well head flowing temperature (°C)	0-60

Platform total maximum gas production: 16500 ton/d.

5.4 Fluid Composition

The following fluid compositions have been used for the design of the platform facilities:

Component	Mole %(dry basis)
CO_2	96-100
N_2	TBD
H_2	<1.0
NO_x	TBD
SOx	TBD
CO	TBD
Ar	TBD
H_2O	<100 ppm (TBC)
H_2S	0

5.5 Injection Profile

The following injection profiles have been used for the design of the Hewett Platform facilities:

Sealine design pressure: 150 barg.
Fluid flowrate: 16500 ton/d

5.6 Live Loads

The following permissible loads will be adopted for floors design:

DECK AREA	LIVE LOAD FOR FLOOR STRUCTURE CHECK [KN/m^2]	REDUCTION FACTORS FOR JACKET/PILE CHECK
Lay-down area	20	0.5
Upper Deck Drilling Area (if any – for local check only)	20	n.a.
Upper Deck Free Area	9.0	0.5
Mezzanine Deck Free Area	9.0	0.5
Cellar Deck Free Area	9.0	0.5
Stairs, Walk ways	4.5	0.5

6 METEO MARINE DATA

6.1 Water Depth

The water depth at Hewett site is 30m (TBC).

6.2 Seawater Characteristic

As reported in [4], the minimum, mean and maximum values of water temperature T, salinity S and density ρ are reported below for different water depths:

	TEMPERATURE T [°C]			SALINITY S [%]			DENSITY ρ [kg/m^3]		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
SURFACE	0	10	23						
BOTTOM	0	9.8	17						

Table 1 – Water Temperature, Salinity and Density

The mean density of sea water is 1028 kg/m3.

6.3 Air Temperature

The behaviour of the minimum, mean and maximum values of air temperature vs month is supplied in the following table:

AIR TEMP (°C)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
UP TO -8.0	2											1	3
-7.9 TO -7.0	1												1
-6.9 TO -6.0	1												1
-5.9 TO -5.0	2	1											3
-4.9 TO -4.0	1	3											4
-3.9 TO -3.0	5	13											18
-2.9 TO -2.0	21	34	1									5	61
-1.9 TO -1.0	40	51	1									28	120
-0.9 TO 0.0	63	85	20								1	35	204
0.1 TO 1.0	115	194	67	8								66	450
1.1 TO 2.0	209	218	133	14							12	145	731
2.1 TO 3.0	237	326	200	17							29	178	987
3.1 TO 4.0	277	400	317	58						1	48	197	1298
4.1 TO 5.0	416	530	479	160	3						79	315	1982
5.1 TO 6.0	626	649	699	353	15					9	130	391	2872
6.1 TO 7.0	799	692	840	574	45	1				21	228	506	3706
7.1 TO 8.0	790	523	850	749	206	1				47	326	560	4052
8.1 TO 9.0	488	333	559	732	394	18			1	161	483	657	3826
9.1 TO 10.0	245	151	247	597	668	64	1		1	333	695	484	3486
10.1 TO 11.0	137	55	88	395	799	179	3	2	8	417	810	307	3200
11.1 TO 12.0	36	9	34	219	792	468	19	6	55	480	554	181	2853
12.1 TO 13.0	7	3	8	76	570	683	102	22	178	584	404	48	2685
13.1 TO 14.0			7	42	392	772	322	92	373	631	171	16	2818
14.1 TO 15.0				26	193	798	699	302	558	625	67	3	3271
15.1 TO 16.0			1	5	92	539	937	620	771	533	19	1	3518
16.1 TO 17.0				3	45	297	831	913	828	267	14		3198
17.1 TO 18.0				1	22	146	514	982	604	104			2373
18.1 TO 19.0				1	4	64	400	679	394	20			1562
19.1 TO 20.0					1	45	210	362	177	3			798
20.1 TO 21.0						1	96	109	42				248
21.1 TO 22.0						2	54	70	18				144
22.1 TO 23.0						1	27	30	2				60
23.1 TO 24.0							6	2					8
24.1 TO 25.0						1	7	1					9
25.1 TO 26.0							2						2
26.1 TO 27.0							1						1
27.1 TO 28.0													
28.1 TO 29.0													
29.1 OR MORE													
TOTAL	4518	4270	4551	4030	4241	4080	4232	4192	4010	4236	4070	4124	50553

The peak values to be considered are:

Tmax: +27°C
Tmin: -8°C for all equipment

Design values for piping/equipment are:

Tmax: +40°C
Tmin: -10°C

6.4 Service Temperature

The structural elements will be design with service temperature as below:

- Jacket → +0.0°
- Deck → -10.0°

6.5 Tides

The sea level variation is correlated to the astronomical tide and storm surge elevation.

Astronomic tidal ranges are summarized in the following table.

TIDAL LEVELS [m]	*The following parameters do not vary with return period*
HAT	3.19
MHWS	2.91
MHWN	2.29
MSL	1.65
MLWN	0.98
MLWS	0.29
LAT	0.00

Surge contribution due to storms is reported in the following table for different return periods along with still water level and extreme water levels (i.e. wave crest height).

LEVELS [m]	1-Year	10-Year	50-Year	100-Year	1K-Year	10K-Year
Positive Surge Levels (MSL)	1.47	1.94	2.26	2.40	2.86	3.33
Negative Surge Levels (MSL)	-1.30	-1.69	-1.96	-2.09	-2.48	-2.88
Still Water Level (LAT)	4.39	4.62	4.78	4.85	5.08	5.32
Extreme Water Level (LAT)	9.4	11.3	12.5	13.0	14.7	15.4

6.6 Waves

Extreme Waves

The wave data given in Ref.[4] will be used for platform design. A summary of the main parameters is reported here below.

Extreme waves directional characteristics for different return periods are summarized in the tables below. All directions have to be intended as wave coming from. They are relevant to true geographical North.

Return Period	Hs	Tz			Tp			Tass			Hmax	Crest Height
		(lower)	(central)	(upper)	(lower)	(central)	(upper)	(lower)	(central)	(upper)		
	(m)	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(m)*	*(m)*
1-year												
N	5.3	6.8	7.4	8.5	8.6	10.0	13.0	7.8	9.5	11.1	9.7	6.2
NE	5.3	6.8	7.4	8.5	8.6	10.0	13.0	7.8	9.5	11.1	9.6	6.1
E	5.0	6.6	7.2	8.2	8.4	9.7	12.7	7.6	9.2	10.8	9.1	5.8
SE	4.2	6.0	6.6	7.6	7.7	8.9	11.6	7.0	8.4	9.9	7.6	4.8
S	4.3	6.1	6.7	7.6	7.8	9.0	11.8	7.1	8.6	10.1	7.8	4.9
SW	3.7	5.7	6.2	7.1	7.2	8.4	10.9	6.6	7.9	9.3	6.8	4.3
W	4.6	6.3	6.9	7.9	8.0	9.3	12.1	7.3	8.8	10.4	8.3	5.3
NW	5.3	6.8	7.4	8.5	8.6	10.0	13.0	7.8	9.5	11.1	9.7	6.2
10-years												
N	6.6	7.6	8.3	9.5	9.6	11.2	14.6	8.8	10.6	12.5	11.9	7.6
NE	6.5	7.5	8.2	9.4	9.5	11.1	14.4	8.7	10.5	12.3	11.7	7.5
E	6.2	7.3	8.0	9.2	9.3	10.8	14.1	8.5	10.2	12.0	11.2	7.1
SE	5.1	6.6	7.3	8.3	8.5	9.9	12.8	7.7	9.3	11.0	9.3	5.9
S	5.2	6.7	7.3	8.4	8.5	9.9	12.8	7.7	9.3	11.0	9.5	6.1
SW	4.6	6.3	6.9	7.9	8.0	9.3	12.1	7.3	8.8	10.4	8.3	5.3
W	5.6	7.0	7.6	8.7	8.8	10.3	13.4	8.1	9.7	11.4	10.2	6.5
NW	6.6	7.6	8.3	9.5	9.6	11.2	14.6	8.8	10.6	12.5	11.9	7.6
50-years												
N	7.4	8.0	8.8	10.0	10.2	11.9	15.5	9.3	11.3	13.2	13.4	8.5
NE	7.2	7.9	8.6	9.9	10.0	11.6	15.1	9.1	11.0	12.9	13.2	8.4
E	6.9	7.7	8.5	9.7	9.9	11.5	15.0	9.0	10.9	12.8	12.6	8.0
SE	5.7	7.0	7.7	8.8	8.9	10.4	13.6	8.2	9.9	11.6	10.4	6.6
S	5.2	6.7	7.3	8.4	8.5	9.9	12.8	7.7	9.3	11.0	9.5	6.1
SW	4.6	6.3	6.9	7.9	8.0	9.3	12.1	7.3	8.8	10.4	8.3	5.3
W	5.6	7.0	7.6	8.7	8.8	10.3	13.4	8.1	9.7	11.4	10.2	6.5
NW	7.4	8.0	8.8	10.0	10.2	11.9	15.5	9.3	11.3	13.2	13.4	8.5

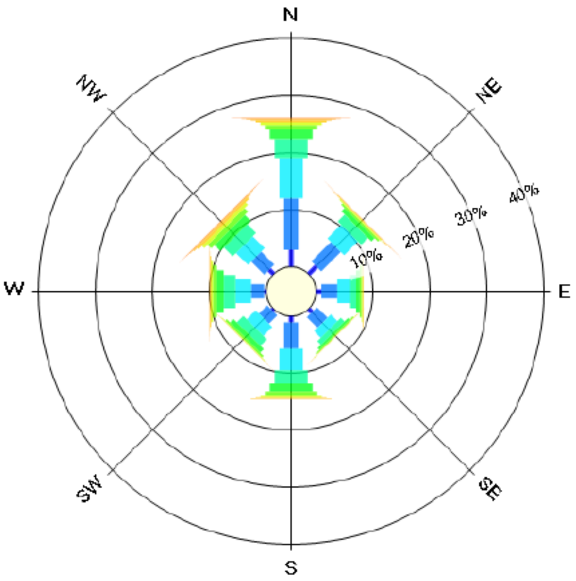
Return Period	Hs	Tz			Tp			Tass			Hmax	Crest Height
		(lower)	(central)	(upper)	(lower)	(central)	(upper)	(lower)	(central)	(upper)		
	(m)	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(s)*	*(m)*	*(m)*
100-years												
N	7.7	8.2	8.9	10.2	10.3	12.0	15.7	9.4	11.4	13.4	14.0	8.9
NE	7.6	8.1	8.9	10.2	10.3	12.0	15.7	9.4	11.4	13.4	13.8	8.8
E	7.2	7.9	8.6	9.9	10.0	11.6	15.1	9.1	11.0	12.9	13.1	8.3
SE	6.0	7.2	7.9	9.0	9.2	10.7	13.9	8.4	10.1	11.9	10.9	6.9
S	5.5	6.9	7.6	8.6	8.8	10.3	13.4	8.1	9.7	11.4	10.0	6.3
SW	4.7	6.4	7.0	8.0	8.1	9.5	12.3	7.4	9.0	10.5	8.5	5.4
W	5.6	7.0	7.6	8.7	8.8	10.3	13.4	8.1	9.7	11.4	10.2	6.5
NW	7.7	8.2	8.9	10.2	10.3	12.0	15.7	9.4	11.4	13.4	14.0	8.9
1,000-years												
N	8.8	8.7	9.6	10.9	11.1	13.0	16.9	10.2	12.3	14.4	15.9	10.1
NE	8.6	8.6	9.4	10.8	10.9	12.7	16.5	10.0	12.0	14.1	15.7	10.0
E	8.2	8.4	9.2	10.6	10.7	12.4	16.2	9.8	11.8	13.8	14.9	9.5
SE	6.0	7.2	7.9	9.0	9.2	10.7	13.9	8.4	10.1	11.9	10.9	6.9
S	5.7	7.0	7.7	8.8	8.9	10.4	13.6	8.2	9.9	11.6	10.4	6.6
SW	4.7	6.4	7.0	8.0	8.1	9.5	12.3	7.4	9.0	10.5	8.5	5.4
W	5.6	7.0	7.6	8.7	8.8	10.3	13.4	8.1	9.7	11.4	10.2	6.5
NW	8.5	8.6	9.4	10.7	10.9	12.7	16.5	10.0	12.0	14.1	15.5	9.8
10,000-years												
N	9.8	9.2	10.1	11.5	11.7	13.6	17.8	10.7	12.9	15.2	17.8	11.3
NE	9.6	9.1	10.0	11.4	11.6	13.5	17.6	10.6	12.8	15.0	17.5	11.1
E	9.2	8.9	9.8	11.2	11.4	13.2	17.2	10.4	12.5	14.7	16.7	10.6
SE	6.6	7.6	8.3	9.5	9.6	11.2	14.6	8.8	10.6	12.5	12.0	7.6
S	6.4	7.4	8.1	9.3	9.4	10.9	14.3	8.6	10.4	12.2	11.6	7.4
SW	5.1	6.6	7.3	8.3	8.5	9.9	12.8	7.7	9.3	11.0	9.3	5.9
W	6.2	7.3	8.0	9.2	9.3	10.8	14.1	8.5	10.2	12.0	11.2	7.1
NW	9.5	9.1	9.9	11.4	11.5	13.4	17.4	10.5	12.7	14.9	17.3	11.0

Number of Seastates

The probability of wave occurrence per incoming direction is summarized in the follow in table.

Significant Wave Height (m)		Wave Direction - FROM (deg)								
Lower	Upper	N	NE	E	SE	S	SW	W	NW	Sum
0	0.5	4748	3041	1579	1275	1752	562	698	1730	15385
0.5	1	14576	7839	4509	4250	7457	3291	3580	5256	50758
1	1.5	11538	5513	3556	2691	6157	3622	4445	4778	42300
1.5	2	5406	2735	1772	1451	3750	2587	3393	3541	24635
2	2.5	2621	1289	1021	681	2193	1379	2024	2345	13553
2.5	3	1330	590	565	379	1199	630	1055	1426	7174
3	3.5	769	362	299	134	640	206	526	899	3835
3.5	4	495	190	160	56	222	62	252	592	2029
4	4.5	308	99	57	27	124	21	102	310	1048
4.5	5	201	43	14	8	34	9	37	176	522
5	5.5	114	21	1	0	6	1	19	91	253
5.5	6	64	13	2	0	2	0	9	33	123
6	6.5	31	4	0	0	0	0	1	12	48
6.5	7	15	0	0	0	0	0	0	2	17
7	7.5	2	0	0	0	0	0	0	1	3
7.5	8	1	0	0	0	0	0	0	0	1
8	8.5	1	0	0	0	0	0	0	0	1
8.5	9	0	0	0	0	0	0	0	0	0
Sum		42220	21739	13535	10952	23536	12370	16141	21192	

It is also shown in the figure below.



Scatter diagram in terms of significant wave height versus upcrossing period is detailed in the table below.

Significant Wave Height (m)		Zero Crossing Period (s)													
Lower Bound		0	1	2	3	4	5	6	7	8	9	10	11		
	Upper Bound	1	2	3	4	5	6	7	8	9	10	11	12		
8.5	9.0													0	0
8.0	8.5											1		1	1
7.5	8.0											1		1	2
7.0	7.5									1	1	1		3	5
6.5	7.0								2	6	9			17	22
6.0	6.5							1	4	37	6			48	70
5.5	6.0							13	41	66	3			123	193
5.0	5.5							30	175	48				253	446
4.5	5.0							162	341	19				522	968
4.0	4.5						45	656	346	1				1048	2016
3.5	4.0						496	1413	120					2029	4045
3.0	3.5						2131	1687	17					3835	7880
2.5	3.0					137	6268	756	9	4				7174	15054
2.0	2.5					4608	8553	361	25	4	1	1		13553	28607
1.5	2.0				10	18017	5831	628	131	15	3			24635	53242
1.0	1.5				5810	28754	5797	1720	203	10	4	1	1	42300	95542
0.5	1.0			288	24969	17713	6808	843	103	25	5	3	1	50758	146300
0.0	0.5			903	9019	4325	769	198	100	36	26	6	3	15385	161685
		0	0	1191	39808	73554	36698	8468	1617	272	58	14	5	Sum	
		161685	161685	161685	160494	120686	47132	10434	1966	349	77	19	5		Cumulative Sum

Steepness > 1/13	1/16 > Steepness < 1/13	1/21 > Steepness < 1/16	Steepness < 1/21

6.7 Current

The extreme values of current for the 1 year and 100 years return period are taken from [4].

They are reported in the following tables.

Height/Depth Ratio	North	Northeast	East	Southeast	South	Southwest	West	Northwest	Omni
1 Year									
Surface	0.82	0.33	0.54	1.74	0.76	0.25	0.31	1.64	1.74
75% of Water Depth	0.82	0.33	0.54	1.74	0.76	0.25	0.31	1.64	1.74
50% of Water Depth	0.82	0.33	0.54	1.74	0.76	0.25	0.31	1.64	1.74
40% of Water Depth	0.79	0.32	0.52	1.68	0.74	0.24	0.30	1.58	1.68
30% of Water Depth	0.76	0.31	0.50	1.62	0.71	0.23	0.29	1.52	1.62
20% of Water Depth	0.72	0.29	0.47	1.52	0.67	0.21	0.27	1.43	1.52
10% of Water Depth	0.65	0.26	0.43	1.38	0.60	0.19	0.25	1.30	1.38
5% of Water Depth	0.59	0.24	0.39	1.25	0.55	0.18	0.22	1.18	1.25
1m asb	0.58	0.23	0.38	1.23	0.54	0.17	0.22	1.16	1.23
10 Years									
Surface	0.89	0.36	0.58	1.88	0.82	0.26	0.34	1.77	1.88
75% of Water Depth	0.89	0.36	0.58	1.88	0.82	0.26	0.34	1.77	1.88
50% of Water Depth	0.89	0.36	0.58	1.88	0.82	0.26	0.34	1.77	1.88
40% of Water Depth	0.85	0.34	0.56	1.82	0.80	0.26	0.32	1.71	1.82
30% of Water Depth	0.82	0.33	0.54	1.74	0.76	0.25	0.31	1.64	1.74
20% of Water Depth	0.77	0.31	0.51	1.65	0.72	0.23	0.29	1.55	1.65
10% of Water Depth	0.70	0.28	0.46	1.49	0.65	0.21	0.27	1.40	1.49
5% of Water Depth	0.63	0.26	0.42	1.35	0.59	0.19	0.24	1.27	1.35
1m asb	0.62	0.25	0.41	1.33	0.58	0.19	0.24	1.25	1.33
50 Years									
Surface	0.93	0.38	0.61	1.98	0.87	0.28	0.35	1.86	1.98
75% of Water Depth	0.93	0.38	0.61	1.98	0.87	0.28	0.35	1.86	1.98
50% of Water Depth	0.93	0.38	0.61	1.98	0.87	0.28	0.35	1.86	1.98
40% of Water Depth	0.90	0.36	0.59	1.91	0.84	0.27	0.34	1.80	1.91
30% of Water Depth	0.86	0.35	0.57	1.84	0.80	0.26	0.33	1.73	1.84
20% of Water Depth	0.81	0.33	0.53	1.73	0.76	0.24	0.31	1.63	1.73
10% of Water Depth	0.74	0.30	0.48	1.57	0.69	0.22	0.28	1.48	1.57
5% of Water Depth	0.67	0.27	0.44	1.42	0.62	0.20	0.25	1.34	1.42
1m asb	0.66	0.26	0.43	1.40	0.61	0.20	0.25	1.31	1.40
100 Years									
Surface	0.95	0.38	0.62	2.02	0.89	0.28	0.36	1.90	2.02
75% of Water Depth	0.95	0.38	0.62	2.02	0.89	0.28	0.36	1.90	2.02
50% of Water Depth	0.95	0.38	0.62	2.02	0.89	0.28	0.36	1.90	2.02
40% of Water Depth	0.92	0.37	0.60	1.95	0.85	0.27	0.35	1.84	1.95
30% of Water Depth	0.88	0.35	0.58	1.87	0.82	0.26	0.33	1.76	1.87
20% of Water Depth	0.83	0.33	0.54	1.77	0.77	0.25	0.32	1.66	1.77
10% of Water Depth	0.75	0.30	0.49	1.60	0.70	0.22	0.29	1.51	1.60
5% of Water Depth	0.68	0.27	0.45	1.45	0.63	0.20	0.26	1.36	1.45
1m asb	0.67	0.27	0.44	1.42	0.62	0.20	0.25	1.34	1.42

6.8 Marine Growth Density

Data for marine growth are assumed as follows:

	MARINE GROWTH THK [mm]
from 0.31 LAT to -20.0 m LAT	120
from -20 m LAT to sea bottom	100

The fouling density in air is 1380 kg/m^3.

6.9 Wind

All directions are given in degrees, clockwise with respect to the Geographic North.

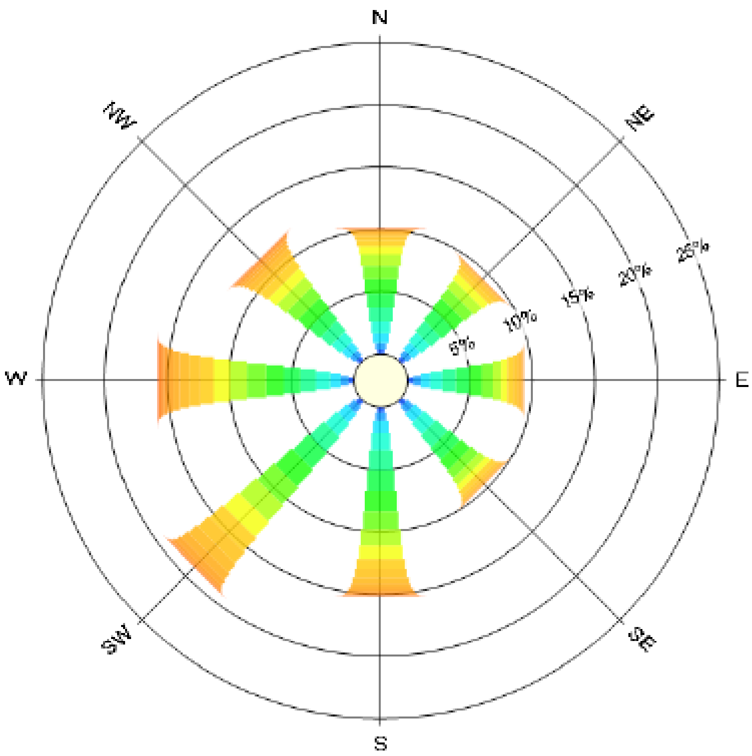
The wind speeds at el.10m LAT are taken from [4] and listed in the following tables:

Direction	24-hr (m/s)	12-hr (m/s)	6-hr (m/s)	3-hr (m/s)	1-hr (m/s)	10-min (m/s)	1-min (m/s)	15-sec (m/s)	5-sec (m/s)	3-sec (m/s)
1-year										
N	20.7	22.5	24.0	25.1	**25.8**	28.2	31.3	33.2	34.7	35.3
NE	19.9	21.7	23.1	24.1	**24.9**	27.2	30.1	31.8	33.2	33.9
E	19.5	21.2	22.6	23.6	**24.4**	26.6	29.4	31.1	32.4	33.0
SE	18.2	19.8	21.1	22.0	**22.7**	24.7	27.2	28.8	30.0	30.5
S	19.7	21.4	22.9	23.9	**24.6**	26.9	29.7	31.5	32.8	33.5
SW	20.7	22.5	24.0	25.1	**25.8**	28.2	31.3	33.2	34.7	35.3
W	21.5	23.4	25.0	26.1	**26.9**	29.5	32.8	34.7	36.3	37.0
NW	21.5	23.4	25.0	26.1	**26.9**	29.5	32.8	34.7	36.3	37.0
10-year										
N	22.9	24.9	26.7	27.8	**28.7**	31.5	35.1	37.3	39.0	39.8
NE	22.1	24.0	25.7	26.8	**27.6**	30.3	33.7	35.8	37.4	38.2
E	21.6	23.5	25.1	26.2	**27.0**	29.6	32.9	34.9	36.5	37.2
SE	20.2	21.9	23.4	24.5	**25.2**	27.5	30.5	32.3	33.7	34.4
S	21.9	23.8	25.4	26.5	**27.3**	29.9	33.3	35.3	36.9	37.7
SW	22.9	24.9	26.7	27.8	**28.7**	31.5	35.1	37.3	39.0	39.8
W	23.9	26.0	27.8	29.0	**29.9**	32.9	36.7	39.1	40.9	41.8
NW	23.9	26.0	27.8	29.0	**29.9**	32.9	36.7	39.1	40.9	41.8
50-year										
N	24.4	26.5	28.3	29.5	**30.4**	33.5	37.5	39.9	41.8	42.7
NE	23.5	25.5	27.3	28.5	**29.3**	32.3	36.0	38.3	40.1	40.9
E	23.0	25.0	26.7	27.8	**28.7**	31.5	35.2	37.4	39.1	39.9
SE	21.4	23.3	24.9	26.0	**26.8**	29.3	32.6	34.5	36.1	36.8
S	23.2	25.2	27.0	28.2	**29.0**	31.9	35.6	37.8	39.6	40.4
SW	24.4	26.5	28.3	29.5	**30.4**	33.5	37.5	39.9	41.8	42.7
W	25.4	27.6	29.5	30.8	**31.7**	35.0	39.3	41.8	43.9	44.8
NW	25.4	27.6	29.5	30.8	**31.7**	35.0	39.3	41.8	43.9	44.8

Direction	24-hr (m/s)	12-hr (m/s)	6-hr (m/s)	3-hr (m/s)	1-hr (m/s)	10-min (m/s)	1-min (m/s)	15-sec (m/s)	5-sec (m/s)	3-sec (m/s)
100-year										
N	25.0	27.1	29.0	30.3	**31.2**	34.4	38.6	41.0	43.0	43.9
NE	24.1	26.2	28.0	29.2	**30.1**	33.1	37.0	39.4	41.2	42.1
E	23.5	25.6	27.4	28.5	**29.4**	32.3	36.1	38.4	40.2	41.0
SE	21.9	23.9	25.5	26.6	**27.4**	30.1	33.5	35.5	37.1	37.9
S	23.8	25.9	27.7	28.8	**29.7**	32.7	36.6	38.9	40.7	41.6
SW	25.0	27.1	29.0	30.3	**31.2**	34.4	38.6	41.0	43.0	43.9
W	26.0	28.3	30.2	31.5	**32.5**	35.9	40.3	43.0	45.1	46.1
NW	26.0	28.3	30.2	31.5	**32.5**	35.9	40.3	43.0	45.1	46.1
1,000-year										
N	26.8	29.2	31.2	32.5	**33.5**	37.1	41.7	44.5	46.7	47.8
NE	25.8	28.1	30.0	31.3	**32.3**	35.7	40.1	42.7	44.8	45.7
E	25.3	27.5	29.4	30.6	**31.6**	34.9	39.1	41.6	43.6	44.6
SE	23.6	25.6	27.4	28.6	**29.5**	32.4	36.2	38.5	40.3	41.1
S	25.6	27.8	29.7	31.0	**31.9**	35.3	39.6	42.2	44.2	45.2
SW	26.8	29.2	31.2	32.5	**33.5**	37.1	41.7	44.5	46.7	47.8
W	27.9	30.4	32.5	33.9	**34.9**	38.8	43.7	46.7	49.0	50.1
NW	27.9	30.4	32.5	33.9	**34.9**	38.8	43.7	46.7	49.0	50.1
10,000-year										
N	28.5	31.0	33.2	34.6	**35.7**	39.6	44.8	47.8	50.3	51.4
NE	27.5	29.9	32.0	33.3	**34.4**	38.1	42.9	45.8	48.1	49.2
E	26.9	29.2	31.3	32.6	**33.6**	37.2	41.9	44.7	46.9	48.0
SE	25.1	27.3	29.2	30.4	**31.4**	34.6	38.8	41.3	43.3	44.2
S	27.2	29.6	31.6	33.0	**34.0**	37.7	42.4	45.3	47.5	48.6
SW	28.5	31.0	33.2	34.6	**35.7**	39.6	44.8	47.8	50.3	51.4
W	29.7	32.3	34.5	36.0	**37.1**	41.4	46.9	50.2	52.8	54.0
NW	29.7	32.3	34.5	36.0	**37.1**	41.4	46.9	50.2	52.8	54.0

For the structural design the 1 min gust shall be considered for global analysis, while 3s guest have to be considered for local design of topside members and equipment supports.

The frequency distribution of wind speed versus incoming direction is given in the following figure.



7 SEALINE DESIGN AND FLOW ASSURANCE STUDY

7.1 Hewett CO2 Pipeline Sizing

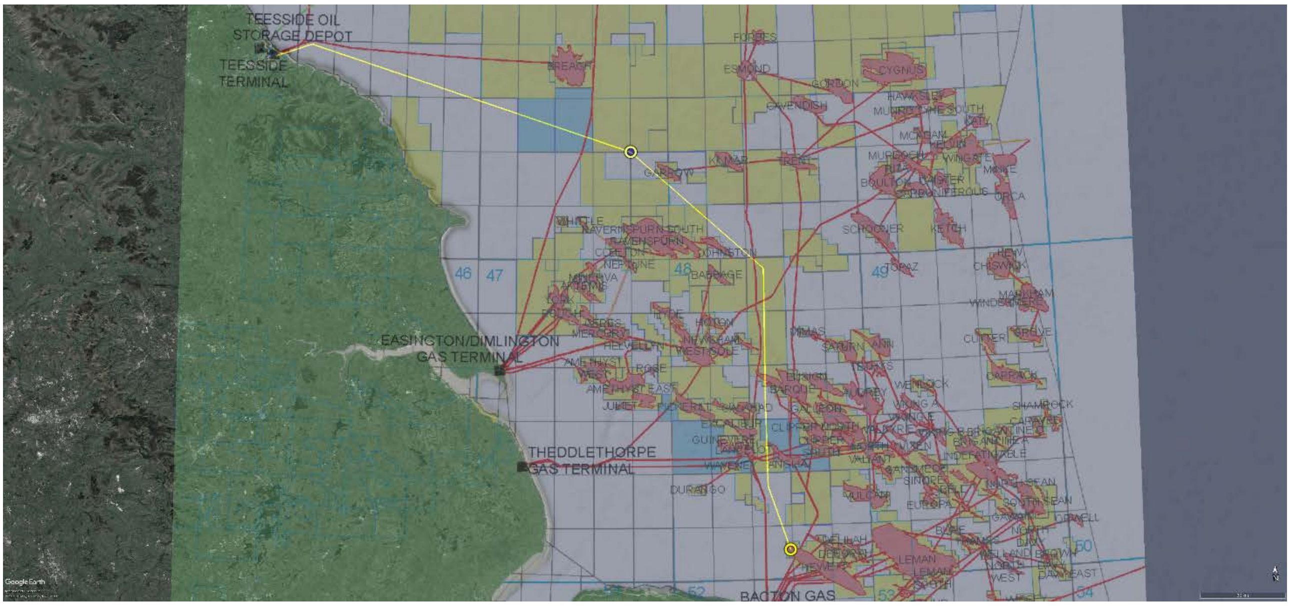
The present Clause outlines the results of the preliminary sizing of the offshore long running pipeline required to transport the CO2 produced by Teesside Bay industries (East UK coast) up to the Hewett offshore depleted field, more specifically the Lower and Upper Bunter Sandstone reservoirs.

Preliminary pipeline routing has been planned in order to pass in the proximity of the not yet exploited Endurance concession, to pass as much as possible far from already exploited fields along the pipeline path and to minimize the crossings with already existing offshore pipelines. Anticipated number of not avoidable pipeline crossings is 5, according to the last updated available information taken from the UKCS Oil and Gas Activity database.

The resulting preliminary overall pipeline routing length is approximately 285 km, the maximum water depth is 63 m and maximum local slope is 1.2%. The preliminary pipeline coordinates starting and ending points are listed in the following table.

Coordinates	LONGITUDE	LATITUDE
Starting point (Teesside coast)	-1.109234 deg EAST	54.609939 deg NORTH
Ending point (Heweitt field)	1.584389 deg EAST	53.112556 deg NORTH

The following figures show the resulting preliminary pipeline routing superimposed to the UKCS Oil and Gas Activity pipeline and field database and the associated preliminary offshore pipeline profile.



The preliminary mechanical sizing of the Hewett CO2 offshore pipeline has been performed according to ISO 13623 International Standard – Petroleum and natural gas industries – Pipeline transportation systems, as far as are concerned the pressure containment requirements, supplemented by DNVGL-ST-F101 – Submarine pipeline systems Standard, as far as are concerned the external collapse and propagating buckling requirements.

The following main Project assumptions have been taken into account to perform the pipeline preliminary mechanical sizing: different Project options have been considered as far as are concerned the pipeline Steel Grade Material, the Design Pressure and pipeline outside diameters.

Design Temperature	50°C (no material strength de-rating)
Corrosion Allowance	6 mm
Maximum Water Depth	70 m (63 m + 10% allowance)
Line pipe manufacturing	UOE (T_{fab} = 1 mm)
Steel Grade Material (2 options)	L415 – L450
Design Pressure (2 options)	60 bar – 160 bar
Pipeline Outside Diameter (OD) (4 options)	30” – 28” – 26” – 22”

The main results in terms of pipeline minimum Wall Thickness sizing are reported in the two following tables as a function of the two envisaged different Steel Grade Materials, the two envisaged different Design Pressures and the four different pipeline Outside Diameters.

The tabulated minimum pipeline Wall Thicknesses are the ones required to meet the external collapse and the propagating buckling requirements according to DNVGL-ST-F101 Standard at the maximum envisaged water depth of 70 m (external pressure maximization with pipeline in void condition) and to meet the pressure containment requirements according to ISO 13623 International Standard at sea water level (differential pressure maximization).

Pipeline OD [inch]	***Design Pressure [bar]***	***Wall Thk. [mm] - L415***		
		Collapse	***PropBuck***	***Bursting***
30	60	16.9	23.3	14.1
30	160	16.9	23.3	25.6
28	60	16.3	22.2	13.6
28	160	16.3	22.2	24.4
26	60	15.6	21.0	13.1
26	160	15.6	21.0	23.1
22	60	14.4	18.7	12.2
22	160	14.4	18.7	20.6

Pipeline Steel Grade Material Option 1 – L415 (SMYS 415 MPa)

Pipeline OD [inch]	Design Pressure [bar]	Wall Thk. [mm] - L450 Collapse	PropBuck	Bursting
30	60	16.9	22.8	13.5
30	160	16.9	22.8	24.2
28	60	16.3	21.7	13.1
28	160	16.3	21.7	23.0
26	60	15.6	20.5	12.7
26	160	15.6	20.5	21.9
22	60	14.4	18.3	11.8
22	160	14.4	18.3	19.6

Pipeline Steel Grade Material Option 2 – L450 (SMYS 450 MPa)

From the above tables it is possible to ascertain the following:

- The wall thickness sizing determined by the external collapse verification is independent from both the Material Steel Grade and the Design Pressure and it is dependent only from the pipeline outside diameter.

- The wall thickness sizing determined by the propagating buckling verification is independent from the Design Pressure and it is dependent from both the Material Steel Grade and the pipeline outside diameter.

- The wall thickness sizing determined by the pressure containment verification is dependent from the Material Steel Grade, the Design Pressure and the pipeline outside diameter.

- Considering the use of the L450 steel Grade Material with respect to the use of the L415 steel Grade Material, the steel material and cost saving for pipelines sized by the propagating buckling requirement is approx. 2% while the steel material and cost saving for pipelines sized by the pressure containment requirement is in the range of 3%÷6%, hence the selection of the L450 steel Grade Material is recommended.

- Considering a Project Design Pressure of 160 bar, the governing criterion for the pipeline sizing is the pressure containment requirement, hence the following pipeline sizing is recommended as a function of the pipeline outside diameters:

Pipeline OD [inch]	Design Pressure [bar]	WT [mm]
30	160	24.2
28	160	23.0
26	160	21.9
22	160	19.6

- Considering a Project Design Pressure of 60 bar, the governing criterion for the pipeline sizing is the external collapse requirement. However, for pipelines sized according to external collapse the installation of buckle arrestors is required to prevent the likelihood of propagating buckling: in this specific case buckle arrestors would be required in the water depth range from maximum 70 m w.d. up to 24÷27 m w.d. (as a function of the different pipeline diameters) i.e. for almost the overall length of the pipeline according to the preliminary offshore pipeline profile. To avoid the installation of buckle arrestors a viable alternative is to size the pipeline according to the propagating buckling requirement (thicker line pipes), however for this specific case the cost/benefit preliminary analysis is in favour of the former alternative since the anticipated cost of the additional buckle arrestors to be supplied is well below the additional anticipated cost of the thicker line pipes. In this case the following pipeline sizing is recommended as a function of the pipeline outside diameters:

Pipeline OD [inch]	***Design Pressure [bar]***	***WT [mm]***
30	60	16.9
28	60	16.3
26	60	15.6
22	60	14.4

Being the pipeline overall length to be laid in very shallow / shallow waters it is mandatory to overweight all the line pipes by concrete overweighting minimum 40 mm thickness; this is also necessary to guarantee a specific gravity verification greater than 1.1 to avoid the pipeline self-buoyancy.

7.2 FLOW ASSURANCE – CO_2 composition

The simulations have been carried out with Olga 2018.1.0, both with the Single Component Pressure-Enthalpy mode, for pure CO_2, and the ".tab" Pressure-Temperature mode for impure CO_2.

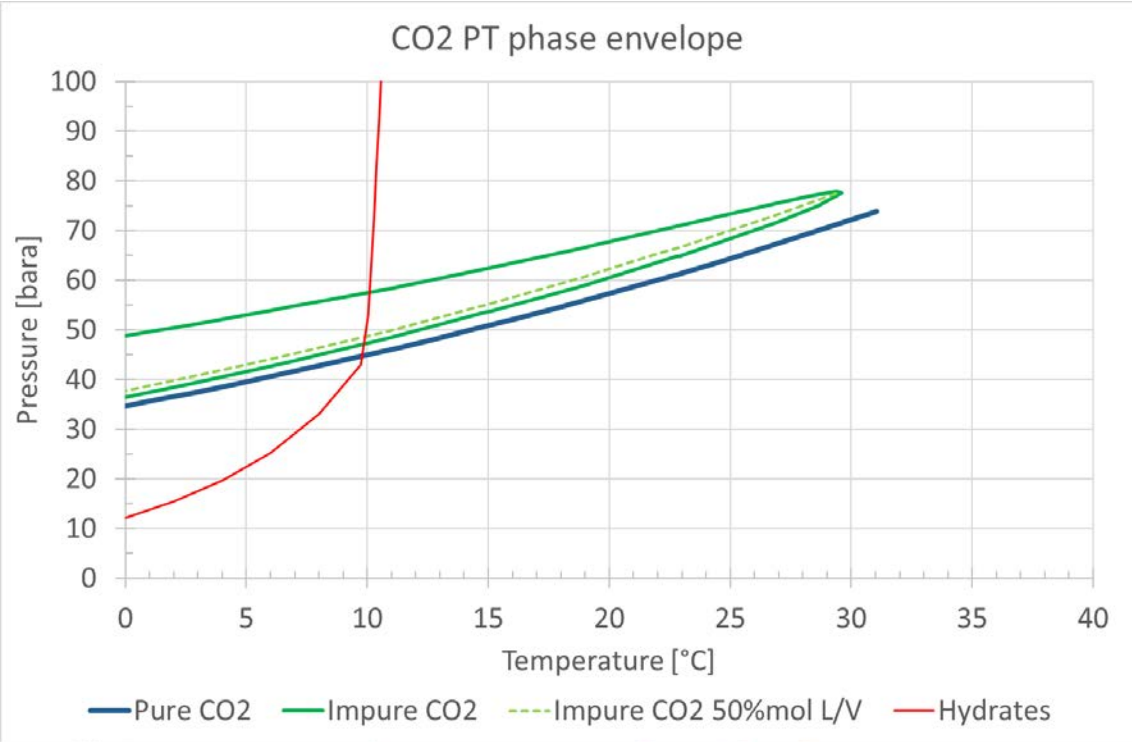
In the latter case, the table of the PVT properties has been generated with Calsep PVTSim Nova v4.2. Given the characteristics of the latter approach, more suitable to hydrocarbon mixtures, the representativeness of the results has to be further checked.

The impure composition is notional (not associated to specific information):

	Mol%
H_2	0.75
N_2	1.40
Ar	0.40
CO_2	97.45

The phase diagrams of the CO_2 compositions used in this study are shown below.

The hydrate dissolution curve is shown in red, even if during transportation and injection into the wells it has no relevance, since the water concentration makes hydrates formation negligible even inside of the stability region. In case of hydrates formation risk during some transient operations, hydrate inhibitor (MEG) is available on the injection platform.



7.3 FLOW ASSURANCE – HEWETT WELLS

Flow assurance analyses have been carried out by simulating the lifetime behavior of the field during CO_2 injection. The simulation activity started from the wells since the boundary conditions are dictated by the reservoir pressure evolution, itself determined by the injection flow rate history and reservoir characteristics.

Consequently, a number of preliminary iterations with the Reservoir and Drilling & Completion departments have been performed in order to set up a self-standing scenario on which the final simulation have been carried out. All these preliminary attempts are not reported here.

Two injection strategies have been considered:

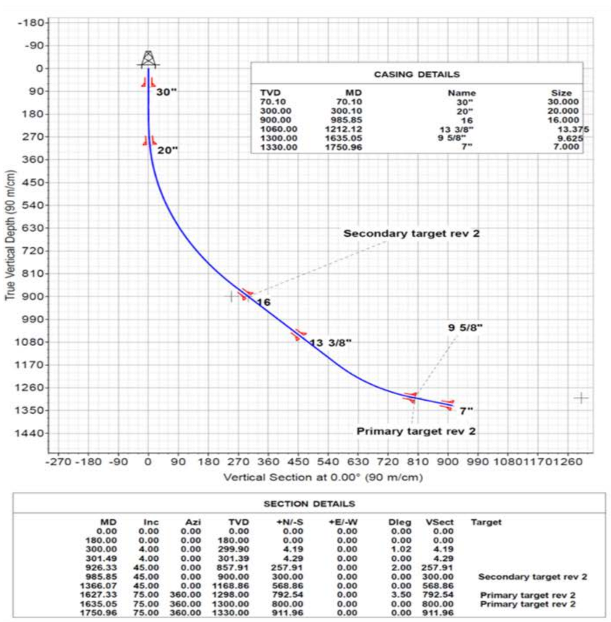
A. Lower Bunter only (to be followed decades later buy Upper Bunter injection)
B. Lower Bunter and Upper Bunter at a coordinated pressure, sharing the injection rate

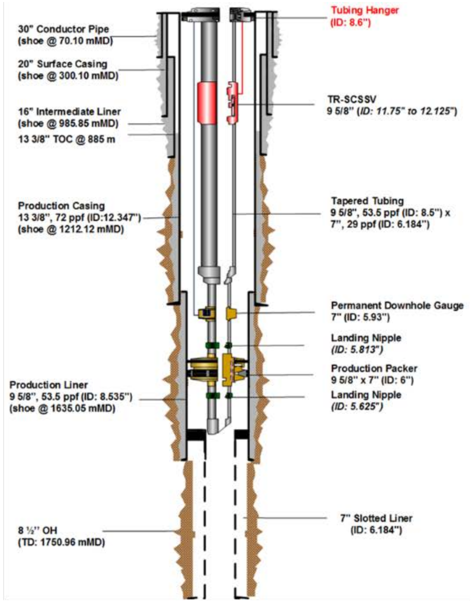
Moreover, two transportation configurations have been simulated:

- dense-phase transportation, heating, depressurization and well injection
- gas and multiphase transportation and direct well injection (no heating)

Despite the fact that technological doubts exist on the latter, it deserved attention here since, if effective, it could lead to significant plant simplifications and power savings.

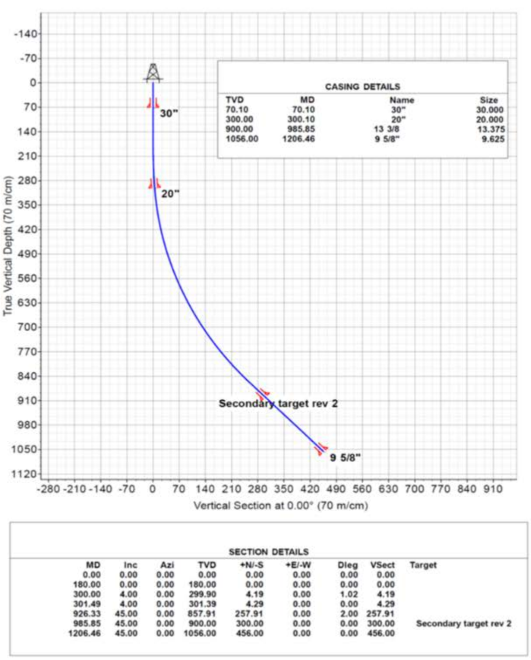
For the Olga models, the well completions for the Lower and Upper Bunter have been taken by the data reported below. The tubing diameters have been selected together with the Completion office to be as large as possible, given the well geometry and the reservoir data. Preliminary simulations have in fact shown that smaller diameters may limit the injection rate, especially in the no-heating injection scenario.

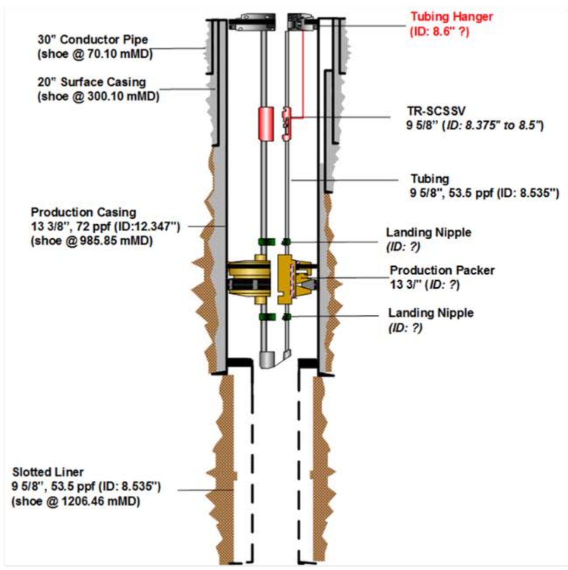




Notional schematic – Feasibility still TBC

Lower Bunter well completion





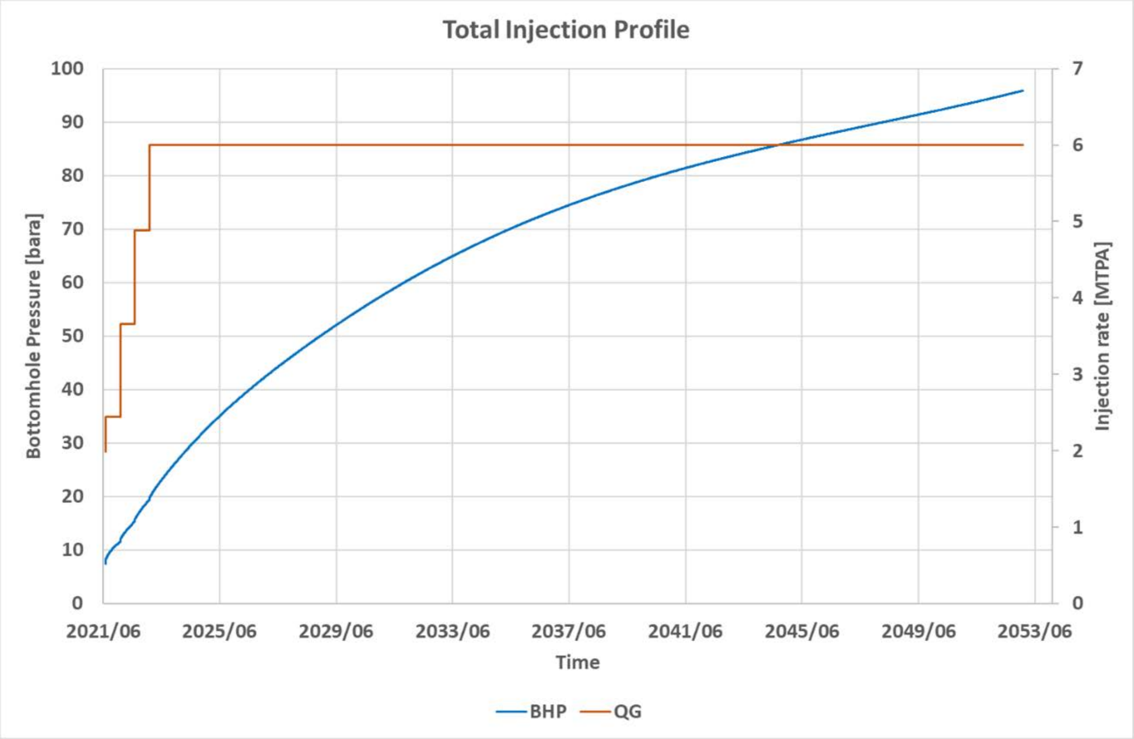
Notional schematic – Feasibility still TBC

Upper Bunter well completion

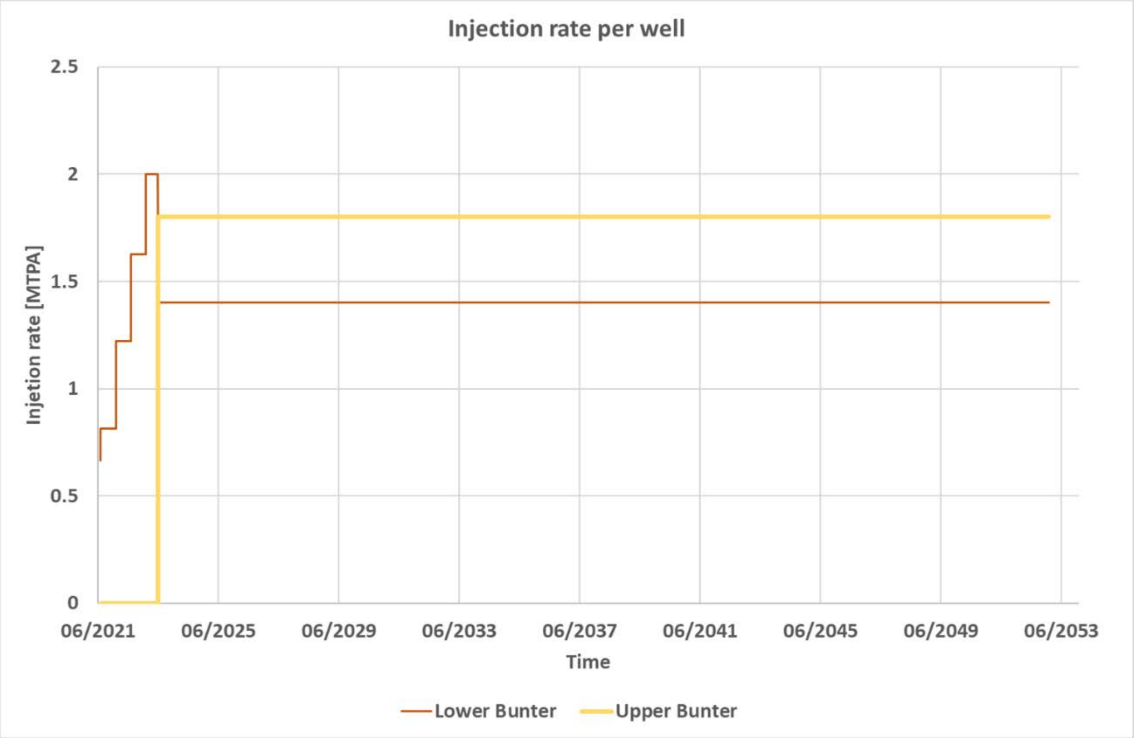
For the Lower Bunter wells, the tubing size has to be reduced from 9”5/8 to 7” at a TVD of about 1060m, to comply with D&C feasibility constraints. Instead, the Upper Bunter tubing is 9”5/8 for its whole length.

7.4 FLOW ASSURANCE – INJECTION RAMP UP

The injection rate has not been assumed to start immediately at the plateau rate (6 MTPA), but to ramp up in a number of steps. This injection profile is both consistent with the industrial development scenarios and also with a very low initial reservoir pressure, which suggests to adopt lower rates at the beginning of the injection history. In particular, the following total injection profile has been adopted.



In case of strategy A (injection in Lower Bunter only) the total injection rate has been split among the wells in equal proportion. Instead in case of strategy B (coordinated injection in Lower and Upper Bunter) a reservoir-driven flowrate partition has been adopted, in order to keep aligned the pressurization of both reservoir levels. In fact, injection in the upper bunter level (starting at 23 bara) only begins when the lower bunter pressure assumes the same value. Then, the two injection rates are balanced to achieve a similar reservoir pressure increase in time.



7.5 FLOW ASSURANCE – WELLS UNDER STEADY STATE CONDITIONS

For the Olga simulations, a particular strategy has been used in order to simulate the whole injection history of the wells: the time in weeks of the reservoir study have been converted into hours for the Olga simulations, so that, e.g., the gradual pressure changes occurring in 52 weeks are compressed into 52 hours. This allowed to simulate 30 years of injection in a reasonable time, but also to simulate the application of flowrate changes in a realistic timeframe (e.g. 1 hour) so that the possible effect of transients could also be examined.

Moreover, the following can be observed:

- Olga models have been run separately for wells and pipelines
  It was observed that the complete model, including wells and pipelines, is not only much slower but is also generally unstable in case of CO2 simulations. Consequently, the complete model has been used for qualitative comparison, but not for the screenings.

- Seasonal temperature changes have not been simulated during the injection lifetime. Some rough tests in which a yearly sinusoidal ambient temperature change has been imposed have been simulated, showing the absence of significant phenomena, both in the pipeline and in the wells.

- As will be reported in a subsequent paragraph, well transients have been simulated in some injection histories every about 30 weeks, to assess the effect of shut-downs and, after 3 hours, of the following start-ups. No criticalities have been observed in Upper and Lower Bunter wells.

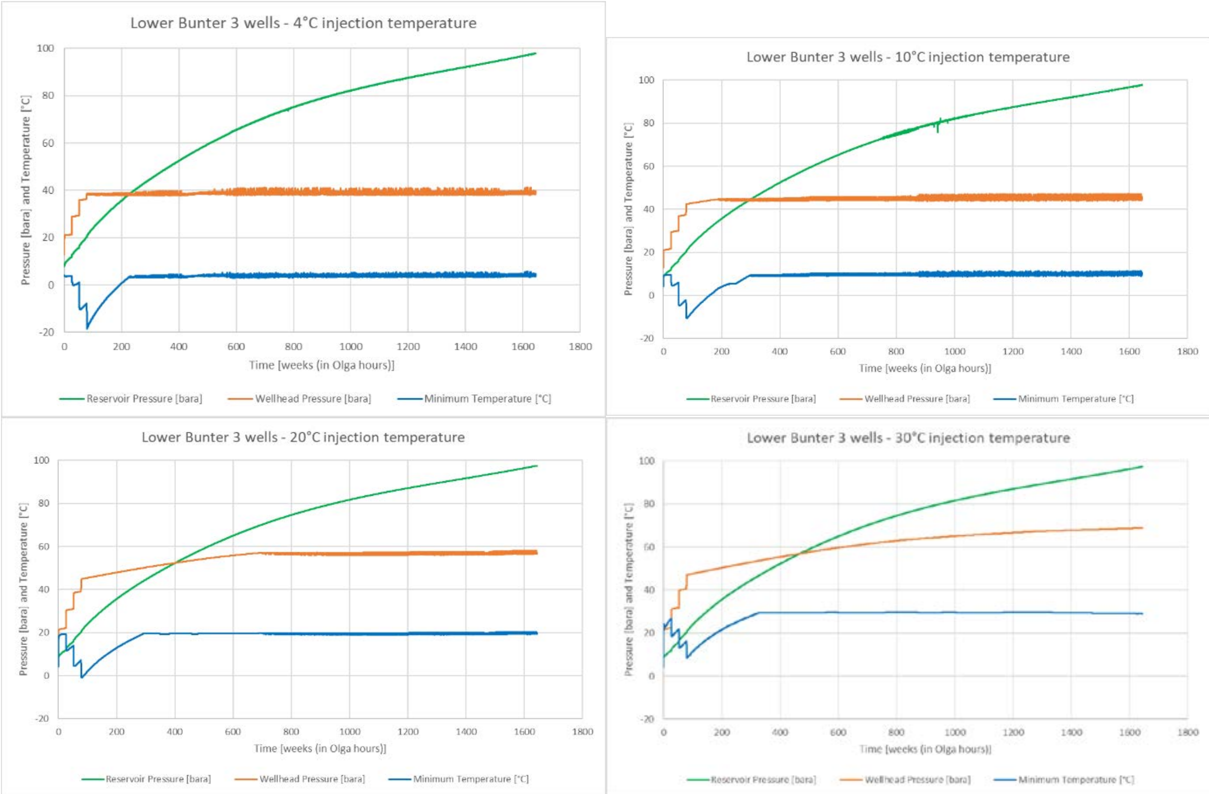
- In general, care has been taken to identify the design choices which can be applied also in the scenario which does not include any heater. This may have imposed some additional restrictions in the heating case, but these did not seem significant.

7.5.1 Scenario A – Lower Bunter Only

For the well simulations, the CO_2 injection rate has been varied assuming the values 4°C, 10°C, 20°C and 30°C, and the number of wells has been varied from 3 to 4.

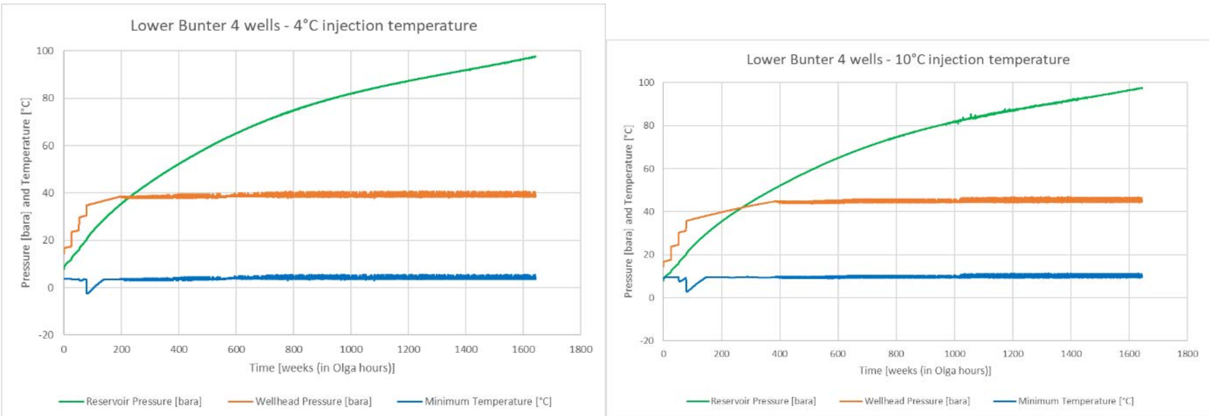
As can be seen in the following charts:

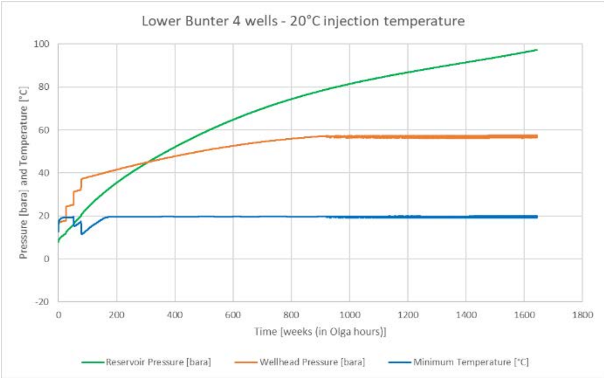
- with 3 wells, for the cases with inlet temperature of 4°C and 10°C, the minimum fluid temperature in the tubing temperature drops significantly below zero during the flowrate ramp-up. The case at 20°C is just below zero and a small delay in the flowrate ramp-up can likely increase the minimum temperature above zero. Nevertheless, the erosional velocity ratio EVR becomes significantly high in the 7” tubing region, reaching values just below 4. This may render the three-well case challenging to accomplish.

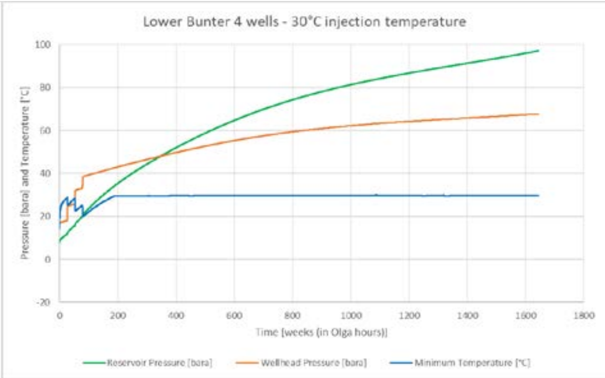


From the simulations, it can also be noticed that the wellhead pressure stabilizes substantially at the CO_2 equilibrium pressure pertaining to the injection temperature (See chart at §7.2). This may be operationally important since it disconnects the wellhead pressure from the bottomhole pressure: all the pressure excess between bottomhole and wellhead is compensated by the CO_2 density along the tubing.

- With 4 wells, for the case with inlet temperature of 4°C, the minimum tubing temperature drops for a short period of time down to -2.5°C for the last flowrate step, the one which reaches the maximum rate. This seems more likely a transient effect (Olga simulations are in hours and not weeks). When the bottomhole pressure increases from 20 to 25 bar, the minimum fluid temperature in the tubing temperature returns to 4°C. In other terms, this phenomenon seems avoidable with an appropriate operation and a small ramp-up rescheduling. Also, the EVR assumes a maximum value of 2.8 at the beginning of the last flowrate increase and then decreases rapidly below 2.5, which seems acceptable.

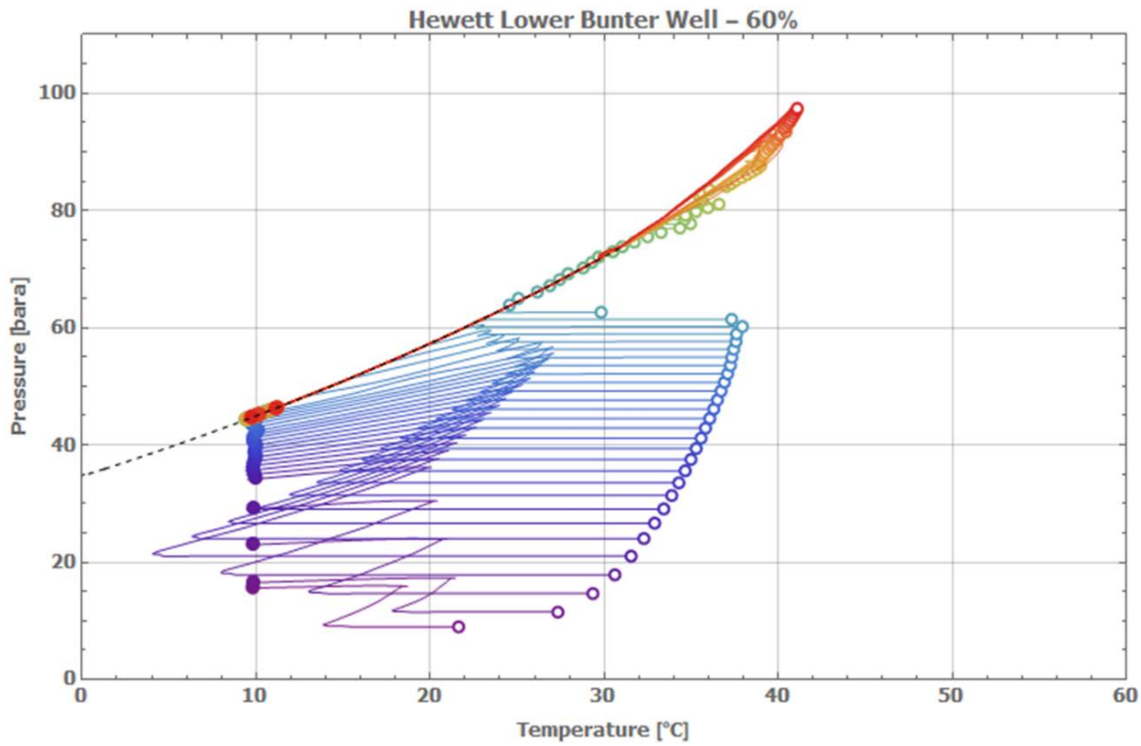






Consequently, the reference case seems to foresee 4 wells.

An example of the P/T evolution along the injection lifetime for a Lower Bunter well (injection temperature set at 10°C) is shown below, where time is indicated with a rainbow color scheme, from violet to red, respectively for early injection and late injection rates. Filled and Empty dots represent respectively wellhead and downhole conditions. The line joining them represents the P/T values along the whole tubing.

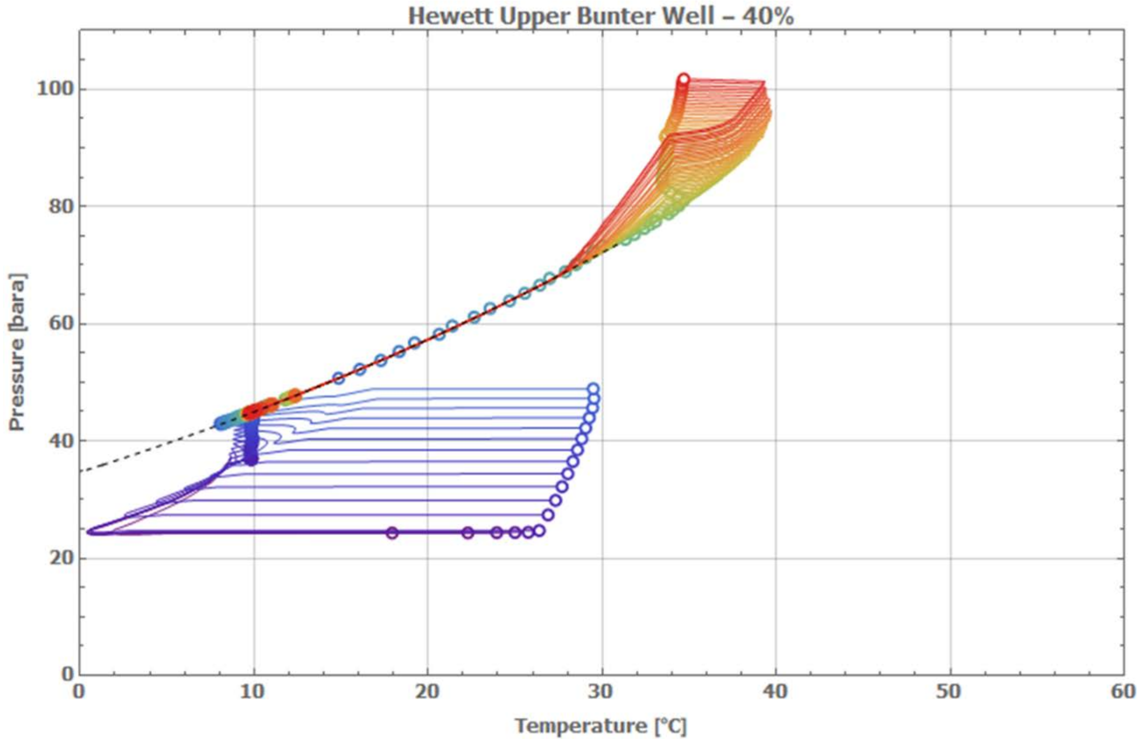


7.5.2 Scenario A – Lower Bunter Only

The coordinate injection in the two levels is achieved by injecting into three wells in the Lower Bunter level until a pressure of about 23 bar is achieved. This coincides substantially with the last injection rate increase, which would be accomplished by starting injection also in the Upper Bunter with a rate of about 35% of the total rate. This is feasible since the Upper Bunter completion is all 9”5/8 and does not suffer from the limitations imposed by the 7” section of the LB wells.

A simulation imposing 40% of the total rate on the UB is shown below, for a 10°C injection temperature.

An example of the P/T evolution along the injection lifetime for an Upper Bunter well (injection temperature set at 10°C) is shown below, where time is indicated with a rainbow color scheme, from violet to red, respectively for early injection and late injection rates. Filled and Empty dots represent respectively wellhead and downhole conditions. The line joining them represents the P/T values along the whole tubing.



Consequently, also this scenario foresees 4 wells and seems technically acceptable.

7.6 FLOW ASSURANCE – WELLS UNDER TRANSIENT CONDITIONS

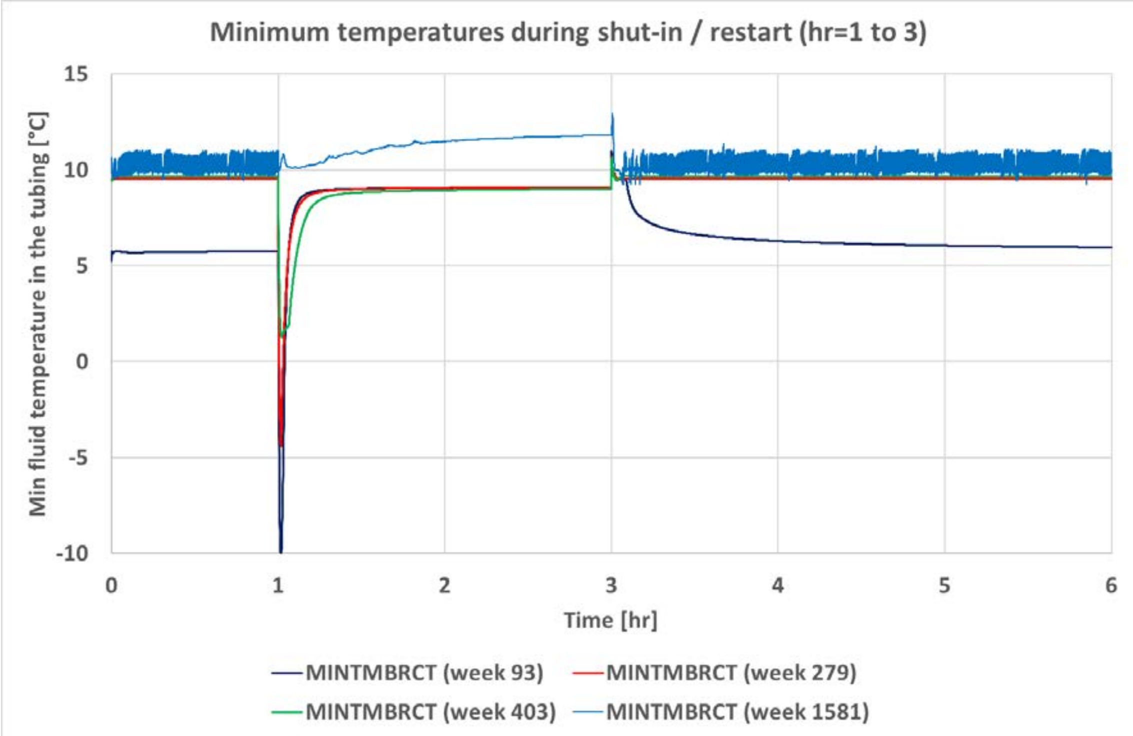
The behavior of wells under transients has been explored by simulating a 3h shut-in and subsequent restart every 31 weeks along the whole history. This has been done for the case of 4 wells (or about 70% of the flowrate for 3 wells).

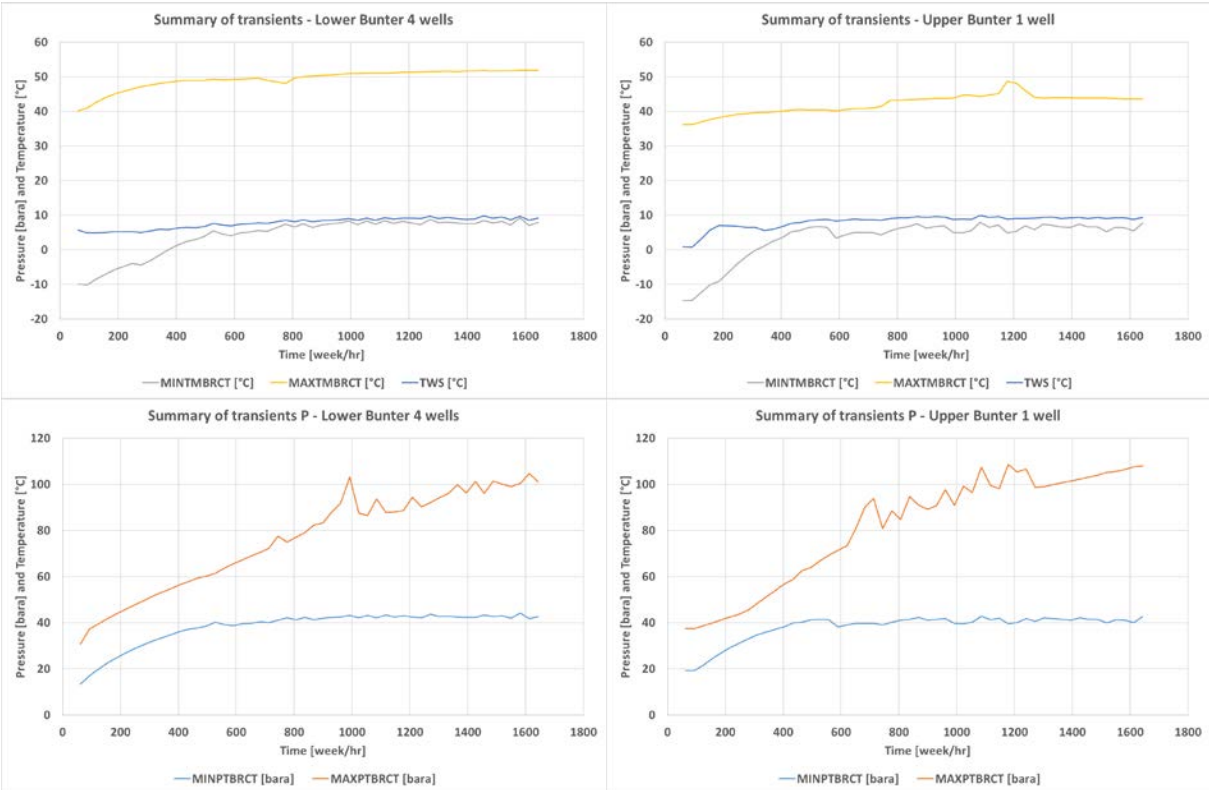
A chart showing the P and T behavior for a transient is reported below. The shut-in starts at time 1hr and finishes at time 3hr. The flowrate is stopped and restarted abruptly. The injection temperature is 10°C.

The minimum temperatures occur in the initial section of the lifetime, as seen in the subsequent charts.

It can be observed that the minimum temperature occurs for a very short time and only in the fluid (not in the tubing material). This indicates that the problem is likely mitigated or eliminated by making the shut-in less abrupt and that, in any case, it should not have structural effect on the tubing.

This is the only type of transient which has been simulated. Slow flowrate transients, longer shut-ins, well depressurization or bull-heading operations have not yet been addressed.





7.7 FLOW ASSURANCE – PIPELINE

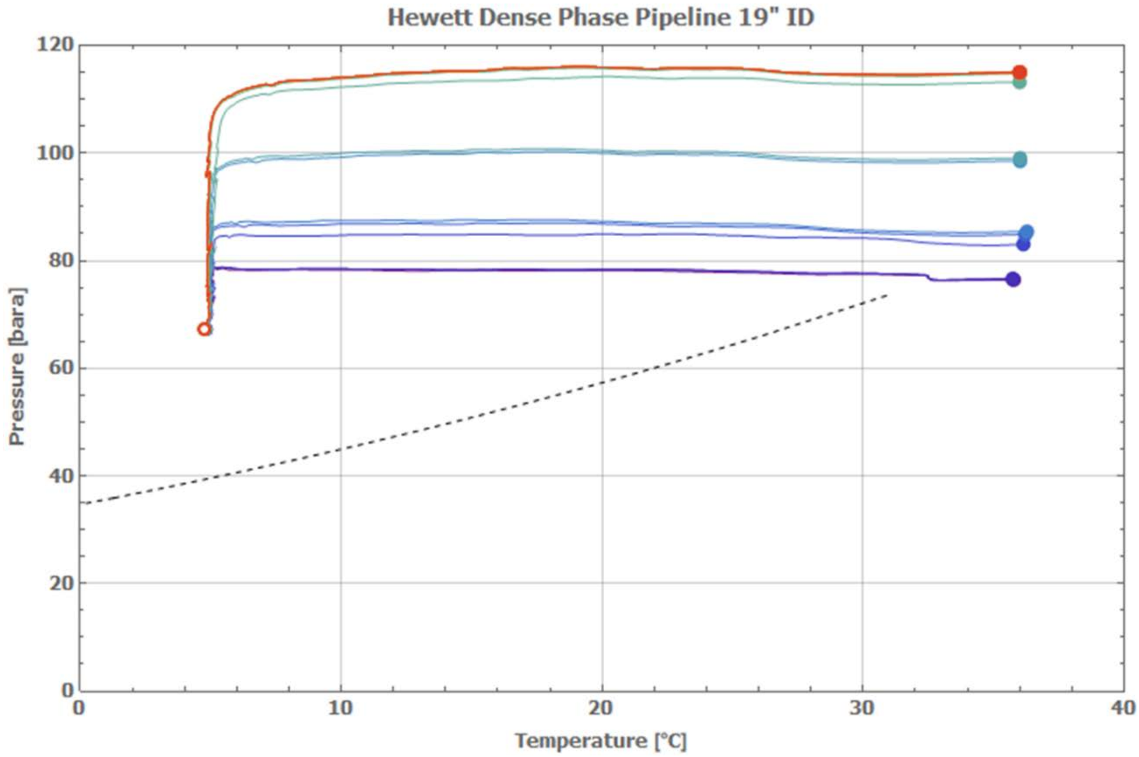
The pipeline transport has been simulated both for full liquid phase conditions (which imply heating needs since start-up) and for gas/multiphase conditions (which might require heating after some years of injection).

7.7.1 Liquid (=dense) phase pipeline

For the liquid transportation case, the pipeline inner diameter has been sized as 0.483m (19") in order to:

- Minimize the line diameter
- Minimize outlet pressure (minimize platform choking)
- Minimize inlet pressure (minimize compressor power)
- avoid the phase transition curve in any line positions

An arrival pressure of 67 bara seems to allow reaching the above objectives (under steady state conditions) for all the flowrate values considered. This is visible in the following chart, where the P/T values along the pipeline and along the whole injection history can be seen (time is indicated with a rainbow color scheme, from violet to red, respectively for early injection and late injection rates; filled and Empty dots represent respectively wellhead and downhole conditions). Ambient temperature has been set to 5°C and inlet temperature to 35°C.



An arrival pressure of 75 bara may allow to avoid the phase transition line also during shutdowns. Smaller or larger diameters, have the only effect to raise or reduce the inlet pressure, thus modifying the compressor power needed onshore. The selection of the optimal diameter thus can be selected through a cost comparison between the pipeline CAPEX with varying diameter and the compressor lifetime OPEX at different discharge pressures, which is beyond the scope of this document.

The temperature falls exponentially from the inlet to ambient temperature in about 60km even at the highest injection rates and then remains constant. The effect of the inlet temperature on the inlet pressure is negligible, even passing from 36 to 75°C.

7.7.2 Gas – multiphase pipeline

The simulation of this case is much more complex, and definitive conclusions about its feasibility have not been achieved yet.

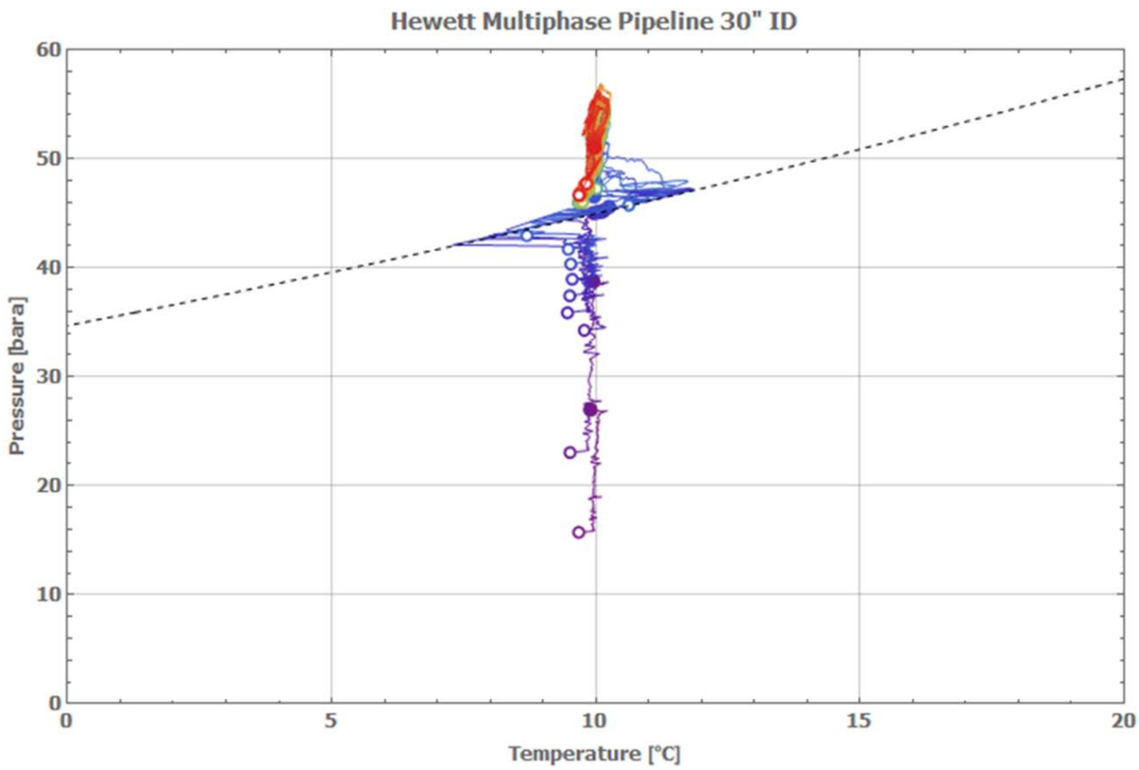
An easy achievement is the minimum pipeline inner diameter, which has to be above about 26": this is dictated by the Joule Thompson effect, which reduces the outlet temperature for the highest injection rates to below 0°C for any diameter smaller than 24" included. Consequently, the reference inner diameter has been selected to be 30".

The evolution of P/T along the pipeline depends on the starting temperature and the pipeline insulation. Two examples are reported below. In the charts, as elsewhere, time is indicated with a rainbow color scheme, from violet to red, respectively for early injection and late injection rates; filled and Empty dots represent respectively pipeline inlet and outlet.

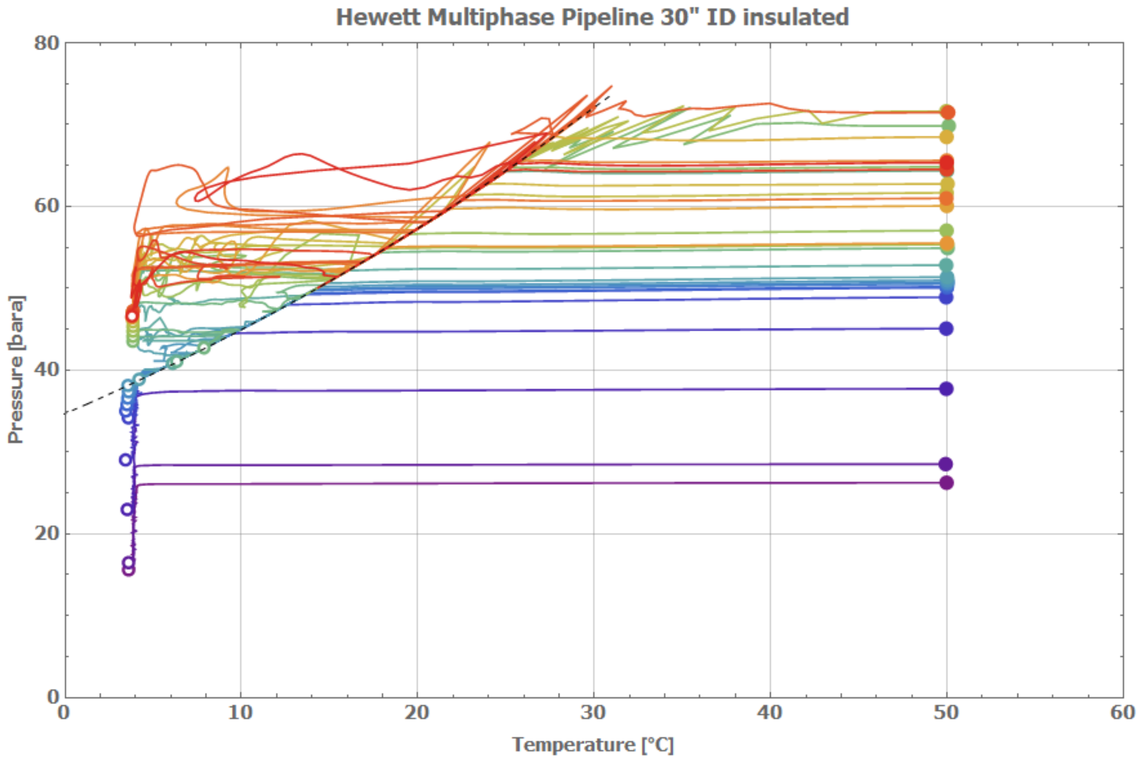
Three cases are reported:

- The inlet temperature is equal to the ambient temperature, 10°C in this simulation.
- The inlet temperature is equal to 50°C
- The inlet temperature is equal to 50°C and the pipeline is insulated with 5cm polyurethane coating

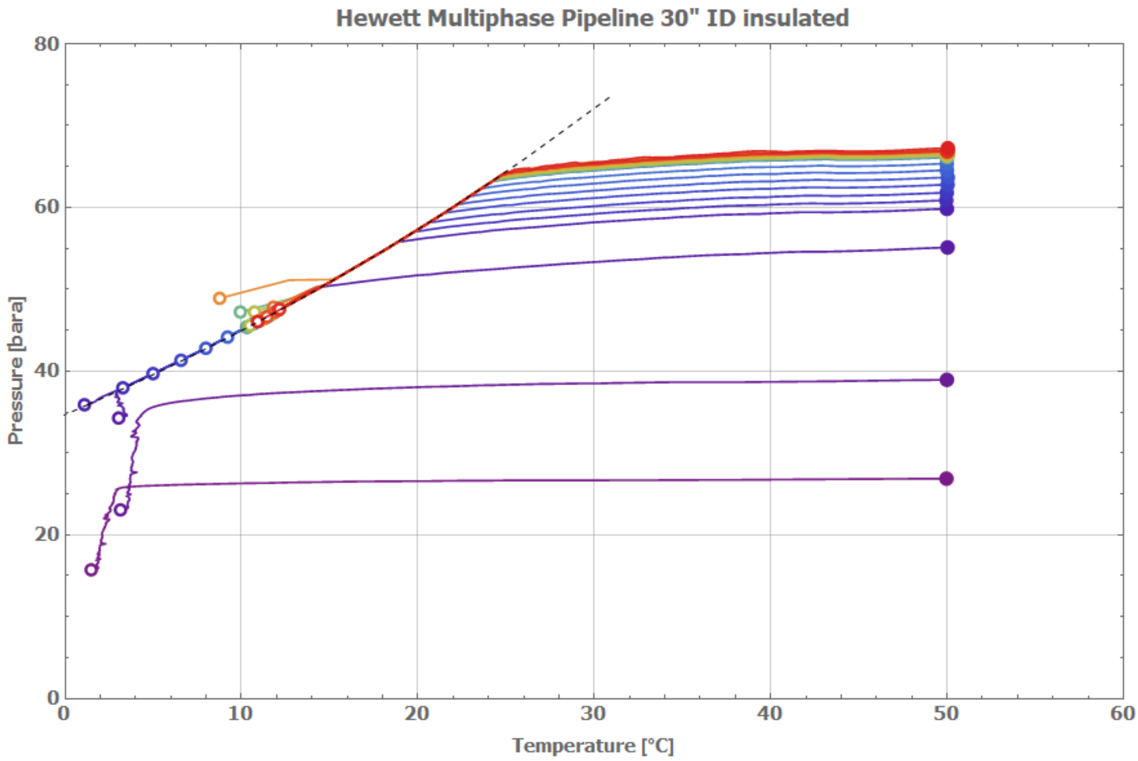
In the first case, the phase transition line is crossed "from above", and a full transition to the liquid phase is foreseen. In this case, heating on the platform might be needed if the transition from the liquid phase to the gas phase is not desired to occur inside of the reservoir. No major instabilities are observed in the simulations.

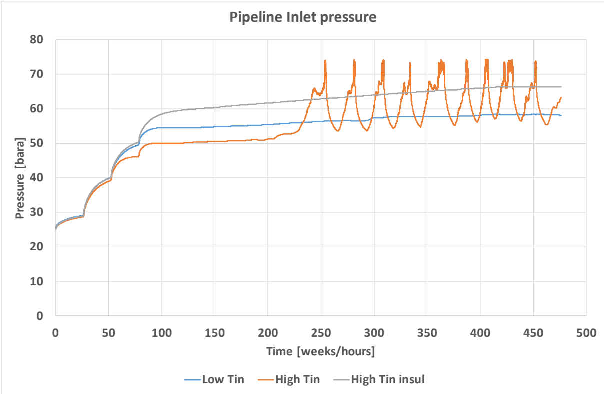


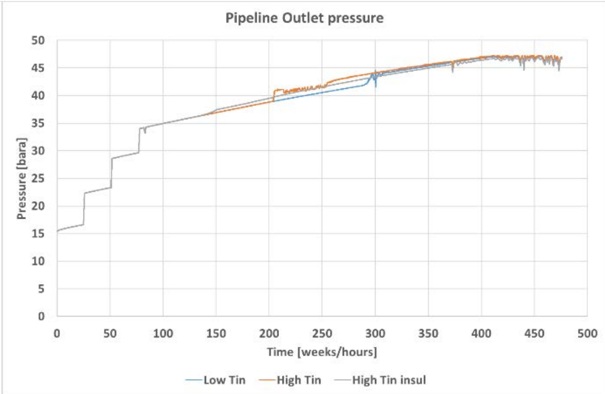
In the second case, the phase transition line is crossed "from below", and a full transition to the liquid phase is foreseen along the pipeline. In this case, severe instabilities are observed at the pipeline arrival, and this particular operating condition is not recommended.



In the third case, only a small entrance in the liquid phase, crossed the transition line "from below", is observed. Most of the pipeline is in a pure multiphase mode but major instabilities are not observed at the pipeline arrival.







As a consequence, it is clear that the overall flow regime depends on the operating mode and further analyses are necessary to identify, if any, the satisfactory multiphase transport mode without heating.

7.7.3 Gas – multiphase pipeline and associated wells

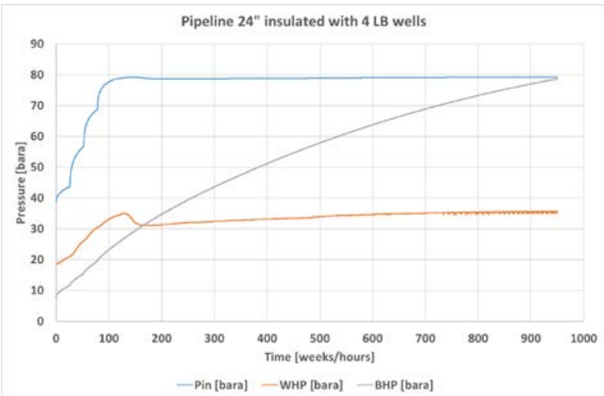
The above results, suggest that a full model encompassing both pipeline and wells is required to properly understand the feasibility of the multiphase transportation and injection. In fact, the pipeline and the well are connected into a single node whose pressure cannot be chosen at will, since it is mostly dictated by CO2 properties and by its liquid/vapor ratio (and the associated latent heat). Moreover, the presence of a choke is not desirable without heating facilities, since it would further lower the wellhead temperature WHT through the Joule-Thompson effect. Consequently, the operating conditions of the whole system need to be assessed by a full model.

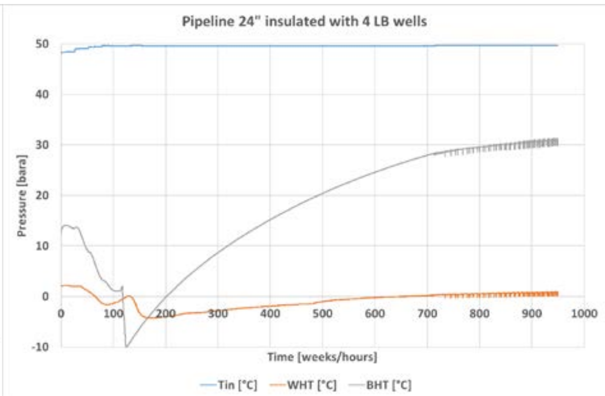
This model takes several days to run and only a partial set of simulations has been carried out. Each of them has been usually stopped after reaching constant conditions (at some point, pressures get fixed to the value pertaining to the CO2 equilibrium curve at the operating temperature).

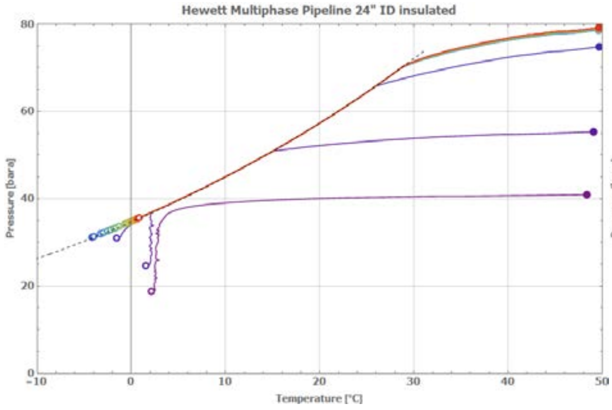
To speed up the full model, a simplification has been made: the four wells have been described as a carbon-copy of one Lower Bunter well (Olga NEQUIPIPE keyword), instead of modelling the different wells independently. As a side effect, it has to be noticed that 4 LB well are not equivalent to 3 LB wells + 1 UB well, since the UB well has a higher injection capacity, due to its larger diameter and shorter length. Consequently, a low bottom-hole temperature for some flowrates was produced as an artifact.

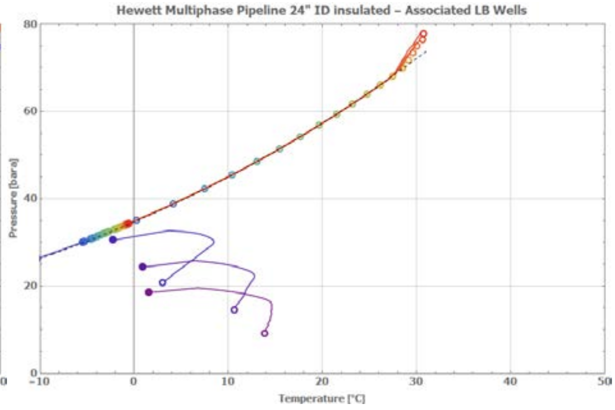
The Inner diameter has been chosen in the range 24” - 26”, in order to explore opportunities for reduction. Moreover, the pipeline has been insulated (50mm of polypropylene in the model), to reduce the thermal exchange with the environment and thus to limit CO2 phase transition from gas to liquid in the pipeline.

The main resulting charts for the 24” line are shown below (color codes for the PT diagrams as above).



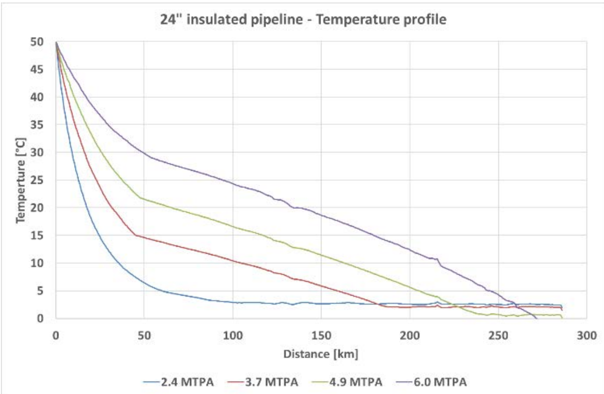


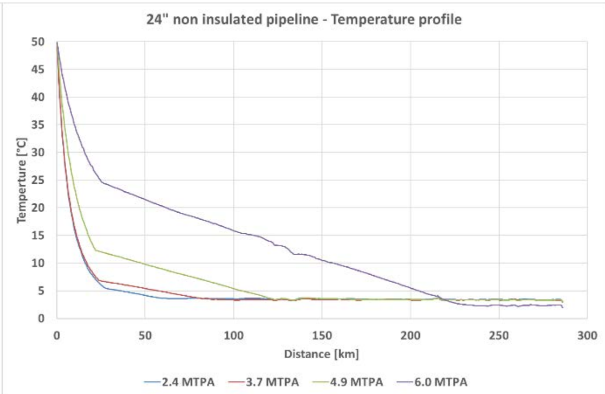




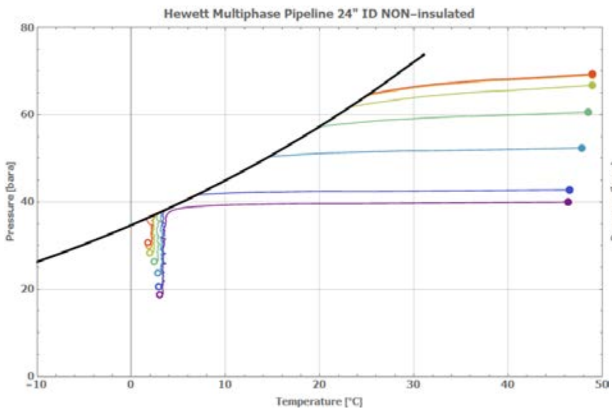
The analysis of the 24" case, shows that the arrival temperature of the pipeline falls below zero (min -4.2°C) for an extended period of time. This phenomenon is also due to the specific insulation value chosen Moreover, the bottom-hole temperature falls temporarily at about -10°C after the last flowrate step up. This seems to be due to a combination of the lower injection capacity of 4 LB wells and to a transient phenomenon, most likely mitigated by carrying out the step-up less abruptly. These hypotheses have not yet been demonstrated by dedicated simulations.

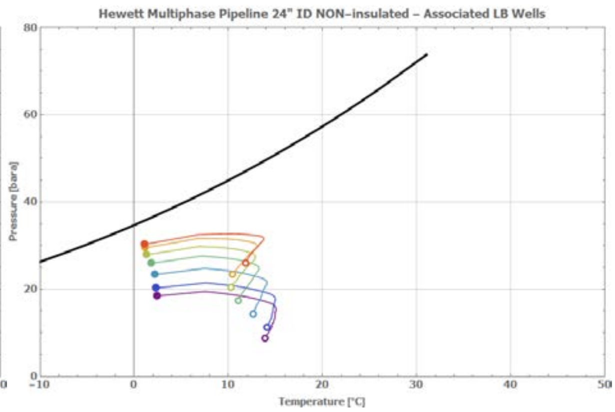
It has to be noticed that the insulation has an influence effect on the thermal profile along the pipeline, but for such a long line, especially for small diameters it has the effect of worsening the arrival temperature for the highest rates. For the 24" pipeline, the thermal profiles with and without insulation are shown below:



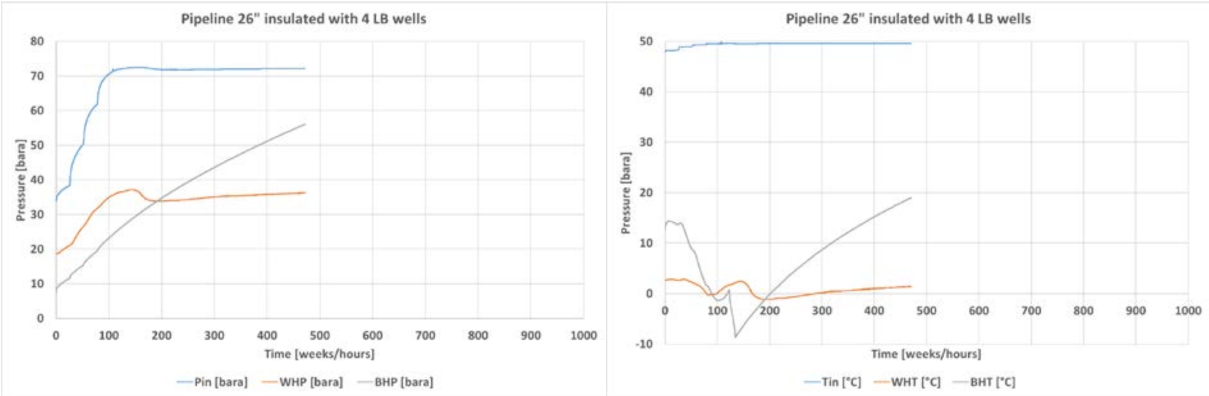


A non-insulated 24" line seems to be able to transport the multiphase flow down to the bottom-hole without violating temperature constraints, both for steady state conditions and some transients (ramp-ups). Shut-ins have not yet been simulated and the shut-in operational logic has to be properly set-up to avoid cooling by depressurization. The first 2 years, up to max injection rate, for the non-insulated 24" are shown below.





The 26”, 28” and 30” cases confirm the same findings but with better thermal conclusions even in the insulated case. Below, it is reported the 26” simulation, stopped at about 500 hours but reported on the same time-axis is used for the 24” case above for easier comparison.



In fact, in this case the arrival temperature of the pipeline has a minimum of -1.2°C and most of the injection history occurs at acceptable operating conditions.

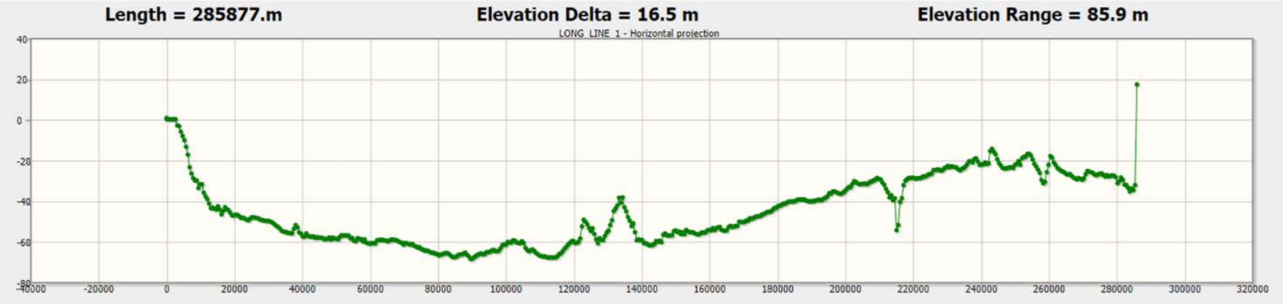
The 28” line insulated results, not reported here, show an even better thermal behavior.

7.7.4 Gas – multiphase pipeline and associated wells – From Bacton or Humberside

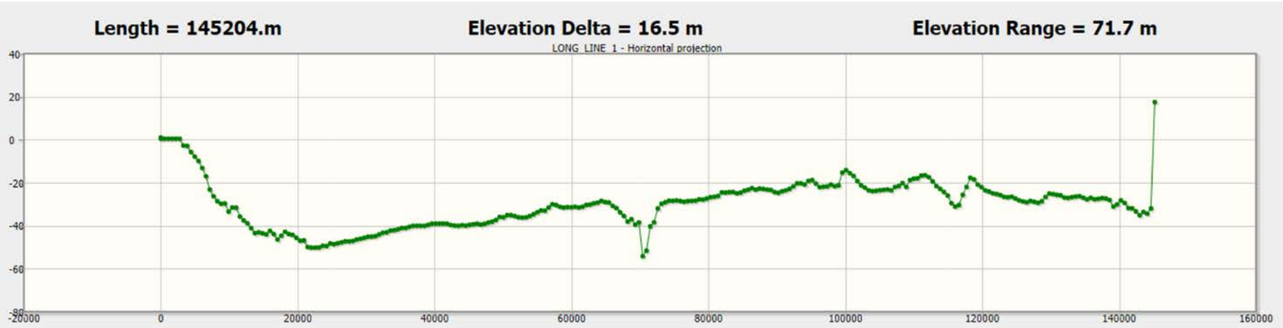
In order to verify the effect of the pipeline length on the results achieved and to identify optimal conditions for transportation, simulations have been performed with “notional” pipeline profiles coming from Bacton and Humberside industrial areas. The bathymetries of such hypothetical lines were derived from the Teesside-Hewett profile. All the cases were considered buried with an inlet temperature of 50°C.

The lengths of the pipelines were respectively 43km and 145km, with the accessible coastal sections suggested by the circles in the picture above.

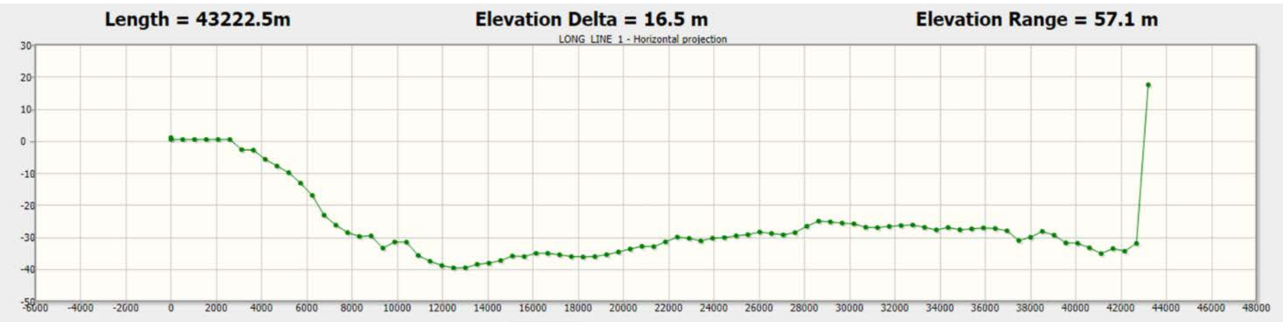
The bathymetries used for the three cases are represented below for direct comparison. The notional cases from Humberside and Bacton have been generated by modifying the reference Teesside case.



Bathymetry for the pipeline Teesside - Hewett



Bathymetry for the pipeline Humberside - Hewett



Bathymetry for the pipeline Bacton - Hewett

The pipeline was connected to 4 identical injection wells, with the Lower-Bunter completion. This simplification allowed for faster simulations, slightly conservative, since the injection capacity of the Upper Bunter well (being shorter and larger diameter) would be larger.

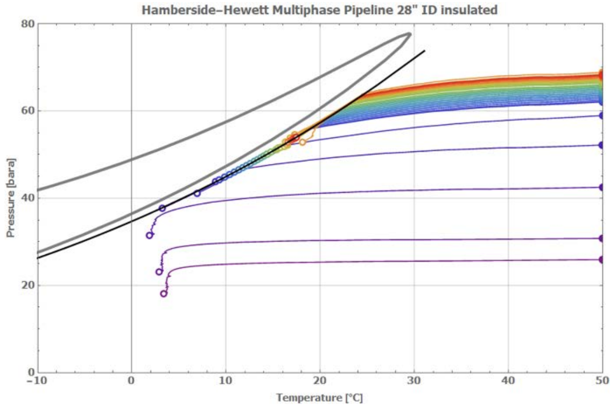
To prevent low temperatures in the wells, the injection rate ramp-up has been regularized as follows:

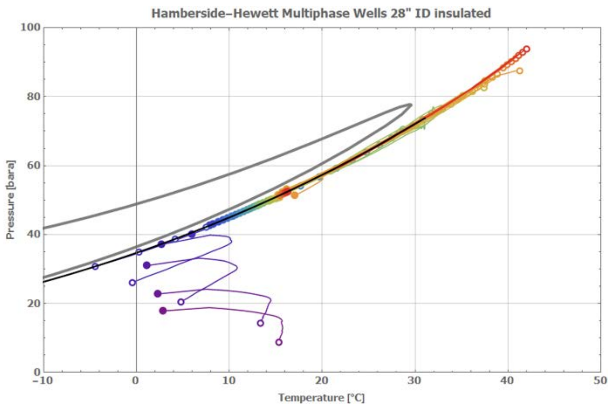
1 year	2.44 MTPA
1 year	3.66 MTPA
1 year	4.88 MTPA
after	6.00 MPTA

This injection profile is qualitatively representative, i.e. is not considered unrealistic for all the cases studied.

Olga simulations can be carried out in the Pressure-Enthalpy plane only with pure CO_2, but as a reference, is the graphics below also the phase diagram of impure CO_2 has been represented, to illustrate the changes that the different phase envelope could imply.

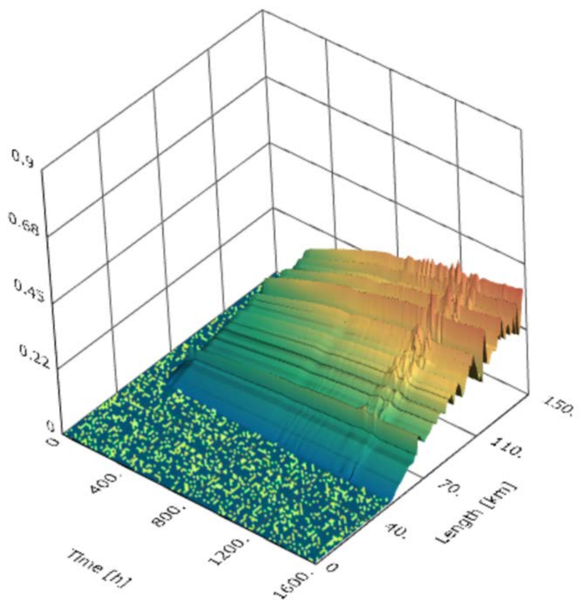
The T-P evolution for the longer line case is illustrated below.

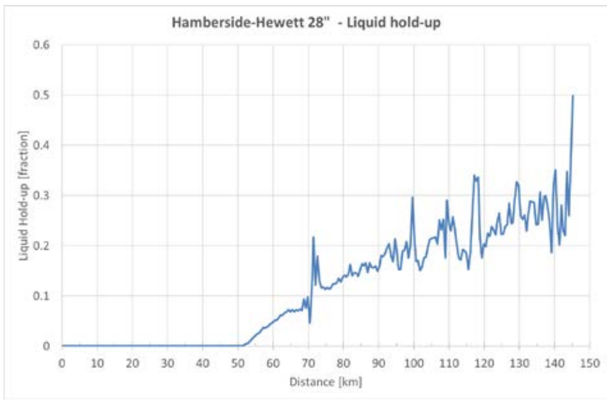




From the diagrams, it is clear that the transportation in the 145 km pipeline and in the wells is almost always multiphase, given the fact that the T-P points do not abandon the phase change line. This is mostly true also for the wells.

The chart of the liquid hold-up in the pipeline (i.e. the pipeline fraction filled with liquid along it length and along the injection history), is shown below.

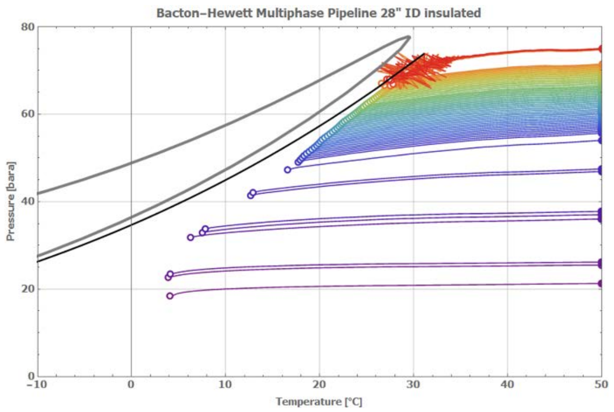


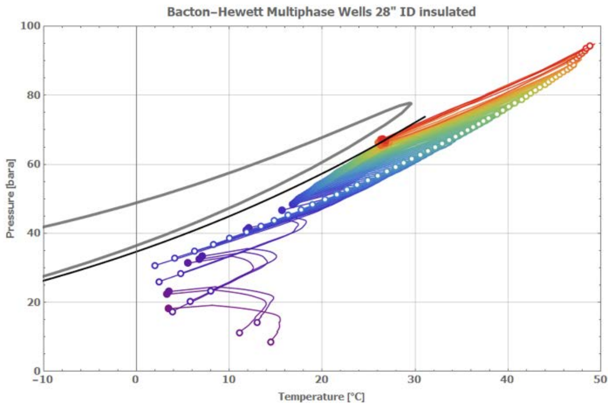


Liquid hold-up at the end of the injection history

The above chart indicates that the first 50km of pipeline are free of liquids, i.e. the combination of pipeline insulation and pressure drop do not allow the CO_2 to enter the phase change region for about 50 km.

This result was checked for the shorter (43 km) 28" ID pipeline from Bacton area, which falls into the 50 km distance. The corresponding simulations are shown below.





At some point in the injection history, when the bottomhole pressure grows above approximately 90 bar, the phase change line is touched and the simulation becomes unstable (irregular red line in the left chart). It is difficult to say if this instability is not only numerical but also physically justified. In any case, two observations can be made:

- The pipeline flow with pure CO_2 becomes multiphase (and unstable) only at the very end of the injection history, when most of the storage volume has already been achieved

- As seen from the position of the impure CO_2 phase diagram (gray line), the phase change region might not be touched at all, since it occurs at higher pressures and lower temperatures.

With a 26” internal diameter pipeline, the multiphase condition is achieved earlier in the injection history, since the arrival temperature are lower by about 5°C.

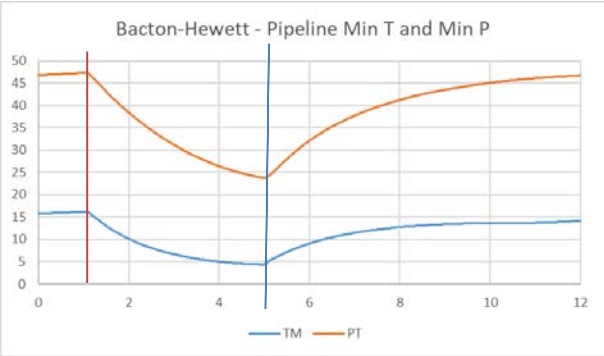
The above results suggest that, for pipeline lengths below 50 km, a single phase steady-state transportation could be achieved throughout the storage life. In that case, multiphase conditions would occur only inside the wells and during prolonged shutdowns, in which the soil thermal capacity would not be sufficient to keep CO_2 temperature above the phase-change region.

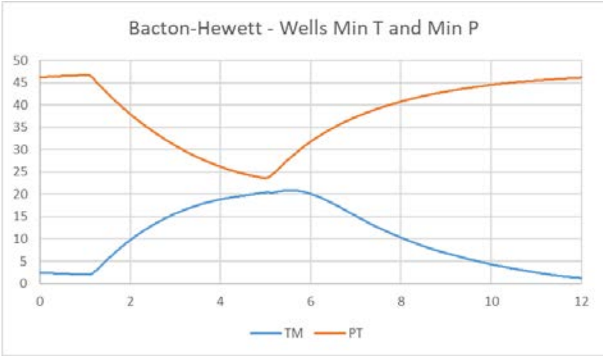
7.7.5 Bacton -Hewett pipeline – Transients

The transient behavior of the 43km pipeline has been explored by performing shut-downs and subsequent start-ups for the first half of the pipeline life, until the wellhead and the bottomhole pressure reach respectively 50 and 77 bara (half of the injection life). Further simulations will be performed, but the results achieved in that period suggest a rather benign behavior.
The steady-state and corresponding transients have been performed for three inner diameters (24”, 26” and 28”), but given the single-gas-phase property of the 28” ID pipeline, only its transients are reported here.

Each transient has been defined as follows: gradual injection shut-down in 1 hour, from the planned rate down to zero, shut-down for 3 hours, restart in 1 hour from zero back to the planned rate.

An example of the evolution of pressure and temperature in the pipeline and wells is shown below for an injection rate of 6 MTPA. This is the transient which achieves the minimum temperatures in the wells.





A table summarizing all the most relevant results for the transients is below.

MASS RATE	PIPELINE MIN T	PIPELINE MAX T	PIPELINE MIN P	PIPELINE MAX P	PIPELINE ACCUM LIQUID	WELLS MIN T	WELLS MAX T	WELLS MIN P	WELLS MAX P	WELLS ACCUM LIQUID
kg/s	*C*	*C*	*BARA*	*BARA*	*M3*	*C*	*C*	*BARA*	*BARA*	*M3*
69	0.6	50.0	8.8	25.2	0.0	0.5	21.8	8.7	23.3	0.0
70	1.0	50.0	11.1	26.2	0.0	0.7	22.2	11.0	24.5	0.0
105	1.5	50.0	14.8	36.7	0.0	1.3	19.3	14.7	34.1	0.0
106	2.1	50.0	17.8	37.8	0.0	1.9	20.7	17.7	35.6	0.0
141	3.5	50.0	21.0	47.2	0.0	3.4	22.0	20.8	44.2	0.0
174	4.4	50.0	23.7	54.0	0.0	1.2	23.4	23.6	50.2	0.0
175	5.2	50.0	25.9	55.9	0.0	4.4	25.3	25.7	52.4	0.0
177	5.6	50.0	27.7	56.5	0.0	5.7	26.5	27.5	53.3	0.0
177	6.1	50.0	29.4	57.1	0.0	6.1	27.4	29.3	54.2	0.0
178	6.6	50.0	31.2	57.7	0.0	6.6	31.4	31.0	55.3	0.0
179	7.1	50.0	32.9	58.3	0.0	7.1	35.3	32.7	56.5	0.0
180	7.6	50.0	34.5	58.9	0.0	7.6	37.3	34.2	57.7	0.0
181	8.0	50.0	36.0	59.4	0.0	8.1	40.0	35.7	59.0	0.0
182	8.4	50.0	37.3	60.0	0.0	8.6	45.3	37.0	60.4	0.0
182	8.8	50.0	38.6	60.6	0.0	9.0	47.0	38.3	61.8	0.0
183	9.3	50.0	39.9	61.1	0.1	9.5	48.0	39.6	63.2	0.0
183	9.8	50.0	41.1	61.7	0.8	9.9	48.5	40.7	64.6	0.0
184	10.3	50.0	42.2	62.3	4.5	10.5	48.9	41.8	66.0	0.0
184	10.9	50.0	43.3	62.8	8.4	11.0	49.1	42.9	67.4	0.0
185	11.3	50.1	44.3	63.3	13.3	11.4	49.4	43.9	68.7	0.0
185	11.7	50.0	45.3	63.8	19.3	11.8	49.5	44.9	70.0	0.0
185	12.2	50.1	46.2	64.2	25.9	12.4	49.6	45.8	71.2	0.0
186	12.5	50.1	47.0	64.7	27.4	12.8	49.7	46.6	72.4	0.0
186	12.9	50.1	47.8	65.2	36.3	13.2	49.7	47.4	73.6	0.0
186	13.4	50.1	48.6	65.6	43.2	13.6	49.8	48.2	74.7	0.1
186	14.0	50.1	49.3	66.0	44.2	14.0	49.9	48.8	75.8	0.1
186	14.5	50.1	50.0	66.4	46.8	14.5	49.9	49.5	76.9	0.2

In all the cases examined, the minimum temperatures and the other statistics reported do not trespass the limits considered for the operations of the pipeline and wells but, in particular in the pipeline, the accumulation of some liquids is detected when the minimum pipeline pressure exceeds 38 bara. This means that, for longer transients, a growing amount of liquids might condensate in the pipeline. Upon injection restart, special actions and/or heating may be required to cope with latent heat and slugging.

The management of such transients has not yet been addressed and must be properly defined.

7.7.6 Gas – multiphase pipeline – Concluding remarks

The simulations performed so far have not ruled out the no-heating multiphase transportation scenario, especially in the case of shorter distance (e.g. a 28” ID buried pipeline from Bacton). Nevertheless:

- Open points remain with respect to pipeline sizing. A 24” non-insulated pipeline gave promising results, allowing (at least in principle) to reduce the ball-park between the dense-phase and the multiphase diameters. The inner diameter range 24”- 30” seems appropriate for the multiphase pipeline. As is generally true for multiphase design, the optimal line diameter is not defined a-priori but has to be selected jointly with distance, insulation and operating conditions. Dense-phase design is undoubtedly easier to carry out

- More work remains to be done with respect to transients, especially pipeline shut-ins and restarts, which have been only partially simulated.

8 PROCESS DESIGN DATA

8.1 Process description

The HCIP platform is designed to minimize equipment and to maximize efficiency while providing systems that are robust and can handle a wide range of operating conditions. The main gas processing facilities consists of gas heating (if necessary) and gas injection in reservoir. All utilities required to support the processing systems are provided along with the equipment needed to ensure safe and environmentally acceptable platform operations.

CO_2 arrives from the Teesside Industrial Area dedicated sealine at a higher pressure as that needed for injection purposes: for this reason, gas pressure is reduced by mean of a pressure reduction valve (one for each injection string).
In normal operation, the gas expansion through the pressure valves causes a fluid temperature drop. Where this temperature drop is critical for reservoir integrity, the gas will be heated before its pressure reduction.
Gas injected in each reservoir level (Upper or Lower Bunter), if necessary, will be heated in order to reach adequate process conditions, by means of multiple oil-bath heaters (each equipped with electrical heater).
Gas pressure is reduced and controlled before injection in multiple pressure control valves and then injected through dedicated wells to Hewett Reservoirs.
The maximum CO2 arrival pressure from onshore facilities is considered 140 barg and minimum gas injection pressure is considered 10 barg. Sealine design pressure: 150 barg.

Fixed MEG injection point are installed upstream of each wellhead.

During normal operation, since gas pressure is reduced from sealine flowing conditions (controlled from onshore facilities) to injection manifold pressure, limited fluid expansion could cause the fluid temperature to drop to a level not so critical with respect to start-up phase. In this situation, fluid won’t be heated up (by means of heat exchanger) and then the pressure will be reduced by means of pressure valve.

A pig receiver will be provided for cleaning and inspecting the CO2 sealine connected to onshore facilities.

The Vent Unit will include one stack, which will be designed to gather and disperse into atmosphere continuously blanketing gas, closed drain vent gas or emergency gas discharges.

The purge burner system, (consisting of 1 purge burner) will burn the fluid coming from the wells during start-up production phase and/or during their work-over operations.

8.2 Process Simulation

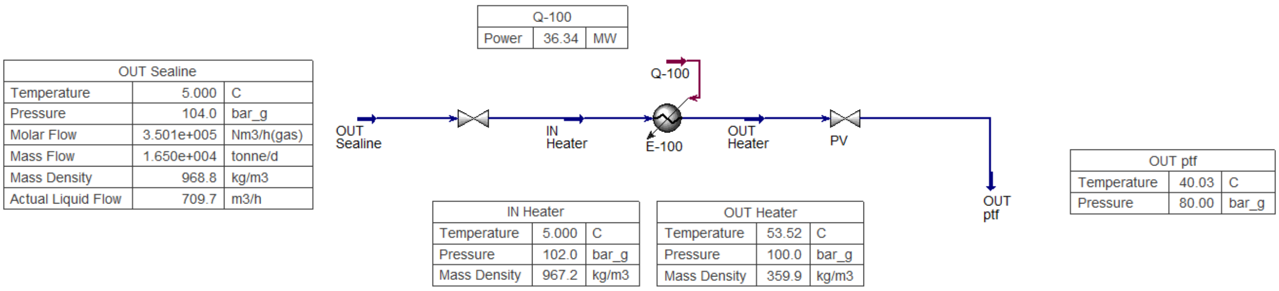
8.2.1 Process Simulation Software

The process software used to model the topsides processing facilities and to prepare the heat and mass balances for the main process is HYSYS version 10.0 from Aspen Tech.
Note that transport properties (surface tension, density, thermal conductivity, viscosity, etc.) have been calculated considering the default models used by HYSYS.

8.2.2 Simulation Property Package

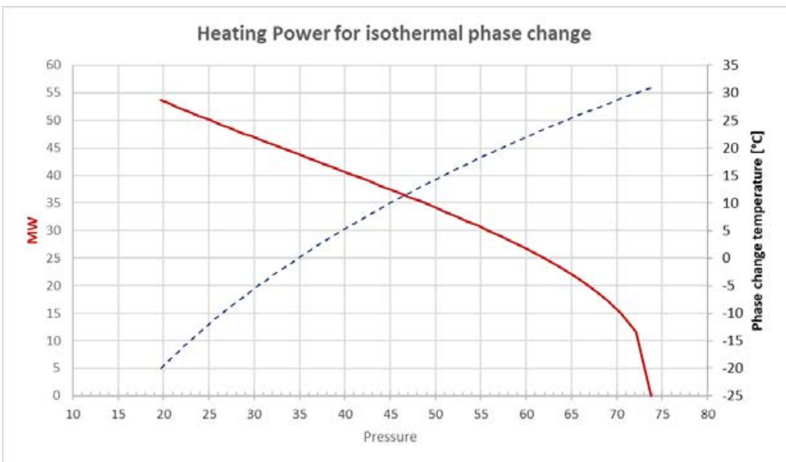
The base thermodynamic equation of state (EOS) used for the process simulations is Peng-Robinson (PR). The liquid density is calculated by the default Costald method even if it is high pressure/high temperature conditions.

8.2.3 Process Flow Diagram



8.2.4 Injection heating power along the injection lifetime

The heating power required during the injection lifetime depends on the wellhead pressure conditions. It can be estimated by examining the following chart, depicting the energy required to completely convert 6 MTPA of pure liquid CO_2 into pure gaseous CO_2 at a fixed temperature.



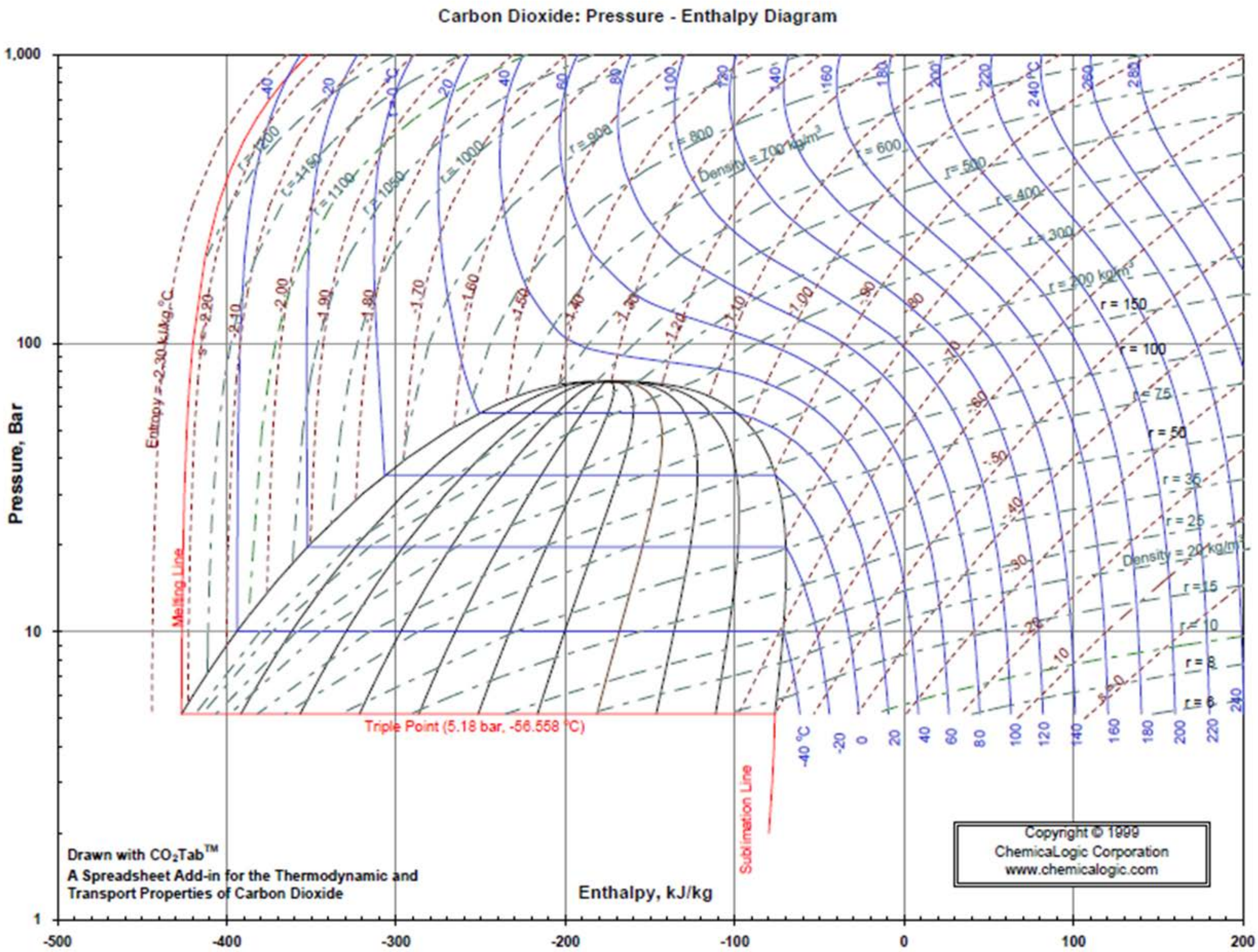
The diagram can be read as follows. If CO_2 is transported at 5°C, phase change will occur at about 40 bara (dashed line). At that P and T, the power required to “gasify” isothermally 6 MTPA of CO_2 is 40 MW (red line). If an additional temperature increase is required, additional power has to be applied, as in the following table:

Starting gas Temperature (6 MTPA)	**Power to achieve the final gas Temperature**		
	20°C	**30°C**	**40°C**
5°C	4.2 MW	6.7 MW	9 MW

The total power required is the sum of the two terms, so that converting 6 MTPA of liquid CO_2 at 5°C to gas CO_2 at 40°C, 49 MW are required.

If the transportation temperature is variable (e.g. due to seasonal changes or pipeline inlet temperature) the heating power can be varied and reduces. E.g. for an inlet temperature of 20°C, isothermal gasification power results in about 27 MW and, if multiphase flow in wells is accepted, no further heating is required, with a significant saving.

The same information can be qualitatively drawn from the Mollier chart below:



8.3 Process Units Description & Design Criteria

The platforms consist of the following units:

Unit 100	Well Head System
Unit 120	Chemical Injection System
Unit 190	Receiving Trap System
Unit 230	Vent System
Unit 240	Purge Burner System
Unit 300	Gas Heating System
Unit 450	Hydraulic Power System
Unit 460	Compressed Air System
Unit 480	Stand-by Diesel Generation System
Unit 540	Drains System
Unit 630	Lifting Facilities
Unit 700	Fire & Gas System
Unit 710	Safety Personnel Equipment
Unit 720	Navigation Aids System
Unit 920	Main Power Distribution System
Unit 970	Remote Terminal Unit (RTU)
Unit 980	ESD System (WHCP)

8.3.1 Unit 100 - Well Head System

SYSTEM DESCRIPTION

Unit 100 connects the reservoir with the topsides facilities by means of dedicated strings.
Four injection wells are foreseen for installation
Each string is equipped with:

- N. 1 sub-surface safety valve (SSSV);
- N. 1 master valve (SSV);
- N. 1 wing valve (WV);
- N. 1 Check valve system

The SSSV valves are hydraulically actuated (by oil), while the SSV and the WV valves are pneumatically (by air) actuated type.
On all injection strings, upstream each wing valve (WV) a fixed MEG injection point is installed.
A check valve system is foreseen in order to avoid reservoir water to reach topside facilities after process shut-off.

8.3.2 Unit 120 – Chemical Injection System

SYSTEM DESCRIPTION

This Unit shall be designed to prevent eventual hydrate formation in the gas stream lines by means of MEG injection.
MEG injection will be used, where necessary, during start-up operations.

The geometric volume of the storage tank shall be about 8 m3.

The storage tank is provided with n°1 PSV as safety device against overpressure (fire case, blanketing gas system malfunction).
The system shall be also equipped with fluid filters, suitable to operate both with methanol and MEG, installed upstream pumps suction header in order to separate solid particles.
Each injection pump will be supplied with a dedicated pulsation damper (installed downstream the pump to minimize pressure peaks and inertia effects caused by rapid stroke motion -sinusoidal tendency) and discharge line provided with a pressure safety valve (PSV) set at 70 barg to ensure safety in blocked outlet condition.
A nitrogen bottle package is used for tank blanketing.

DESIGN DATA

Equipment	Methanol/DEG Tank 001200TA001
Dimensions - ID x (LT-LT)	1500mm x 2600mm
Design temperature/pressure	-10÷60°C / 3.5 barg ÷ FV
Operating temperature/pressure	AMB / 0.02÷0.2 barg
Geometric volume	8 m3

8.3.3 Unit 190 – Receiving Traps System

SYSTEM DESCRIPTION

This Unit shall be designed to perform dewatering of gas export sealine. The trap will be horizontal type, suitable for dewatering pig. The launching trap system will include one (1) horizontal launching trap, for the sealine to HCIP platform.

DESIGN DATA

The system design is based on the following data:

Sealine diameter to HCIP platform:	20”-30”
Design pressure for sealine to HCIP platform:	150 bar g
Design temperature:	-20 / 60°C

The receiving trap system is designed for 150 barg (similarly to fluid sealine). The PSV sizing criteria will be therefore considered the blocked outlet case.

DESIGN CRITERIA

The external diameter of trap tube-end shall coincide with diameter sealine; the launching trap body shall be sized and equipped with mechanical interlock system.
A mechanical type pig signaler shall also be installed.

8.3.4 Unit 230 - Vent System

SYSTEM DESCRIPTION

This Unit shall be designed to collect and disperse into atmosphere emergency gas coming form discharge pressure safety valves and automatic/manual depressurization discharges.

The Vent System includes:

- a stack which collects:
  - the gas relieved during depressurization/emergency phase (discontinuous discharge)
  - gas coming from low pressure PSV and continuous /operational reliving

The vent size and length shall be suitable to ensure that no dangerous concentration of flammable gas neither hazardous levels of radiation reach the platform area in case of accidental ignition of the vented gas.

DESIGN CRITERIA

Vents shall be sized according to API methodology and for the governing relief scenario.

8.3.5 Unit 240 – Purge Burner System

SYSTEM DESCRIPTION

The purge burner system shall be designed to:

- burn the fluid coming from the wells during start-up production phase and/or during workover operations.

Purge burner and vent system shall be sized according to API 521 methodology and will include the following equipment:

- A horizontal stack, 002400FS001;
- A purge burner provided with its ignition control panel;
- Propane bottles to feed the burner pilot.

The horizontal stack size and length shall be suitable to ensure that no dangerous concentration of flammable gas neither hazardous levels of radiation reach the platform area in case of manual or accidental ignition of the vented gas.

DESIGN DATA

The following design data are assumed:

- Number of burner:	1;
- Maximum well head static pressure:	140 bar g;
- Maximum well head flowing pressure:	125 bar g;
- Minimum well head flowing pressure:	4 bar g;
- Operating well head flowing temperature:	50°C.

The system design according to API RP 521 will be based on the following data:

- Max. allowable heat radiation	1.58 kW/(m2)(1);
- Maximum allowable Mach number:	0,7;

- Wind velocity (for well purging operating case): 10 m/s (either with counter-wind and downwind);
- Operating Pressure (during discharge): atm.
- Operating Temperature (during discharge): -25°C

Notes: (1) Heat intensity (corresponding to 500 BTU/(ft2 h)) in areas where personnel with appropriate clothing (e.g. fireproof overalls, boots, gloves, helmet etc. as per API 521) can be continuously exposed; conditions refer to the nearest personnel access point on the deck. Value do not include solar radiation.

DESIGN CRITERIA

The main relevant vent parameters and sizes are listed below:

	Purge Burner System
Design case	Start-up/Purging of the plant
Design temperature, °C	-20 /+200
Design pressure, barg	8

Notes: (1) Maximum design temperature to be confirmed by purge burner Vendor

The size and position of purge burner tube shall be defined in order to match a maximum heat radiation at the nearest personnel access point on the deck of 500 BTU/hr ft2, as per API 521 methodology.
Purge burner orientation will be chosen according to the wind direction.
The purge operation shall be executed only during inspection visits, when the maximum wind speed will reach 10 m/s.
The liquid entrained in the purge burner system shall be collected by a liquid pot.
The liquid collected shall be discharged manually into drain system.

8.3.6 Unit 300 – Gas Heating System

SYSTEM DESCRIPTION

In normal operation, the CO2 expansion in injection string through the pressure reduction valves and the injection well (tubing) causes a fluid temperature drop. Where this temperature drop is critical for reservoir integrity, the CO2 gas will be heated before its pressure reduction.
Multiple hot oil-bath heater type will be used to heat indirectly the liquid CO2 stream.
Heat transfer is indirect since liquid CO2 flows in a coil, which is submerged in diathermic oil (intermediate fluid).
The oil is heated by means electrical heaters (n°4 electric heaters per equipment) CO2 does not come in contact with the elements of the electric heaters.
Design pressure of gas coils shall be sealine design pressure.
The CO2 Heater is provided with two SDV and a BDV valve on the process line and with a dedicated blow down discharge line (to safe location), properly dimensioned to preserve the mechanical integrity of the outer shell in case of coil internal rupture. The tube rupture scenario shall be mitigated assuring that an open flow path is always available for a gas relieving, thus avoiding CO2 heater outer shell pressurization above design value.

DESIGN CRITERIA

Fuel gas heaters or other power source directly associated to CO_2 emission have been discarded in compliance with project philosophy. Oil-bath heater was preferred over water-bath equipment in order to maximize space and weight savings/reduction, favorable material selection and easy routine maintenance (operating fluid top-up etc.).
A 10% overdesign shall be considered for gas/liquid flow rate. The injection profile conditions will be investigated in order to determine the most critical year, i.e. the one leading to the highest duty.
Calculations will be performed based on the reservoir pressurization profile.
The Fluid will be heated where the difference between injected gas operating temperature at reservoir level and reservoir temperature is less than 20°C.

DESIGN DATA

Equipment	Electric CO_2 Heater
Operating pressure (barg)	100
Design pressure (coils) (barg)	150
Design pressure (shell) (barg)	3.5
Operating temperature min / max (°C)	15 /40
Design temperature min/max (°C)	-10 /120
Dimensions (WxLxH) (mm)	3500 x 8000 x 3500
Preliminary Overall Dimensions (WxLxH) (mm)	12000 x 5000 x 5000
Design Duty (MW)	5
Number of heaters	8
Operating weight (ton)	110

8.4 Utilities Description & Design criteria

The main characteristics of utility units are resumed in the following description:

8.4.1 Unit 450 - Hydraulic Power System

SYSTEM DESCRIPTION

One Hydraulic power unit will be designed to ensure the required pressure of hydraulic oil circuit, in order to maintain the subsurface safety valves (SSSV), installed on wells strings, open. The completely enclosed HPU will contain fluid reservoir tanks, accumulators, pumps and filters, hydraulic circuit and instrumentation.
This unit is located in the Wellhead Control Panel.

8.4.2 Unit 460 - Compressed Air System

SYSTEM DESCRIPTION

The Compressed air system is designed to supply instrument and utility air to all the platform users, pneumatic valves, muster room, wellhead control panel and field instrumentation.
Instrument air is generated locally on platform with a dedicated skid unit. The Unit is mainly consisting of one air compression skid, one wet air accumulator and one air filtering and drying package. The air drying package has been foreseen to remove the moisture and to ensure a dew-point of –20°C at 10 bar g to the instrument users.
This package includes as minimum:

- n° 1 prefilter;
- n° 1 air dryer;
- n° 1 postfilter.

The wet air accumulator shall be design to:

- feed the muster room in case of emergency with fresh air for 30 minutes (TBC).
- to ensure 20 minutes hold up based on instrument air emergency consumption

The air accumulator is provided with n°1 PSV as safety device against overpressure in case of fire.

DESIGN DATA

Instrument air dew point:	-20 °C @ 10 barg
Design pressure:	12 barg
Operating temperature on Platform:	AMB
Design temperature:	-10 / 60°C

8.4.3 Unit 470 - Main Power Generation

The Main Power Generation System shall provide energy to the whole platform loads.
A subsea power cable shall be foreseen from onshore facilities at 132 kV (TBC). On platform topside shall be foreseen a stepdown conservatory type oil transformer of 70 MVA with secondary voltage at 20 kV.

Downstream the main transformer a 20 kV a 50 kA/1s MV switchgear shall be foreseen; from such switchgear a set of 6 MVA dry type transformers 20/0,72 kV shall be foreseen to power feed the heater LV switchgear (provided by heaters manufacturer). A 2MVA dry type transformer 20/0,44 kV shall be foreseen to power supply the auxiliary loads from a LV switchgear.

The above LV switchgear shall have a normal bus bar section and an Emergency bus bar section connected by a bus tie. The Emergency section shall be connected to the Stand by Diesel Generator.

Item	Quantity	Dimensions (mm)	Weight per item (ton)
132 kV Incomer	1	5000x4000x3000	5
132/20 kV transformer 70MVA	1	6500x5000x6000	75
20kV SWBD	1	3000x1250x2800	3
20/6kV transformer 20MVA	3	4700x3200x3900	30
6kV SWBD	3	3200x1500x2500	4
6 kV Coil Heater Control Panel 3MW	12	6000x800x2500	2
6kV Coil Heater Skid 3MW	12	5500x2500x2000	7
20 / 0.4 kV transformer 2MVA	3	2200x1500x2400	6
0.4 kV SWBD	4	4000x1000x2200	3
0.4 kV UPS	2	3500x800x1800	5
0.4 kV EDG 1MVA	1	2800x2000x1900	6

Topside Facilities Power Consumption Estimation

System	Power Consumption [MW]
Chemical Injection System	0.01
Vent and Purge Burner System	0.01
Gas Heating System	40
Compressed Air System	0.05
Lifting Facilities	0.30
Fire Fighting System	2.0
Other Utilities	0.10
TOTAL *(including allowances)*	45

8.4.4 Unit 480 – Stand-by Diesel Generation System

SYSTEM DESCRIPTION

"Stand-by Diesel Generator – SDG shall provide energy to the
loads:

- Recharge battery set when voltage drops below rated value (24V) and contemporaneously, feed the whole "Instrument/Safety" load.
- Platform crane.
- Platform lighting network.
- Platform LV sockets

Diesel engine Start/Stop shall be automatically performed; anyway also manual commands shall be foreseen both from local and remote manned station through R.T.U.

Diesel generator is fed by gravity from a diesel fuel storage tank located nearby.
The capacity of diesel fuel storage tank is calculated for 48 h (TBC) of diesel generator operation.
The fuel supply line to diesel engine shall be equipped with a pneumatic SDV that will be closed in case of fire (fusible plugs network intervention).
The tank refilling shall be made from boat landing by means of a dedicated line (drum and pump installed on supply vessel). The generator shall be placed in a dedicated skid with relevant local control panel, starting battery, diesel fuel storage tank, stand-by diesel generator and silencer.

The diesel engine generator shall have the following main features:

- Installation inside enclosure (max. 85 DB at 1 meter) together with starting battery and frontal control panel;
- Engine exhaust piping with silencer having spark arrestor.
- Design Temperature -10 / 60°C.

8.4.5 Unit 540 - Drains System

SYSTEM DESCRIPTION

The system aim is to collect and evacuating the following closed and open drains.

- Closed Drains:
  - Oily drains from process equipment (from Unit 300);
  - MEG unit drains.
  - Diesel fuel system and hydraulic oil system drains;
- Open Drains:
  - Rainy water drains from containment basin;
  - Rainy water from platform decks drain boxes.

Any drain, which can be contaminated with hot oil/MEG, has been called "potentially oily drain".
Any drain coming from hot oil/MEG, has been called "oily process drain".

One oily process drain tank will be dedicated to process equipment/MEG unit drains.
Another drain tank will be divided in 2 compartments.
The open drains, i.e. potentially oily water drains (mainly rainy water) coming from containment basin, shall be routed to a dedicate compartment of the Open Drains recovery tank by means of a dedicated header.

The closed drains from diesel fuel and hydraulic oil system shall be convoyed together and routed to the other compartment of Drain recovery tank by means of a dedicated header; this compartment shall be used to empty diesel fuel system and hydraulic oil system in case of maintenance.

DESIGN CRITERIA

The system design criteria for the oily process tank is to ensure a storage capacity suitable to accommodate the biggest volume coming from one hot oil gas heater or from the MEG storage tank.
The system design criteria for the open drain tank is to ensure in the open drain compartment (mainly rain water) a compartment a storage capacity suitable to accommodate a fraction of the platform equipment closed drains coming from process equipment and eventually rainy-water coming from the drip pans.
The diesel oil and hydraulic oil is periodically discharged into the supply vessel, while the water accumulated into the other compartment can be discharged into the sump caisson by means of a draw-off tube, or into the supply vessel.

DESIGN DATA

Regarding the rainy water drains collecting philosophy, the following criteria shall be adopted:

- rainy water from the drip pans shall be separately collected and routed to the Drain recovery tank;
- rainy water from the drain boxes of the platform decks have been convoyed into a dedicated header and directly discharged into the Sump Caisson.

Design Daily Rainfall shall be: 120 mm/m2/day (TBC).
Peak rainfall shall be: 40 mm/h (TBC).
Peak duration: 20 minutes
Oil density: 750 kg/m3
Water density: 1028 kg/m3
Oil drop separation efficiency: min 200 micron

Equipment	**Oily Process Drain Tank**
Capacity (m3)	80
Dimensions (DiamxL) (mm)	3500 x 8000
Dry Weight (ton)	15
	Open Drain Tank
Total capacity (m3)	8
Dimensions (DiamxL) (mm)	1500 x 4000
Dry Weight (ton)	3

8.4.6 Unit 720 - Navigation AID System

SYSTEM DESCRIPTION

The Unit 720 will be installed on the platforms for marine and aerial signalization purpose.
The marking and signalization of offshore structures will be provided in compliance with the latest edition of the applicable regulating International Codes IALA-AISM code (0-114).

The unit will consist of the following equipment:

- Navaid Battery Charger

- Navaid Distribution Board
- Battery Set
- Battery Cut-off Junction Boxes
- Main Signal Lights
- Navaid Photocell
- Main Fog Horns
- Visibility meter
- Obstruction Lights

Unit 720 shall be remotely monitored and controlled by means of a dual redundant serial link interconnected with the RTU (PCS section) and hardwired connection (ESD section).

8.5 Topside Facilities Weigh Estimation

Preliminary weight estimation of primary topside facility equipment is listed hereafter:

Item	Quantity	Weight per item (ton)	Total Weight (ton)
Mechanical Equipment			
Receiving trap	1	1	1
Electrical heater	8	110	880
Oily drain	1	15	15
Diesel/Open Drains	1	3	3
Total Mech. Equip.			**899**
Power Generation Equipment			
132 kV Incomer	1	5	5
132/20 kV transformer 70MVA	1	75	75
20kV SWBD	1	3	3
20/6kV transformer 20MVA	3	30	90
6kV SWBD	3	4	12
6 kV Coil Heater Control Panel 3MW	12	2	24
6kV Coil Heater Skid 3MW	12	7	84
20 / 0.4 kV transformer 2MVA	3	6	18
0.4 kV SWBD	4	3	12
0.4 kV UPS	2	5	10
0.4 kV EDG 1MVA	1	6	6
Total Power Gen. Equip.			**339**
TOTAL Topside Facilities *(incl. 30% contingencies)*			**1610**

9 CO2 DISPERSION ASSESSMENT STUDY

The scope of this chapter is to present high level carbon di oxide gas dispersion analysis at the offshore platform and evaluate the CO_2 hazards through PHAST software version 8.11:

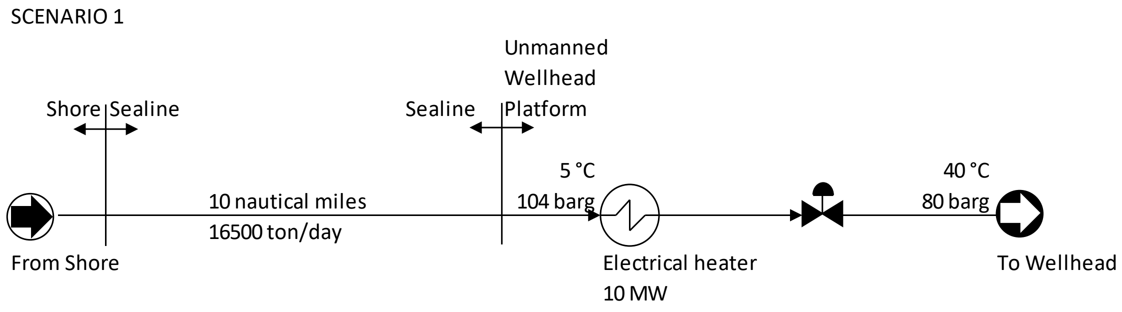
- A rough estimate of dispersion behavior for key hole sizes to provide design input for layout and positioning of key sub-facilities and stand-by vessel.
- Using three concentration levels which are of interest to the personnel;
- Preliminary correlation of experimental data to provide estimate of low temperature due to leaks and
- Graphical representation of few critical leak hole sizes of interest

This chapter also recommends the measures to protect personnel and asset against the CO_2 hazards based on the dispersion analysis outcome.

9.1 SYSTEM CONFIGURATION

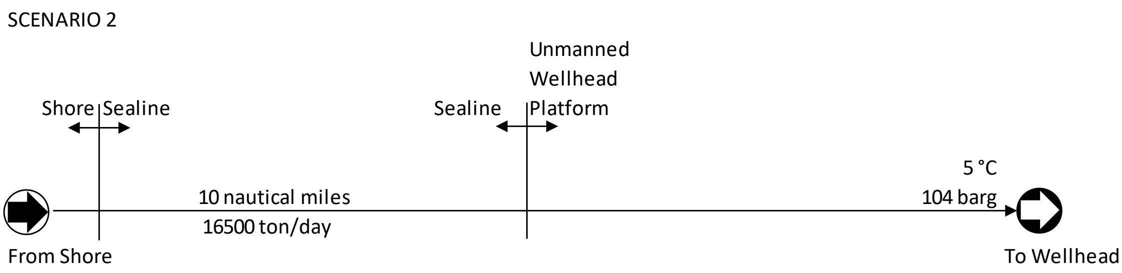
Two scenarios have been considered in the project.
Both assume injected fluid is composed of 100% CO2, however, at different pressure, temperature and mass flowrates.

First scenario



In the first scenario, CO_2 will be transported in dense phase from shore to the new unmanned wellhead platform, located about 10 nautical miles far from shore.
In the wellhead platform the fluid will be heated by means of an electric heater (assumed duty: 10 MW) and pressure will be reduced in order to inject the fluid into reservoir at 40°C and 80 barg.
This scenario has been used for the preliminary gas dispersion analysis since at this stage the consequences are worst and hence the it's safety impact is significantly higher. The outcome of this scenario can be extended to the later scenario since based of fluid conditions, the results for second scenario closely follows the result for scenario 1.

Second scenario



In the second scenario CO_2 will be transported in dense phase.
In this second scenario heating of the fluid is not foreseen.

9.2 MAIN AVAILABLE DATA AND MAIN ASSUMPTIONS

Fluid composition: 100% CO_2
Sea water depth: 30 m
Distance shore/WHP: 10 nautical miles
Transported flowrates: from 2500 ton/day to 16500 ton/day
Pipeline diameter: 30”
Topside inventory: 80 m^3 (considering appropriate topside ESDVs)
Operating Pressure 104 barg
Design pressure: 200 barg

It has been assumed that the at the platform end pipeline will have a riser ESD valve to limit the carbon dioxide inventory and furthermore a subsea safety isolation valve may be beneficial subject to further safety study.

9.2.1 Environmental data

Since no detailed information about the environmental conditions are available, the wind parameters adopted within the consequences assessment have been selected considering the approach usually adopted in risk analysis recommended by Company specifications.
In particular, for the characterization of the wind and weather stability class based on North Sea typical weather conditions have been adopted:

- 2F
- 5D

9.3 ASSESSMENT RESULTS

The study takes into account two main hazards:

- Asphyxiation (toxic) study
- Low temperature hazard for asset and personnel

9.3.1 Dispersion Study

9.3.2 Concentration threshold

The following CO_2 concentration levels in air are considered as reference for the monitoring of CO_2 [1]:

Table 1: Concentration vs time consequences for CO_2 inhalation

Inhalation exposure time	SLOT: 1-5% Fatalities		SLOD: 50% Fatalities	
	CO_2 Concentration in air*		CO_2 Concentration in air*	
	%	ppm	%	ppm
60 min	6.3%	63 000 ppm	8.4%	84 000 ppm
30 min	6.9%	69 000 ppm	9.2%	92 000 ppm
20 min	7.2%	72 000 ppm	9.6%	96 000 ppm
10 min	7.9%	79 000 ppm	10.5%	105 000 ppm
5 min	8.6%	86 000 ppm	11.5%	115 000 ppm
1 min	10.5%	105 000 ppm	14%	140 000 ppm

Note: * Concentration by volume

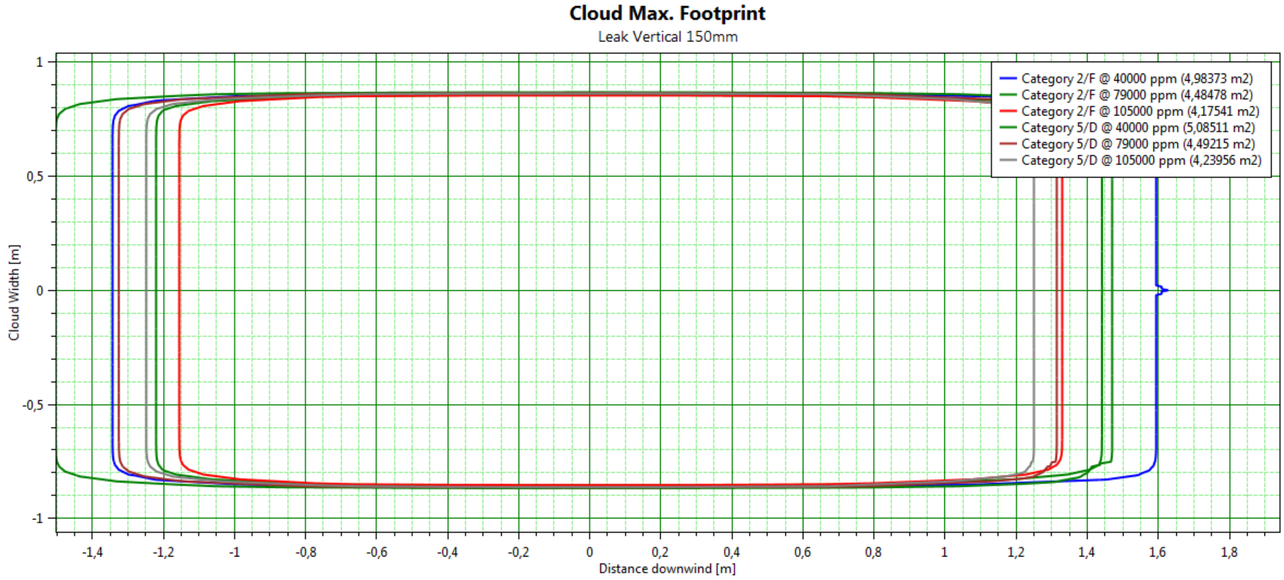
Three concentrations (in ppmv) are used in this report:

a) 40 000 – IDLH 30 min exposure for start of adverse health impact; time within which people evacuate the facility
b) 79 000 - 10 min exposure for 1 % fatality; time required for people to make escape to a safe area
c) 105 000-1 min exposure for 1 % fatality; time required by the people to don Breathing Apparatus.

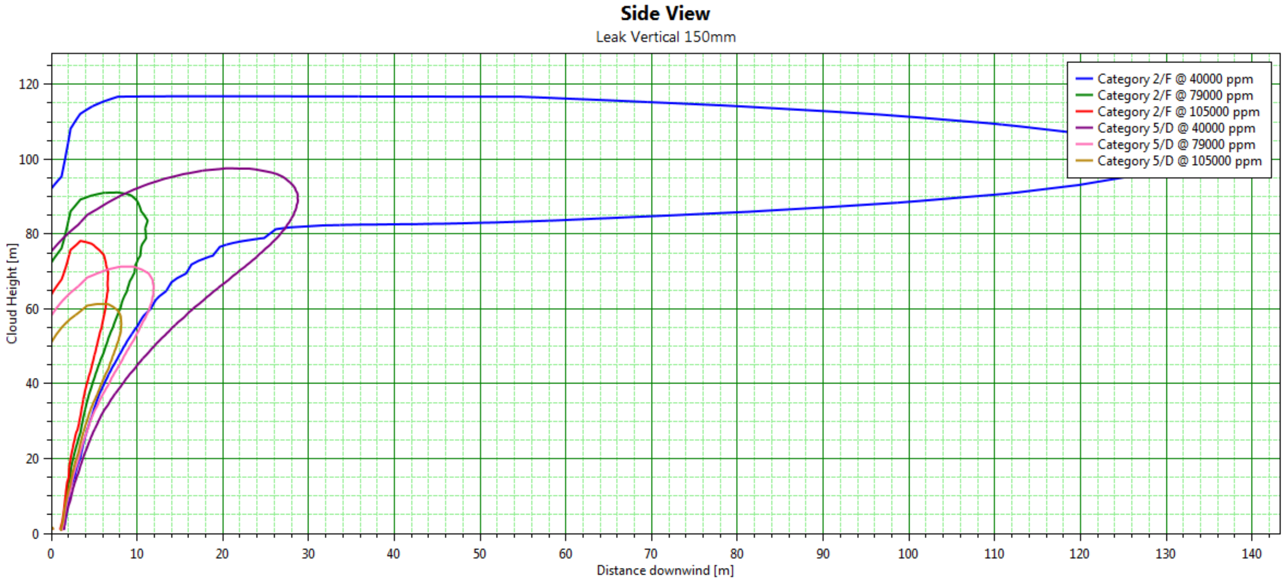
9.3.3 Dispersion result

9.3.4 Pressure 104 barg; 150 mm (catastrophic) leak; orientation: vertical

This case is the worst case representation at the platform

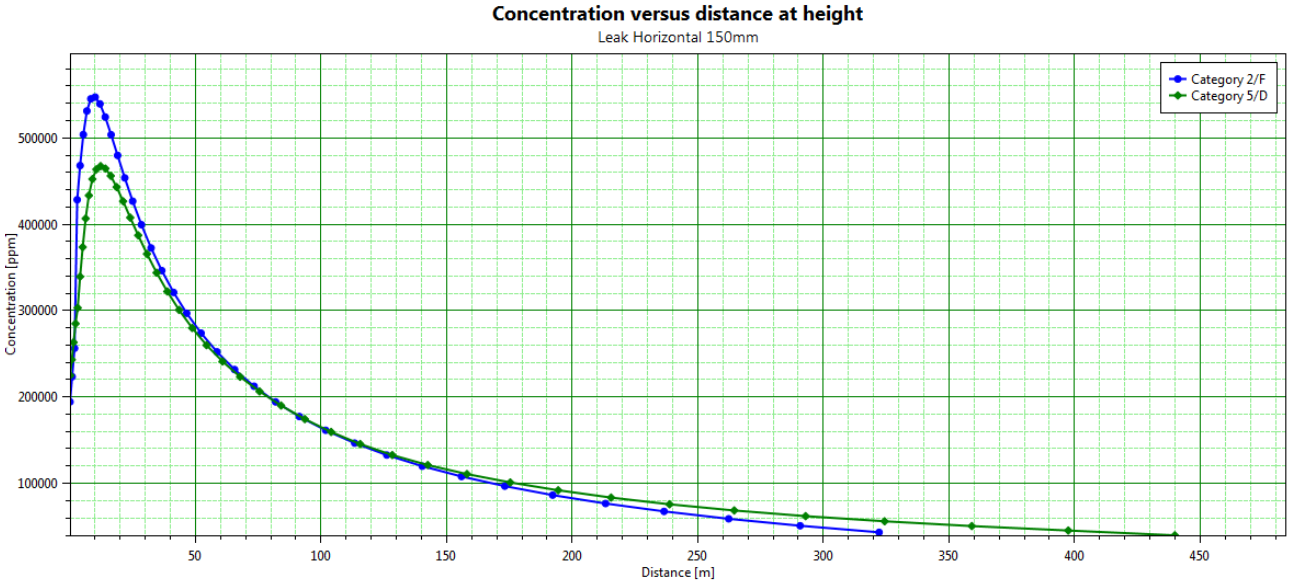


At working height level (2 m), all concentrations of interest are exceeded only in the area in the proximity of the leak (3.2 m x 2 m).

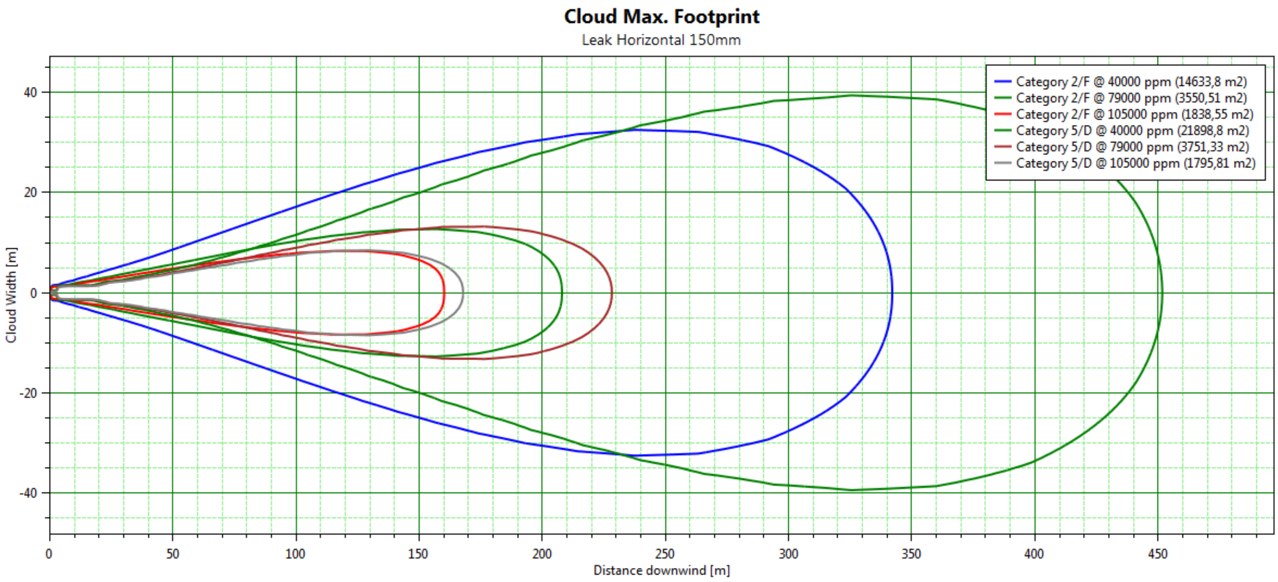


However, as it can be noted from the above graph, the dispersion cloud is oriented upward and will endanger the personnel who may work in the decks above the leak source. Furthermore, if the deck above is plated, the cloud will be dispersed sideways based on the wind direction. For significant release of this size, in such cases, complete deck area may be considered engulfed by fatal concentration of CO2 cloud within a very short time (few seconds)

9.3.5 Pressure 104 barg; 150 mm (catastrophic) leak; orientation: horizontal

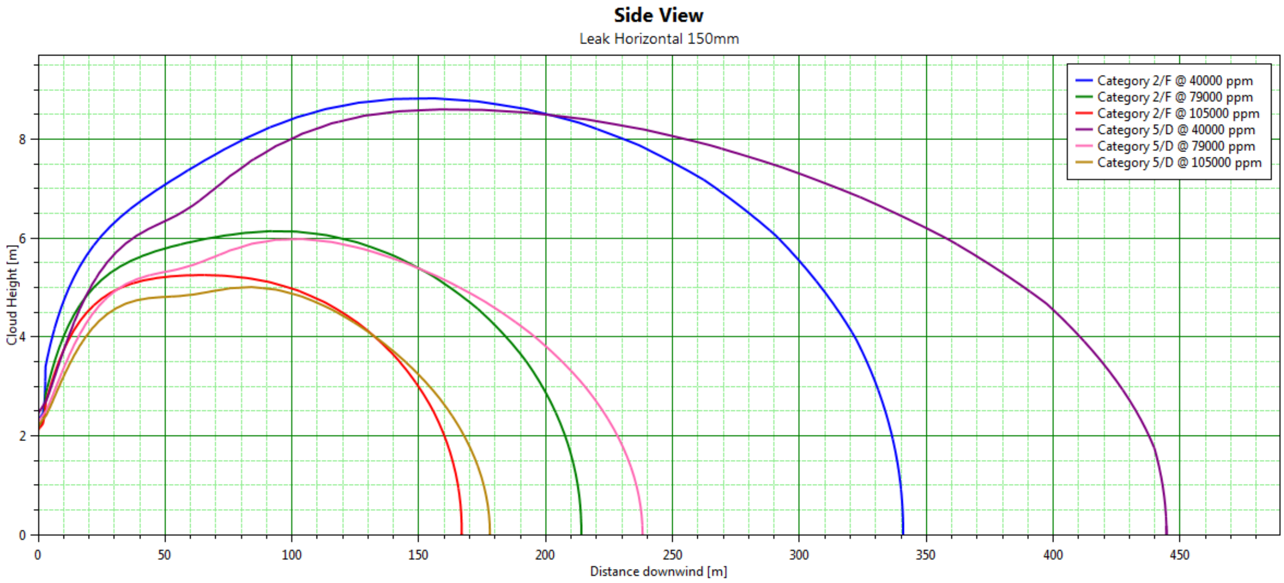


The graph reported above shows how concentrations at the height of 2m at different weather conditions, for a 150 mm horizontal hole, are higher than 105000 ppm (1 min SLOT) in a very long distance (approx. 160 m).



At 2 meters height from the leakage:

- The concentration on the deck of the platform is more than 300,000 ppm, fatal concentration for short exposure.
- IDLH threshold is extended from 340 m to 450 depending on climatic conditions.
- 10 min SLOT is extended from 210 m to 230 depending on climatic conditions.
- 1 min. SLOT is extended from 170 m to 180 depending on climatic conditions.

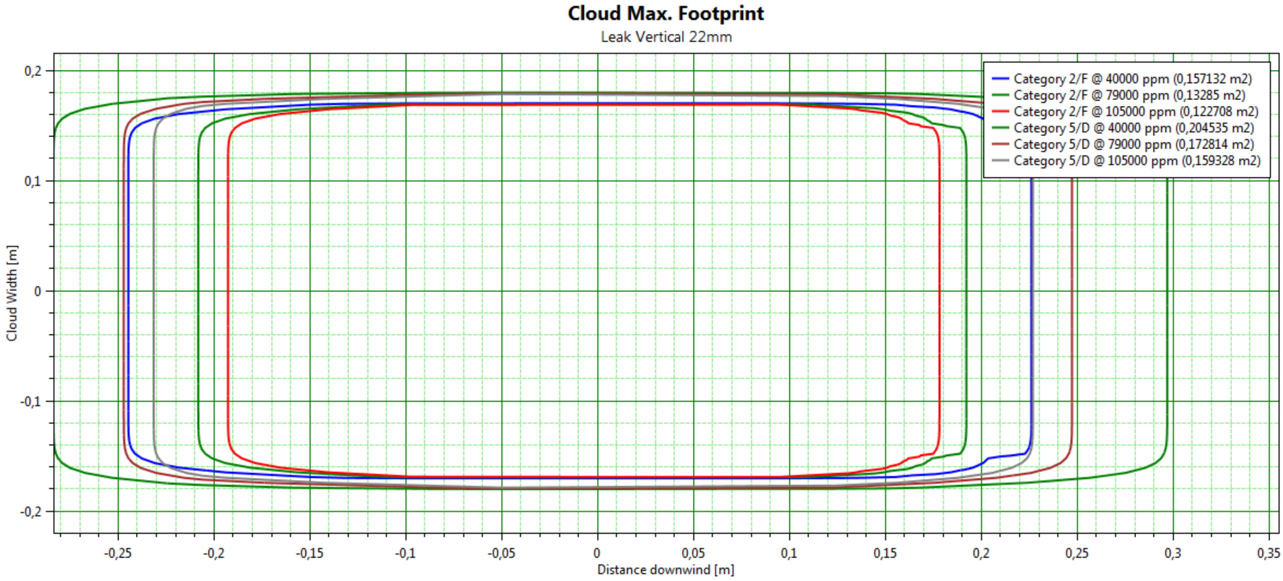


Side view from the leakage:

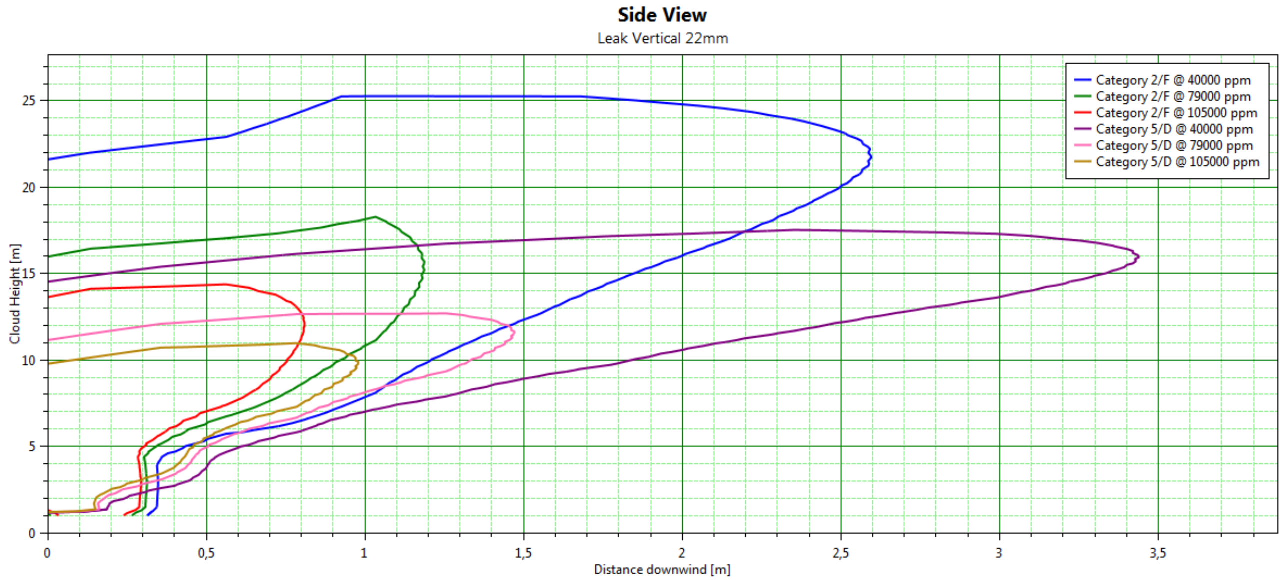
- IDLH threshold is extended from 340 m to 450 depending on climatic conditions.
- Upper deck may or may not be affected depending upon their clearance from the source
- 10 min. SLOT is extended from 210 m to 240 depending on climatic conditions.
- 1 min. SLOT is extended from 170 m to 180 depending on climatic conditions.

9.3.6 Pressure 104 barg; 22 mm (credible) leak; orientation: vertical

This is the design case for the gas release case is considered credible.

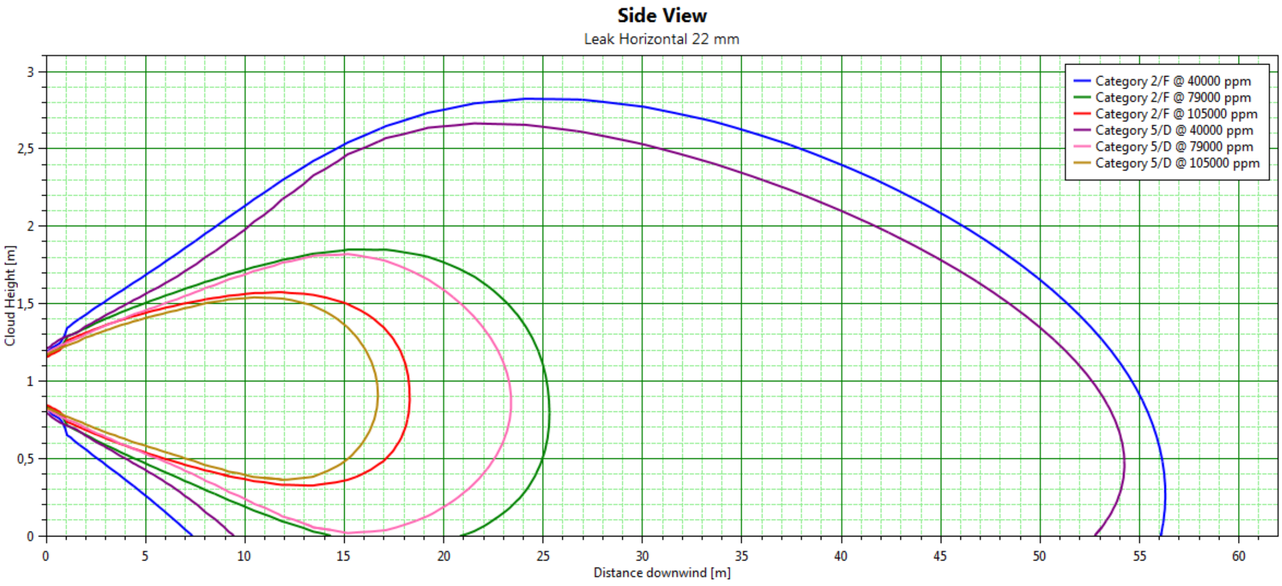


At 2 m height, all relevant concentrations are exceed in an area in the proximity of the 22 mm vertical leak (0.6 m x 0.4 m). The graph reported above shows expected CO_2 concentration at the height of 2m, assumed as the height of a person working in the area. Close to the 22 mm vertical leak, all relevant thresholds are exceeded.



In case of 22 mm vertical leak, the dispersion cloud is oriented upward, endangering the personnel that may work in the decks above the leakage.
Furthermore, if the deck above is plated, the cloud will be dispersed sideways based on the wind direction. For significant release of this size, in such cases, complete deck area may be considered engulfed by fatal concentration of CO2 cloud within a very short time (few seconds).

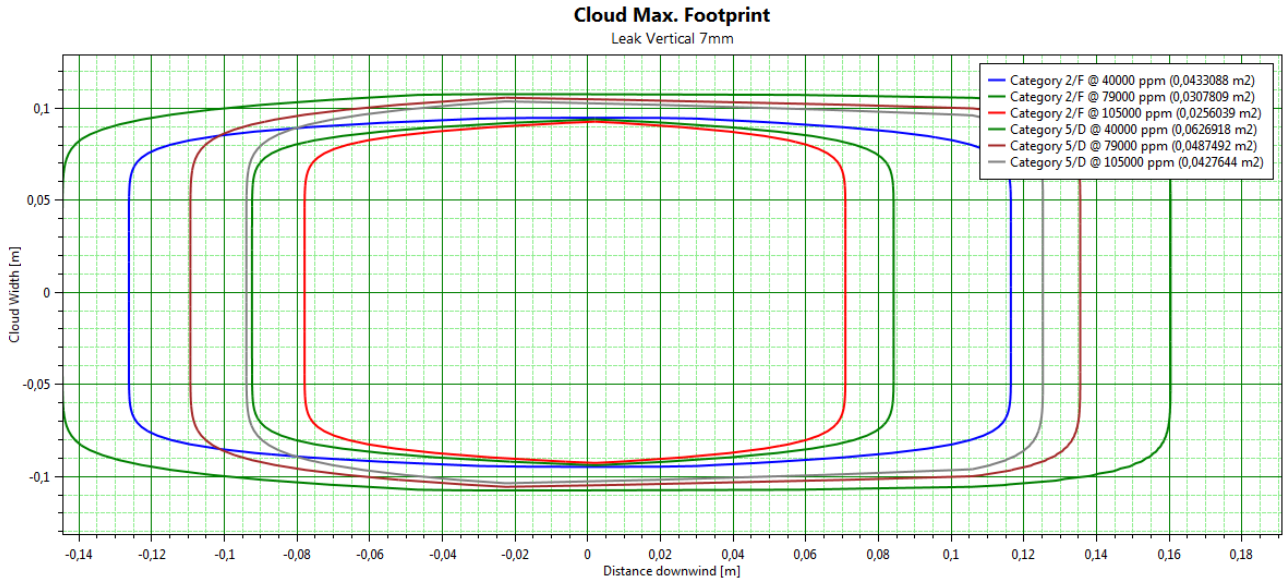
9.3.7 Pressure – 104 barg 22 mm (credible) leak; orientation: horizontal



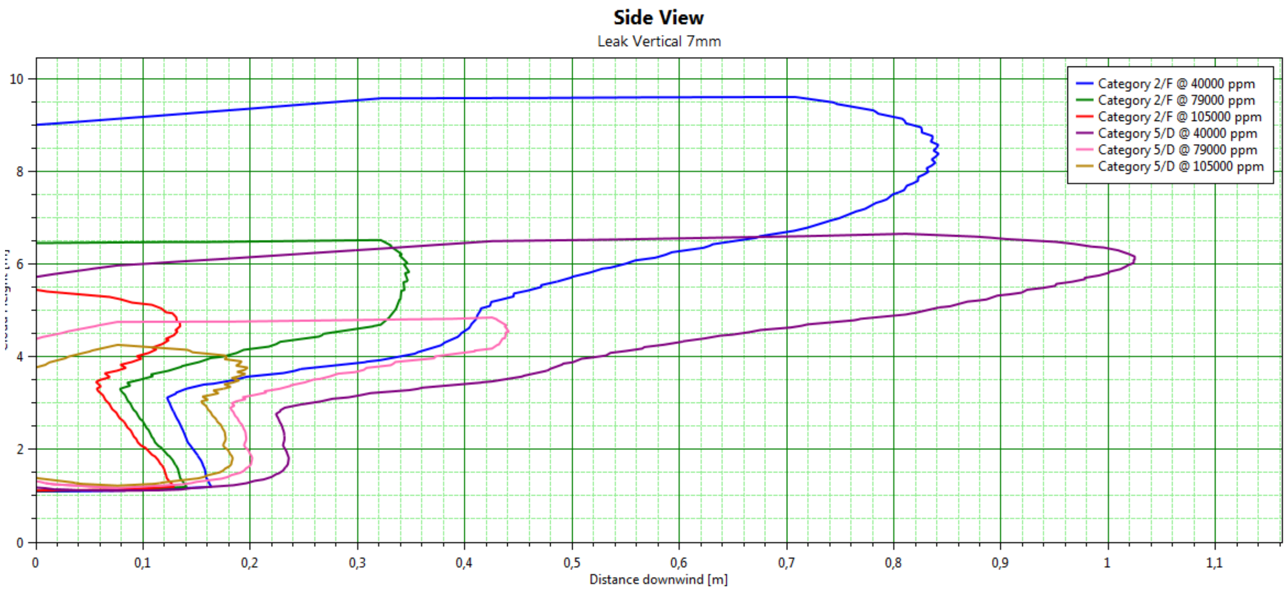
At 2m height from the leakage:
IDLH threshold is extended from 54 m to 56 depending on climatic conditions.
10 min. SLOT is extended from 23 m to 25 depending on climatic conditions.
1 min. SLOT is extended from 17 m to 18 depending on climatic conditions.

9.3.8 Pressure – 104 barg; 7 mm (most probable) vertical leak

This case is for the maintenance and operation activity for the gas release and is most probable.

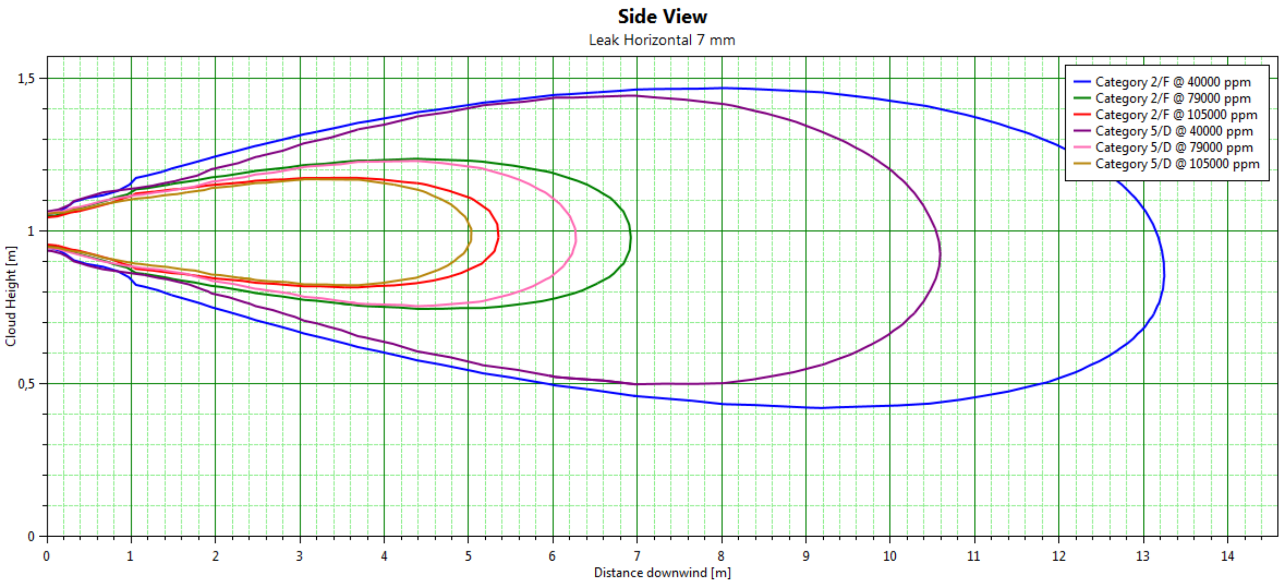


At 2 m height, all relevant concentrations are exceeded in an area in the proximity of the 7 mm vertical leak (0.4 m x 0.2 m).



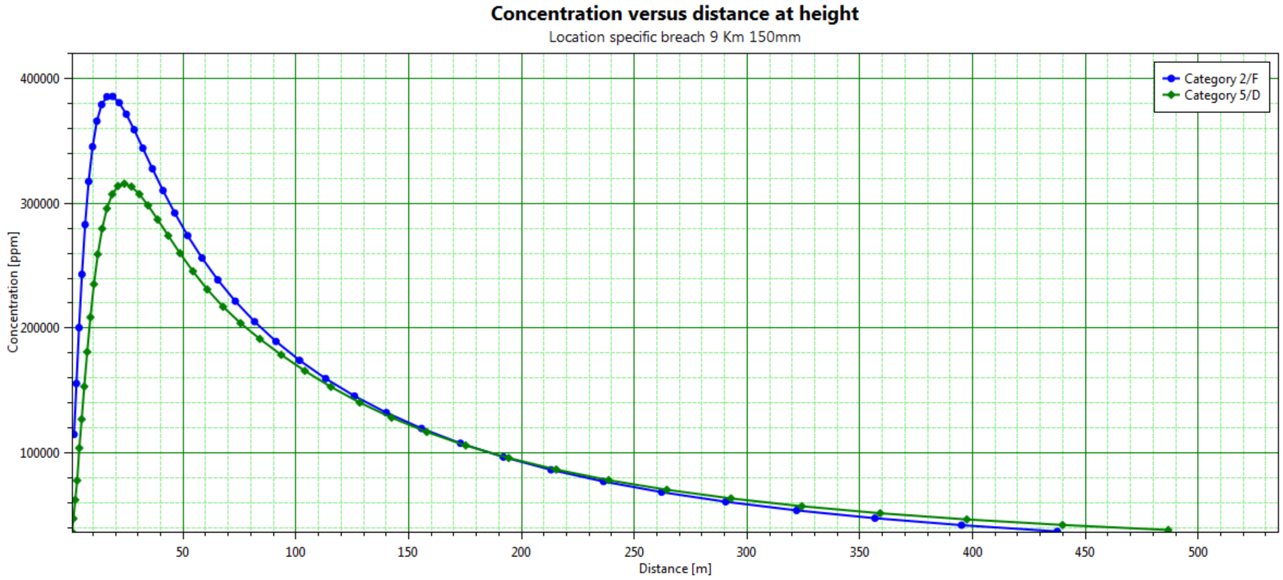
In case of 7 mm vertical leak, the dispersion cloud is oriented upward, endangering the personnel that may work in the decks above the leakage immediately over the leakage (1 m for IDLH).
Furthermore, if the deck above is plated, the cloud will be dispersed sideways based on the wind direction. For significant release of this size, in such cases, complete deck area may be considered engulfed by fatal concentration of CO_2 cloud within a very short time (few seconds).

9.3.9 Pressure – 104 barg 7 (most probable) mm horizontal leak

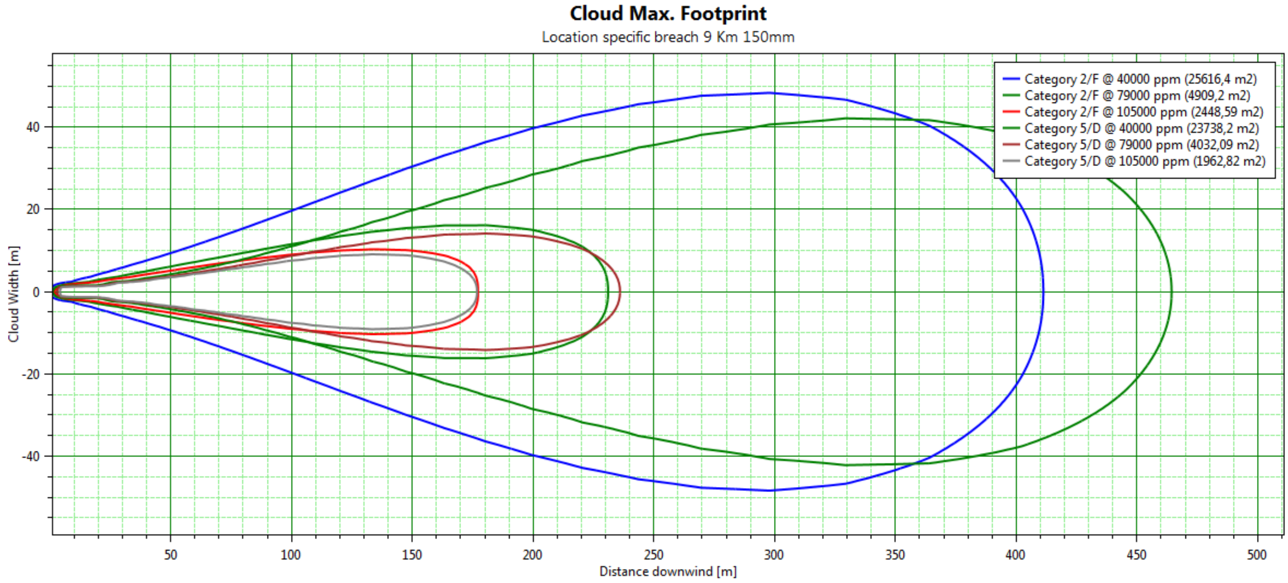


At 2 m height from the leakage:
IDLH thresold is extended from 10.5 m to 13.2 m depending on climatic conditions.
10 min. SLOT is extended from 6.2 m to 7 m depending on climatic conditions.
1 min. SLOT is extended from 5 m to 5.4 depending on climatic conditions.

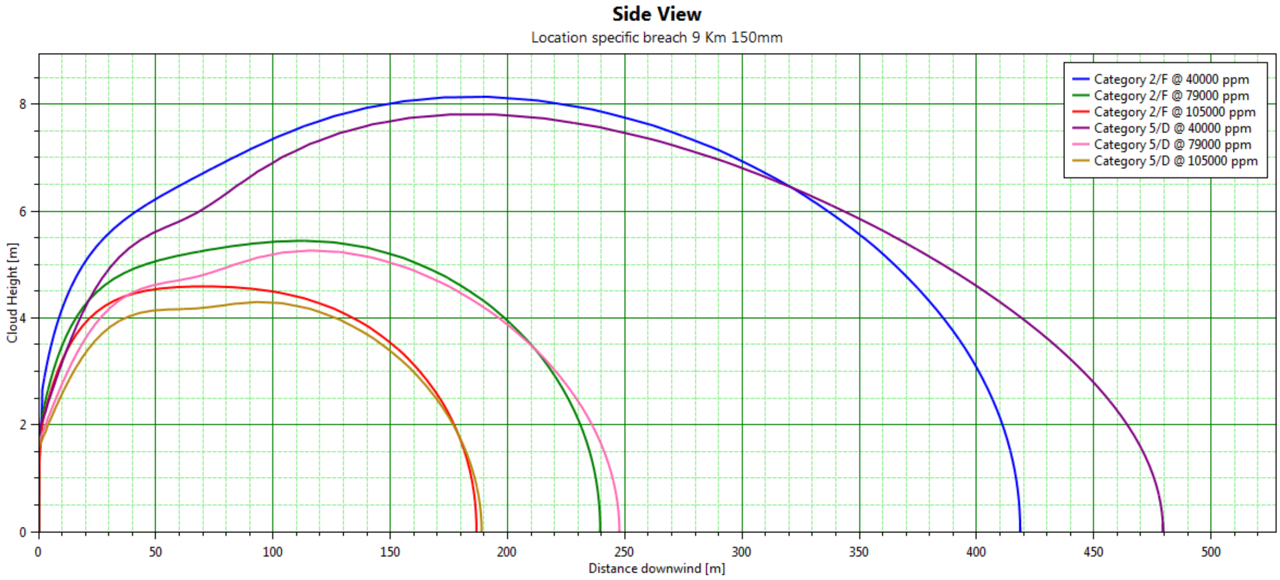
9.3.10 19 km pipeline 150 mm breach rupture on riser – 104 barg



In case of 150 mm breach on the subsea pipeline riser, concentration can reach dangerous CO_2 concentration in a very large length (> 500 m) in the surrounding of the leak.

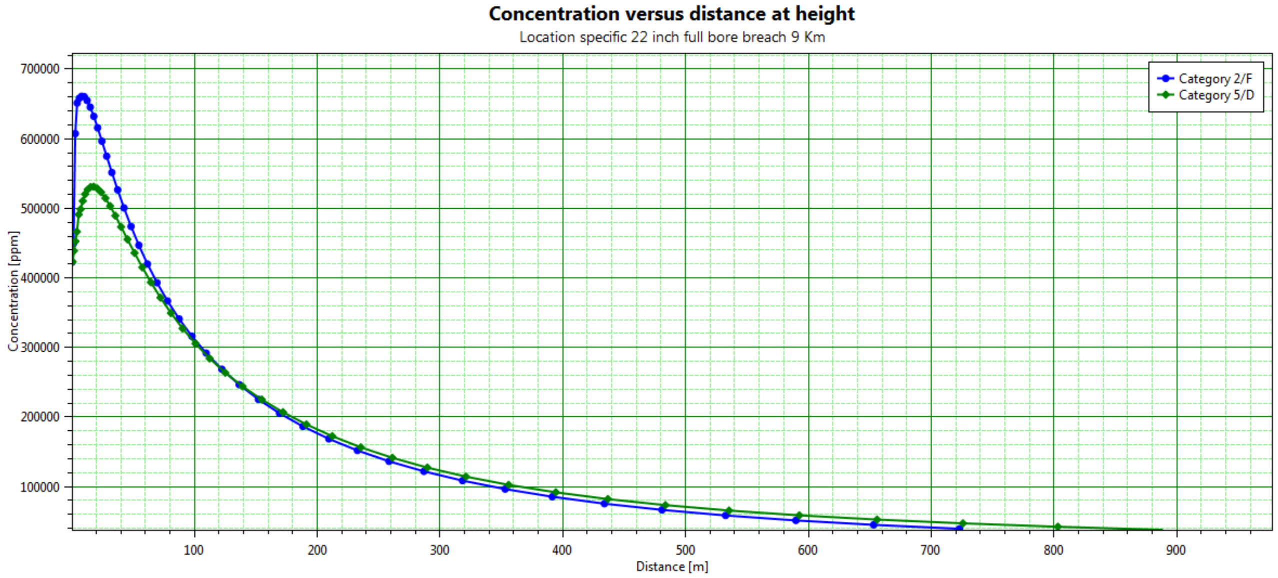


IDLH thresold is extended from 410 m to 465 m depending on climatic conditions.
10 min. SLOT is extended from 230 m to 235 m depending on climatic conditions.
1 min. SLOT is extended up to 180 m depending on climatic conditions.

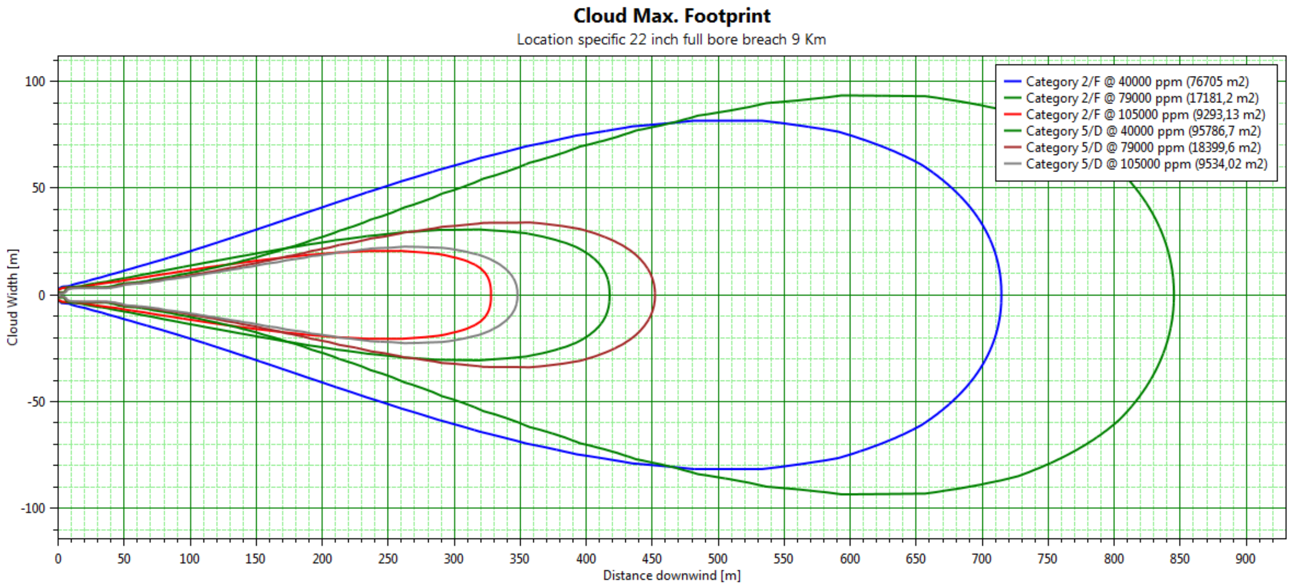


IDLH thresold is extended from 420 m to 480 m depending on climatic conditions.
10 min. SLOT is extended from 240 m to 250 m depending on climatic conditions.
1 min. SLOT is extended up to 190 m depending on climatic conditions.

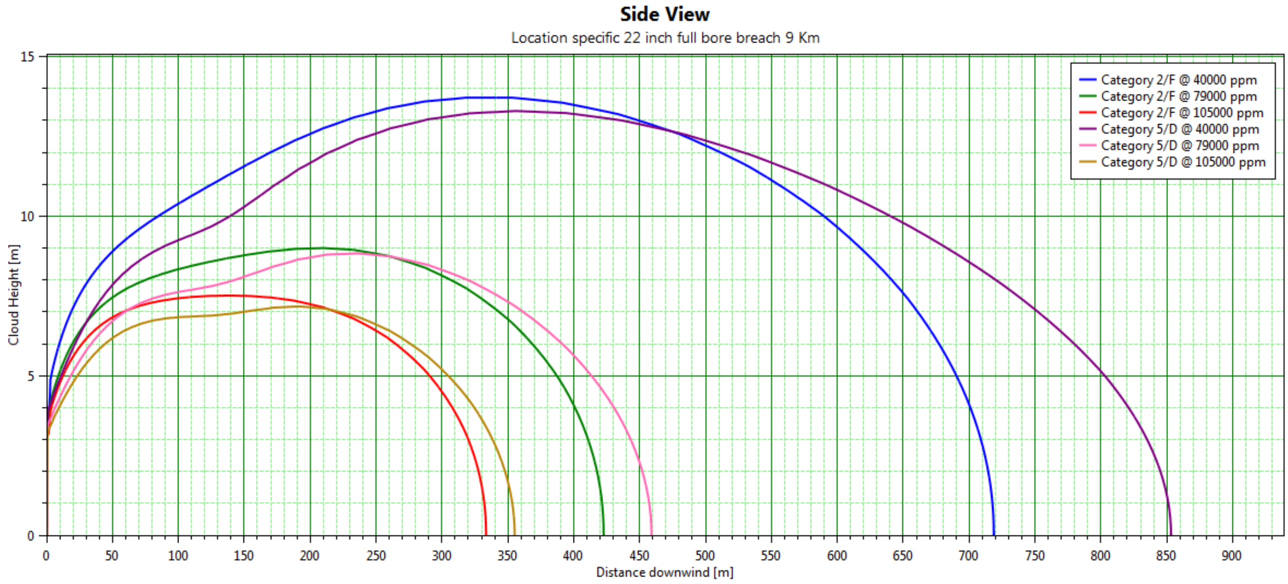
9.3.11 19 km pipeline 22" full bore rupture – 104 barg



In case of full bore breach on the subsea pipeline riser, concentration can reach dangerous CO_2 concentration in a very large length (> 900 m) in the surrounding of the leak.



IDLH thresold is extended from 710 m to 850 m depending on climatic conditions.
10 min. SLOT is extended from 420 m to 450 m depending on climatic conditions.
1 min. SLOT is extended from 330 m to 350 m depending on climatic conditions.

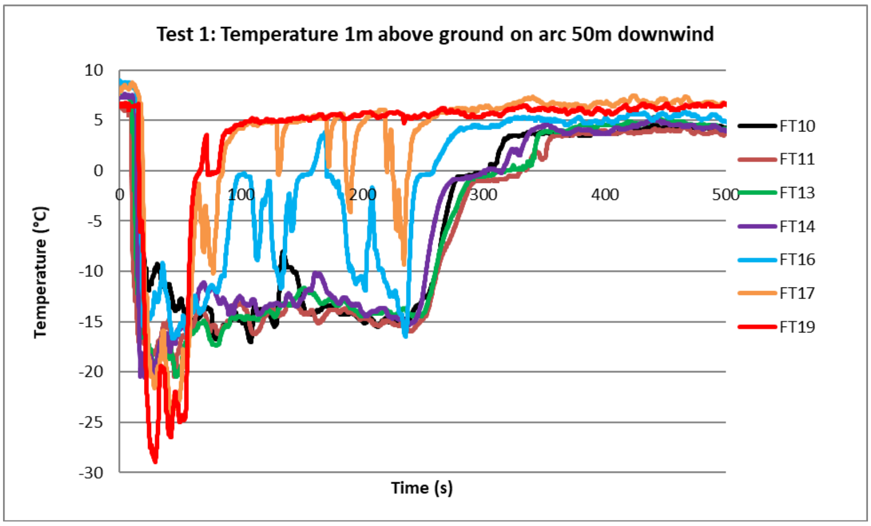


IDLH thresold is extended from 720 m to 850 m depending on climatic conditions.
10 min. SLOT is extended from 420 m to 460 m depending on climatic conditions.
1 min. SLOT is extended from 330 m to 350 m depending on climatic conditions.

9.3.12 Cold temperature hazard

In case of depressurization or leaks (starting form 104 barg) temperature decrease rapidly up to -88°C due to J-T effect. Therefore, the material selection shall consider the embrittlement hazard due to low temperature effect. A more detailed assessment should be performed in the next phase of the project
During an accidental leak CO_2 scenario, the cold temperature in the surrounding of the breach can cause a hazard for personnel's.

Test figures:
Pressure: 150 barg
Temperature 8°C
Released flowrate: 618 kg/s



In Hewett case, the maximum operating pressure (104 barg) is lower than the tested one, however, –during an upset condition, when pressure could increase up to the design pressure (assumed to be 200 barg), temperature can reach dangerous levels near the leak in the WHP area.
The case represented above is closer to 150 mm leak from the riser.
In these latest scenarios materials can be object of cold temperature stress during a leakage event and the cold temperature associated to the relies may cause harm to personnel working in the area.
Due to limitation on used software, it has not been possible to model the variation of temperature in the area after a leakage. However, data gathered form CO_2 piping experimental leaks [2] has been used in a conservative manner to predict–in order to consider the temperature, drop effect after a CO_2 piping leak on the WHP. The CFD analysis shall be performed in next phase of engineering to better analyses this critical low temperature hazard for personnel and asset.

9.4 CONCLUSIONS

Personnel shall access the unmanned platform only with the self-contained breathing apparatus (SCBA) and portable CO_2 detectors. In case of pressurized equipment (heater, manifold, piping, etc.) inspection and maintenance activities, the personnel shall wear SCBA, since the dispersion analysis highlights the immediate probability of death due to very high concentration even in case of small leaks (refer to the 7mm hole size).

The unmanned WHP shall be equipped by fixed CO_2 gas detectors, the locations and numbers shall be subject of further study.

An adequate restricted area surrounding the WHP platform shall be defined in order to restrict the vessel movement. Generally, UK safety regulation requires 500 m safety zone around the platform. The standby/attending vessel should have adequate means of protection for the personnel onboard. The riser leaks and catastrophic leaks on the platform has potential to engulf the standby and attending vessels. The riser location should be downwind to the platform as far as practicable. Similarly, standby vessels should be located up wind.

In case of CO_2 detection alarm raised by the fixed gas detection system, the personnel shall wear SCBA and proceed to muster/safe area on the platform, thereafter depending upon the scenario, a further appropriate action (evacuation, etc.) should be undertaken.

To mitigate the cold temperature hazard, the selected material shall be resistance to embrittlement in case of uncontrolled depressurization (due to a leak), since there is the possibility of subzero temperature.

The main load supporting structure (jacket) shall resist low temperature since the riser leaks are likely to cause severe subzero temperature in the vicinity and this may affect the jacket structural integrity due to the embrittlement. This aspect should be further developed during the concept definition phase of the project through a detailed CFD study.

For the operation and maintenance activity involving work on the live equipment, SCBA shall be donned, this is based on the outcome of the 7 mm hole sizes.

9.5 ATTACHMENTS

[1] http://www.hse.gov.uk/carboncapture/assets/docs/major-hazard-potential-carbon-dioxide.pdf
[2] COSHER RuptureTest1_Report13_Aug13

10 MECHANICAL DESIGN BASIS

Minimum design requirements and applicable Standards & International Codes for mechanical equipment, machinery, packages and piping have been listed in 28069.ENG.PIP.PRG “Mechanical – Machinery – Piping Disciplines Design Criteria”.
For further requirements and for equipment, machinery packages not included in the list here below, refer to 28069.ENG.PIP.PRG.

10.1 Mechanical Equipment Applicable Codes & Standards

Equipment	International Reference Standard	Company Specification
Pressure Vessels	IOGP S-619 Specification for unfired, fusion welded Pressure Vessels	-
Shell & Tube Heat Exchangers	IOGP S-614 Supplementary Requirements to API 660 Shell-and-Tube Heat Exchangers	-

10.2 Machinery and Packages Applicable Codes & Standards

Machinery / Package	International Reference Standard	Company Specification
General Purpose Centrifugal Pumps	ISO 5199 Technical Specifications for centrifugal pumps – Class II	01205.ENG.MAC.STD
Process Centrifugal Pumps	IOGP S-615 Supplementary Requirements to API 610 Centrifugal Pumps	-
Reciprocating Internal Combustion Engines	ISO 3046 Reciprocating internal combustion engines — Performance	03023.ENG.MAC.STD
Reciprocating Pumps	API 674 Positive Displacement Pumps - Reciprocating	03590.ENG.MAC.STD
Flares and Vent Stacks	API 537 Flare Details for General Refinery and Petrochemical Service	04927.ENG.MAC.STD
Intermediate Fluid Heaters	API 12K Specification for Indirect Type Oilfield Heaters	04941.ENG.MAC.STD
Chemical Injection Pumps	API 675 Positive Displacement Pumps - Controlled Volume for Petroleum, Chemical, and Gas Industry Services	27986.ENG.MAC.STD
Off-shore Pedestal Mounted Cranes	IOGP S-618 Supplement to API 2C IOGP S-617 Supplement to EN 13852-1	-
Air Compressor and Dryer Packages	IOGP S-613 Specification Air Dryer Package	-
HVAC Systems for Offshore/FPSO Production Installations	ISO 15138 Offshore production installations - Heating, ventilation and air-conditioning ASHRAE, IMO SOLAS 1974, SMACNA	20452.ENG.MEC.STD

11 PIPING / SUPPORT / STRESS DESIGN BASIS

11.1 General Criteria

For piping applicable Codes & Company Specifications refer to 28069.ENG.PIP.PRG.
All rules indicated in the P&IDs shall always be considered strictly binding, as for example:

- No pockets
- Self-drain and inclinations fixed for discharge or vent lines
- Sequence of branches and components location
- Minimum and/or maximum distances among lines elements

Horizontal and vertical piping shall be aligned to a bottom pipe to ease the realization of supports.
Connection among the line elements shall be preferably welded type and in compliance with ENI Std doc. ENI 06732.PIP.MEC.SDS with the exception of the valves which shall be exclusively of flanged or threaded type.
Threaded junctions shall be admitted if provided for the piping class of belonging service and, in any case, allowed for instrumentation connections.

11.1.1 Piping Sizing

Piping and line components have been sized in accordance with ASME B31.3, ASME B16.5, ASME B36.19, ASME B36.10, API RP 14E codes and European rule as regards materials characteristics, requirements and test to be performed to obtain the plant certification.
The general criteria and principal requirements for the development of the piping are included in the following ENI Std:

05892.PIP.MEC.SDS	Pipes and piping components for plants

11.1.2 Piping Arrangement

Piping arrangement for the development of Hewett project, shall fulfil economic, functional and safety criteria through the optimization of routes, observing the necessary spaces for first aid interventions and evacuation in order to not cause damages to people or environment and considering operating and maintenance requirements, according to ENI Std and the current regulations.
The layout development shall take into consideration environmental conditions and installation plan.
Manual valves shall be handled from walking plane or from service walkways.
The escape route shall be free of any component, both for width and height, according to ENI Std and the current regulations.

11.1.3 Piping Supports

All Piping and relevant components shall be suitably supported according to ENI Std, the good engineering practice and anyways they shall meet the conditions indicated by the stress analysis calculations, where required.
All Piping supports shall be placed only on structural beam.
The general criteria and principal requirements for the development of the piping supports are included in the following ENI Std:

05329.PIP.MET.PRG	Piping Supports

Supports with trunnions are not allowed.
Spring supports will not be used, as far as possible.

11.1.4 Piping Stress Analysis

The piping of Platform plants is subject to different kinds of stress (compressive/bending/ torque/impact) due to dead weight, occasional loads (wind, earthquake, PSV opening thrusts) and above all thermal expansion in conflict with fixed points (equipment nozzles, clamps, anchor).
The piping systems having high pressure and/or high thermal expansion shall be stress evaluated using qualified Stress Analysis software, like CAESAR II by Coade Engineering Software.
Not all the piping lines included in the line List will be subject to stress analysis.
Usually modelling is not required for piping size lower than 2”.
Some piping lines will be selected because connected to other lines to be stressed in a unique, indivisible circuit (the sole presence gives higher stiffness, modifying the flexibility and stress response of the main line).
A first criterion of selection shall be based on the maximum (and minimum) operative temperature of the piping line, in conjunction with the pipe diameter.
Particular attention will be paid to different operative temperatures for interconnected piping lines, as thermal stress can arise from thermal differences more than absolute temperatures (for example, is 3 pumps are connected to a common header, stress can arise from one them cold and the other two functioning).
Other lines will be selected for stress analysis for their connection to PSV (safety valves) with a high reaction force, or because connected to equipment/lines/structures subject to relevant displacements (such as wellheads vertical movements; horizontal movements of a bridge or a separate part of structure; etc.).

11.1.5 Project Conditions

The minimum design temperature will be considered to define the qualifications and certification, including CVN of the materials.
Limit operating conditions of temperature and pressure as resulting from the process analysis, shall be considered to perform the stress analysis (the analysis shall also be performed with alternative temperature and pressure condition based on different phases of the plant including start-up, cold blow down and depressurization for fire).
Normal operating conditions as resulting from the process analysis shall be considered to defined typology and the thicknesses of the piping insulation.

For this project up to and including 900 pressure rating, piping wall thicknesses have been based on maximum temperature and pressure values of the mating flanges. Consequently, all piping material class except piping material class 97C shall be applied as is without any modifications.

11.1.6 Test Conditions

Before the starting of plant, every circuit shall be internal pressure tested to verify the solidity.
The test pressure and the fluid for each circuit are enclosed in the line list.

11.1.7 Rating

“Rating” (pressure class) is used to define the maximum temperature and pressure conditions to which a normalized component (flange or valve) can be exposed in accordance with rules ASME B16.5, ASME B16.34, API 6D, API 6A.
These classes define, for convention, the project piping class specification to which the development of the project will refer to.

11.2 Piping Classes

These are the documents which assemble and list all piping components needed to realize the required service.
Classes contain the derivation type and "typical installations" (defined during detail engineering) intended as groups of line elements which are used to realize vents and drains, pressure or temperature taps sampling.
The piping class and typical installations included in the ENI Std to use for the development of this project are indicated in the following:

06732.ENG.PIP.STD Piping classes
06737.ENG.PIP.SDS Typical piping assembly

All the manual valves with nominal diameter ≥4" shall be "Top Entry" type;
All the manual valves with nominal diameter ≥4" shall be "Reduced Bore" type, except otherwise indicated on P&IDs and excluding the valves on the pipeline passed by pig that shall be "Full Bore" type.

11.2.1 Insulation

Piping and equipment's shall be insulated from hot, cold or protected for process needs.
Insulation type, material thickness and method of installation will be defined considering the environmental and working conditions, in accordance with general project specifications.
The ENI Std which define, typologies of insulation for this project are:

03652.ENG.CPI.STD Thermal insulation for cold service
03652.ENG.CPI.STD Thermal insulation for hot-temperature

12 ELECTRICAL DESIGN BASIS

12.1 Introduction

12.1.1 Scope

This paragraph gives the minimum technical requirements for the design, engineering and installation of the electrical facilities, for the Hewett Platform.

12.1.2 Operational Safety and Reliability

The design of the electrical installation shall be based on the provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured in all operating and maintenance conditions, including those associated with start-up and shutdown of plant and equipment, and throughout the intervening shutdown periods.
The design of electrical systems and equipment shall ensure that all operating and maintenance activities can be performed safely and conveniently and shall permit periods of continuous operation. To fulfill the above requirements, provisions are required for alternative supply sources and supply route (as far as is reasonable and feasible), spare/standby capacity, etc.
The design of the electrical installation shall ensure that access is provided for all operational and maintenance purposes.

12.2 Normative References

This electrical design basis refers Standards issued by European Committee for Electrotechnical Standardization (CENELEC) and relevant documents issued by International Electrotechnical Commission (IEC). The design of the electrical installation and material selection shall satisfy the requirements of local authorities.
All electrical and non-electrical equipment, to be installed and/or use in “Hazardous classified area” or not installed in dedicated room provided with relevant safe detection and extinguishing system shall be certified according to the EC directive 94/9/EC (ATEX directive) as a minimum requirement.
Type of protection mode shall be defined by EPC contractor during the detail design phase.
Electrical equipment and materials shall be selected in accordance with the relevant ENI E&P Specifications, which in turn shall be considered as supplementary to IEC equipment standard and/or CEI EN standards, which may be used in place of IEC standards for the design and engineering of the electrical installation, provided they are not less stringent in their total requirement.

12.3 Electrical System Design

12.3.1 General Criteria

The design selection and installation of power supply sources and of all electrical distribution system shall be done to ensure an appropriate degree of reliability and availability required by the typologies of loads to be fed.

The electrical system of the platform mainly consists of the following:

- Electrical Power Generation;
- Power distribution to users relevant to process (Instrument/Safety loads) and utilities areas (Maintenance loads)

The electrical power generation is made by a 24VDC photovoltaic generation system provided with battery back-up sized to feed Instrument/Safety load for, at least, 4 days (96 hours) consecutively without any other electrical sources.
The DC system shall be insulated from earth, in compliance with the provision of the standard IEC 61892-2, so that dc safety (24VDC 2 wires) distribution system is considered “IT” by the standard mentioned above.

The main power generation which consist in a photovoltaic system, shall be designed in order to cover the 100% of the electrical platform daily demand (day and night), considering the worst condition case during low sun radiation (winter periods). The continuous supply of electrical energy shall be ensured by battery set designed to guarantee a period of 96 hours of uninterrupted service without any electrical sources.
The battery set shall also be rechargeable by electrical diesel generator if necessary or in case of low or no-sun periods.

The service diesel generator shall therefore have the following capabilities:

- Exhaust gas flowrate 2.7 – 3.14 m^3/min.
- Exhaust gas temperature 445 - 455 °C.
- Exhaust gas pipe diameter 50 mm.
- Minimum pollution gas concentration (0.25%)
- Particolate 130 mg/Nm^3
- CO 650 mg/Nm^3
- NOx 500 mg/Nm^3

The diesel engine shall be homologated in accordance to the “direttiva 97/68/CE e s.m.i. (Stage II)”.

The Stand-by Diesel Generator shall be provided auto start-stop and self-monitoring features.

During maintenance periods, the same Stand-by Diesel Generator (90 kVA @ cosφ = 0.8) shall supply the LV SWITCHBOARD 400V/230 VAC-50 Hz users needed during maintenance activities (maintenance loads), such as power and lighting sockets, lighting system , crane local control panel, etc. according to “Electrical Balance”.
The AC distribution system will be designed “TN-S” in compliance with International Rule
IEC 61892 and IEC 60079-14.

As far as philosophies and technical performances are concerned references to the following documents have to be made:

- Electrical Load balance

12.3.2 Hazardous area classification

IEC EN 60079-10 code covers mandatory requirements governing the classification of areas where there will be dangers of explosion or fire due to liquids, gases, and vapours handled, processed or stored and IEC EN 60079-14 code that covers mandatory requirements governing the design, selection and erection of electrical installation in and near such hazardous areas.
All areas located at sufficient distance (the minimum defined by codes) from the process equipment and permanently free from flammable gases, will be classified as non-hazardous areas. This will be valid upon approval by Company and Local Certified Authority.
All the electrical equipment to be installed in classified areas shall be supplied complete with the relevant certification in accordance with European normative (CEI EN; ATEX).
Conformity Certificates to ATEX code shall be provided and approved by Company.

Electrical apparatus types shall be selected as per following table.

EQUIPMENT TYPE	ALL DECKS ZONE 1	ALL DECKS ZONE 2	WEATHER DECK SAFE AREA
LV GENERATOR	Not allowed	Not allowed	Suitable for outdoor installation with canopy
BATTERY ELEMENTS	Not applicable	Not applicable	Natural ventilated enclosure IP43 min.
LV DISTRIBUTION SWITCHBOARDS	Not applicable	Not applicable	Suitable for outdoor installation IP66 min.
LV SWITCHBOARDS WITH ELECTRONIC DEVICES INSIDE	Not applicable	Not applicable	Suitable for outdoor installation IP55 min.
TRANSFORMERS	Not allowed	Not allowed	Natural ventilated enclosure IP44 min.
LOCAL CONTROL PANELS	“Ex d IIB T3” – ATEX “Ex II 2G” IP55 min.		Suitable for outdoor installation IP66 min.
LV MOTORS	“Ex de IIB T3” – ATEX “Ex II 2G” IP55 min.		
POWER SOCKETS	“Ex de IIB T3” – ATEX “Ex II 2G” IP55 min.		
JUNCTION BOXES	“Ex e IIB T3” – ATEX “Ex II 2G” IP55 min.		
LUMINAIRES	MAINTENANCE FREE IQL based “Ex me II T3” – ATEX “Ex II 2G” or LED based “Ex de IIB T3” – ATEX “Ex II 2G” IP55 min.		

12.3.3 Load Classification

The reliability and the availability of the power supply will be selected according to the loads to be fed which are classified as performing a service which is Instrument/Safety loads (unmanned condition) and Maintenance loads (in manned conditions).

12.3.4 Voltage Levels

The selected voltage levels for the electrical sources on HCPI Platform will be the following:

- 24 Vdc (2 wires - insulated from ground system) for "Navigation Aids" system and system feeding "Instrument/Safety" classified loads (unit 720), for photovoltaic based main electrical power generation system and for PV battery sets (unit 470).
- 400 Vac – 50 Hz 3Phase + N + PE (neutral point accessible and directly earthed) for Stand-by Diesel Generator (unit 480).
- 400/230 Vac – 50 Hz for system feeding "Maintenance" classified loads (3Ph+N + PE - TN-S) (unit 920).
- 400 Vac – 50 Hz for external power supply (3Ph - IT from the on-board service diesel generator of the supply vessel).

12.3.5 Voltage Drops

The components of electric system shall be selected and sized so that the maximum voltage drop, under the normal operating condition (i.e. without overloads and/or faults) shall not be higher than the following values:

- Lighting circuits: 3% from distribution board (unit 920) to final user;
- Power circuits: 5% from distribution board (unit 920) to final user;
- DC circuits: 2% from "Stabilized" bus-bar (inside unit 720) to final user;
- "Navigation Aids" circuits: 2% from control circuit output terminals to final user;
- Unit 0920 power supply line: 3% from the terminal of the on-board service diesel generator of the supply vessel up to the incoming terminals of the unit 920, considering 30 m of power cable connection between the generator and the power socket for external power supply.

The maximum allowable voltage drop at starting condition of the motors will not exceed 15%, if that requirement cannot be guaranteed with direct starting; soft-start system shall be provided.
The ± 2% for DC circuits may be different, according to the operating voltage range of the DC user. For example, the PLC power supplies accepts a voltage range of ± 5%, therefore the relevant DC circuit may be sized for ± 5% of voltage drop.

12.3.6 Studies of the network

The following studies shall be provided:

Load Flow and Short circuit calculation Report
Circuit Booklet and Protections Verifications.

12.3.7 Short circuit currents

The short circuit verification shall be carried out in accordance with the applicable IEC recommendations (60909/61363/61660) taking into account the possible network configuration and shall be extended to all voltage levels and switchboards, either AC and DC system.

For output feeders, it shall be calculated also the minimum short-circuit current in order to verify the relevant operating short circuit protections.

12.3.8 Protective device system

All circuits and system shall be protected against overloads and short circuits.

Selectivity shall be achieved between protective devices installed in series in order to grant the maximum operative continuity.
For each circuits typology (i.e. ac circuits and DC circuits), suitable circuit-breakers shall be installed.

Insulation monitoring devices (K64) shall be provided on DC system in order to monitoring insulation level on both polarities, with alarm in case off loss of insulation.

Suitable protective device against earth fault (differential protection) shall be installed on all AC distribution circuits; circuits feeding users located in "Hazardous classified area" (e.g. power sockets, lights, etc. shall have the following characteristic: IΔn=30 mA, tmax=100ms (for socket with rated current not exceeding 20 A), IΔn=100 mA, tmax=100ms (for all other socket and submersible pump).

Short circuit protections
All circuits will be individually protected against short circuits, both for maximum and for minimum short-circuits currents, in accordance with the outcomes of the "Short circuit studies".
The scope, is the calculation of the protective device setting values, in order to assure protection to the users and obtain selectivity in case of faults into the electrical network.

Protections against overloads
All circuits will be individually protected against overloads, with only the exclusion of excitation circuits of rotating machines.

12.3.9 Measuring and control system

Measures and signals
All incoming of the main electric switchboards (Navaid Battery Charger, Distribution Board, and LV Switchboard) will have a voltmeter with selector switch for measuring line and phase voltages and an ammeter with selector switch, as minimum requirements, however regarding the measure functions that shall be implemented in the electrical system and transmitted to RTU to be processed.

Control and operating system
HCIP Platform shall be controlled by Remote terminal unit (RTU) and protected by Emergency Shut Down (ESD/F&G, which is included in the RTU) during all operating conditions.
It will be designed in order to perform safe and complete operations both during the manned (only for maintenance purpose) and unmanned period.
The platform, linked with onshore premises by mean of a radio communication system that ensures remote control and safety operation. For more detail see cap. 12.2.

Stand-by Diesel Generator shall automatically start every time the Battery System are at 60% of its capacity, re-charge battery set in "Full charge" (max. 10 hours), feed the whole "Instrument/Safety" loads and stop at the end of "Full-charge". Beside automatic command, also local/remote manual commands shall be provided.

The Stand-by Diesel Generator shall be feed the “LV Switchboard” which will be used only in Maintenance Condition.

Monitoring of electrical system shall be implemented, in particular for what concern the monitoring of faults and operating status of electrical power system, battery set, Stand-by Diesel Generator.

The main switchboards shall be connected to “RTU Control and Supervision system and platform” Panel via serial link with MODBUS/TCP protocol and routed to the remote manned telecontrol location through the WLAN link. The ESD commands shall be connected to RTU in hardwired mode.

12.4 System, Equipment and Cables

The main electric system will be able to supply all the users in the plant. Particularly, a load summary will be developed taken into account the platform loads as they are classified at previous chapter 11.3.3 and this will form the basis for provision of the necessary electricity consumption, as well as for the power generation capacity and for distribution system arrangement.
The load assessment will cover all the plant operating condition and the users will be evaluated according to their operation: continuous, intermittent and standby duty. Attention must be paid in determining the load diversity factors for the different operating condition of the plant.

12.4.1 Primary Power Generation

The Main Power Generation System shall provide energy to the whole platform loads.
A subsea power cable shall be foreseen from onshore facilities at 132 kV (TBC). On platform topside shall be foreseen a stepdown conservatory type oil transformer of 70 MVA with secondary voltage at 20 kV.
Downstream the main transformer a 20 kV a 50 kA/1s MV switchgear shall be foreseen; from such switchgear a set of 6 MVA dry type transformers 20/0,72 kV shall be foreseen to power feed the heater LV switchgear (provided by heaters manufacturer).
A 2MVA dry type transformer 20/0.44 kV shall be foreseen to power supply the auxiliary loads from a LV switchgear.
The above LV switchgear shall have a normal bus bar section and an Emergency bus bar section connected by a bus tie.
All switchboards shall be suitable for outdoor installation in Safe Area
In particular, it shall be made in AISI 316 SS
The protection degree shall be according to outdoor installation IP 66.
All Switchboards shall be located in safe and outdoor area on the main deck, under a shelter in a corrosive marine environment.

The Emergency section shall be connected to the Stand by Diesel Generator**.**

12.4.2 Secondary Power Generation

Diesel engine driven generator set will be provided to supply mainly power to all electrical users to be fed under manned operation of the plant. The Stand-by Diesel Generator will be suitable for unattended operation and for automatic black-starting on detection of failure of the photovoltaic system.
The Stand-by Diesel Generator will be connected to DC Panel and LV Switchboard.

12.4.3 Navaid Battery Charger & Distribution Board and Battery set.

The Navaid Distribution Board includes all loads as instrumental, safety and navigation aid system.
This switchboard is fed from:

- LV switchboard
- Battery set
- Stand-by Diesel Generator

The Navaid Charger, Distribution Board and the batteries set (Sealed Lead Battery, located in dedicate cabinets) shall be located in safe and outdoor area on the main deck, under a Roofing.

12.4.4 Low Voltage Switchboard

Low voltage switchboard, "LV Switchboard" shall be suitable for outdoor installation in Safe Area
In particular, it shall be made in AISI 316 SS
The protection degree shall be according to outdoor installation IP 66.
The "LV Switchboard" shall be located in safe and outdoor area on the main deck, under a shelter in a corrosive marine environment.

12.5 Asynchronous motors

The motors and relevant accessories shall be asynchronous squirrel cage rotor type. They shall be suitable for continuous service S1. The direct method at the full voltage shall be assumed. The torque at the start-up shall be such as the allow the start at the motors even with terminal strip voltage of 85%.
Soft-starter shall be utilized when the impact on the electrical system at starting condition is heavy or the needs of the connected load require it.
Each motor will be locally started/stopped through a local push-button station (PBS) with start and stop push-button, with ammeter if Pn ≥ 7.5 kW. Name plate will be used for push button station. The same motor tag number will also be assigned to the relevant PBS

12.6 Cables

All outdoor power and control cables shall have rated temperature 90°C, EPR G10, with steel armoured (braided type), and M1 or M2 quality thermoplastic mix sheathed, not propagating fire and flame, low emission of toxic and corrosive gasses and opaque smokes.
All outdoor power and control cable for “vital” classified users shall be suitable for rated temperature 90 °C, EPR G10, with steel armoured (braided type), and M1 or M2 quality thermoplastic mix sheathed, not propagating fire and flame retardant, low emission of toxic and corrosive gasses and opaque smokes and in addition fire resistant.
In selecting the cable type, as cables normally will be installed as a single un-jointed length, the most arduous conditions applicable along the cable route will be taken into account.

For the sizing of cables, the following aspects will be taken into account:

thermal short circuit capacity
voltage drop (steady-state and starting conditions)
current rating and derating factors
max cable loop impedance for earth faults

Conductors have the following minimum sizes:

low voltage power wires	2.5 mm^2
low voltage control & signaling	1.5 mm^2

12.7 Navigation Aid System Equipment

Navigation aid system will be provided on the platform for marine identification purposes.
It will be designed according to applicable IALA and ICAO code and will normally include luminous and acoustic signal rated.
The system will be included in the Battery Charger and Distribution Board system and must be suitable to feed the relevant load for a period corresponding to that requested by the legislative and normative provisions, that is 96 hours

Relevant items of Navigation Aid System will be located in safe and outdoor area on the main deck:

Battery Charger Panel under roofing.
Distribution Board under roofing.
Battery set under roofing.
Battery set under roofing.
Navaid Batteries Cut-off JB under roofing.
Navaid Batteries Cut-off JB under roofing.

White Marine Lantern) Main deck
White Marine Lantern Main deck
Main Fog Horn Main deck
Navaid Photocell Main deck
Visibility meter Main deck
Obstruction Lights Crane
Obstruction Lights Flare

12.8 Lighting & Small Power System

Lighting fixture, Power and Lighting sockets, and all the assembly materials will not be lower than IP 55 and shall be Ex-de IIB T3 ATEX II 2G execution.
The circuits of normal lighting shall be supply by LV Switchboard during the manned condition.

12.8.1 Lighting and Power Sockets

The power socket will be 32 A rated @ 400 V – 3 Phase+Neutral+PE while lighting sockets will be 16 A rated @ 230 V – Single Phase+Neutral+PE.
Power & Lighting Sockets will be equipped with 4 pole or double pole switches respectively and shall be Ex-de IIB T3, ATEX II 2G.

For each type of sockets (i.e. Power and Lighting) separate feeding circuits shall be foreseen.

12.9 Cable trays

The Ladder type cable tray will be equipped with cover if installed outdoor. Cable tray will be AISI 316 stainless steel material.
To avoid galvanic corrosions, all cable trays shall be insulated from main structure at support side.

12.10 Fittings and accessories

They will be in compliance with the hazardous areas classification and environmental conditions.
Stainless steel made materials will be used.

12.11 Lighting system

The Lighting system will be designed for minimum maintenance and maximum efficiency.
In the design calculation the resulting data will be corrected according to the decrease in lamp output resulting from dust, dirt, chemical changes in reflecting surfaces.
In designing the lighting installations particular attention must be paid avoiding the stroboscopic effects and the glare effects.
In any case lighting fixture will be not located directly over equipment having exposed moving parts (equipment and structures maintenance and dismantling activities will be taken into account in selecting the appropriate type of fixture).
For the Platform the lighting system will be classified as Normal lighting (Maintenance condition)
Lighting system shall be based on “Maintenance Free” lamps with “IQL” or “LED” based design.

12.12 Earthing system

Earthing conductors are required to bond the main components of the Generation and Distribution systems:

- Earthing bus-bar inside unit 720 Switchboard (two points).
- PE bus-bar inside unit 920 Switchboard (two points).
- Star point of the Stand-by Diesel Generator.
- PV Panel local earthing system.
- Skid local earthing system.

The steel deck and structure of an offshore installation is an inherently very low impedance structure capable of conducting earth fault currents without giving rise to sparks or dangerous potential differences. Good electrical continuity is achieved by intimate metal to metal contact through equipment fixing bolts, riveting or by welding, such that earthing bonding cables need not to be used between equipment and the steel deck. Intimate contact between equipment and deck steel structure shall be verified and where it is supposed not be good, suitable earthing bonding cable shall be provided.

12.13 Lightning Protection

The lightning Protection for fixed off-shore platforms is not necessary.
Anyway, the risk analysis relevant to the damages, coming from voltages inducted from strike currents flowing into platform frame, shall be provided, by using the CEI EN 62305/1-4 procedures.

13 INSTRUMENT DESIGN BASIS

13.1 Introduction

The Hewett platform shall be unmanned and will be supervised from onshore premises.
The platform will be controlled by the following main items:

- Remote Terminal Unit (RTU)
- Telecommunication system
- Wellhead control panel (WHCP)
- Field instrumentation

The Remote Terminal Unit (RTU) and Telemetering system shall be installed outdoor in a protected and safe area.
The Wellhead control panel (WHCP) shall be designed to operate in hazardous area zone 1 Gas Group IIB, Temp. Class T3.
All the equipment to be installed in hazardous area shall be supplied complete of conformity certificates to ATEX code.

The instrumentation installed aboard the platform shall comply the following:

➢ Transmitters for process variables and instruments for safety/shutdown operations (ESD), as well as those for process control (RTU), will be hardwire connected to remote I/O (instruments and related cards grouped by skid or by area) via 4÷20mA HART® 2 wire technology for transmitters, and Fail Safe loop for the switches. The remote I/O cards distributed on the platform shall be connected to the main RTU's CPUs via redundant fieldbus link for the ESD section, and via single fieldbus link for the RTU section. The fieldbus link between the CPUs and the remote I/O cards can be manufacturer proprietary protocol.

13.2 RTU, remote terminal & telemetering integrated control system

The system will manage the process control signals, the emergency signals/actions and the fire & gas devices.
The control system shall be designed in order to allow the operators to manage the process production and ESD/F&G signals from onshore premises.
The system will be PLC based with redundant CPU. Control loop shall be independent from safety loop
The system shall be connected with electrical field signals and shall perform the relevant safety and control action.
The RTU will include the radio equipment necessary for the connection.

13.3 Wellhead Control Panel

The panel shall control the 5 double completion operating wells. It shall be electrical / pneumatic / hydraulic type and shall be interfaced with the RTU.
The system shall consist of:

Hydraulic power generation unit
Hydraulic control section
Pneumatic logic section

The master and the wing valves will be pneumatically actuated while the SSSV will be hydraulically actuated.
The well head control system will be used to perform manual and automatic control of the wellhead surface and sub-surface valves and some ESD/PSD intervention.

Wellhead control panel shall ensure the correct opening/closing sequence of the wells.
The hydraulic power generation unit and the hydraulic logic section shall be designed to handle the control of the SSSV valves.
The hydraulic power generation unit shall be composed of:

- Hydraulic fluid reservoir
- Pneumatic pumps and hydraulic distribution system
- Manual pumping facilities
- Filters
- Hydraulic fluid manifold and pressure accumulators

The wellhead control panel shall contain equipment and pneumatic logic circuits that shall perform as a minimum, the following functions:

1. Common devices

Air pressure regulation and filtering
Air instruments supply for all plant
Hydraulic fluid regulation and filtering
Manual and remote control of SDV and BDV valves
Manual shut-down of all the controlled valves (SSSV; SSV; WV)
Remote shut-down of all the master and wing valves for PSD conditions;
Remote shut-down of all valves (SSSV; SSV; WV) for ESD conditions;
Automatic shutdown of all valves (SSSV; SSV; WV) for ESD conditions;

2. Individual String Control

Manual control of surface and sub-surface valves;
Interlock of valve operation so that opening and closing sequence will always be respected. Time delay on closing sub-surface valve after the closure of master valves shall be adjustable;
Remote shutdown of surface valves.

13.4 Fire and Gas Detection

The Fire & Gas detection will be managed by the RTU and shall be designed to detect and to carry out automatic actions for protection against fire and flammable gas.
In the event of fire or gas being detected, the system shall automatically activate the optical/acoustical alarms (in temporary manned condition) and initiate the appropriate intervention according to the Cause & Effect Matrix.

13.5 Telecommunication System

The telecommunication system will include the following systems:
Public Address & General Alarm system (PA & GA)

The PA shall provide the vocal and acoustic general process alarm diffusion on platform.
The GA shall provide different acoustical alarms for the following Three levels of emergency:

- Man overboard
- Gas presence
- Fire

The alarms shall be activated automatically through hardwired connection between the RTU and the GA system; exactly the tone control unit will communicate with the F&G system which will monitor the status of commands.
The system should provide vocal/acoustic alarms only in manned operation.

13.6 Field Instrumentation

Electrical instruments / equipment installed in hazardous area shall be explosion proof type (Ex-d) II B T3 with ATEX Certification and mechanical protection degree shall be IP 55 as minimum.
All field instruments dedicated to the safety logics, and its interface with RTU system (remote I/O included) shall be according to Eni specification.

Electronic Transmitters:
All transmitters for DP measurement (including flow and level applications), and for pressure and temperature measurement (all instruments dedicated to control logics) shall be Smart type with Hart protocol.
For electronic transmitters 2 wires technology 4-20 mA signal shall be used (power supply: 24 Volt d.c.).

On-Off valves:
Either ball valves or gate valves (parallel seat type) will be used, according to the process requirements and the piping specifications.
All the valves will be pneumatically actuated (instrument air), exception made for the downhole valves (SSSV) that will be hydraulic actuated type.
The body material shall be selected in compliance with the piping specification; the inner parts material shall be AISI316 minimum, unless fluid type and process conditions require a different material.
The valves size shall be equal to the line size. Full bore valves shall be utilized on pipelines and lines arranged for the pig passage. Reduced bore valves are accepted for other installations.
The shutdown valves (SDV) shall be of the failure close type (F.C.), while the blow down valves (BDV) shall be of the failure open type (F.O.). SDV and BDV shall be fire safe type, according to API 6FA.
The valves up to 4” (4” included) shall be top-entry type; for sizes >4” the valves shall be split body type.
The main operating element shall be a single-acting piston with spring return or a double-acting piston for valves with diameter equal to or larger than 6”, or for heavy operating conditions (high differential pressure in closed valve conditions) for the valve dimensions.
All the on-off valves shall be complete of limit switches for open and close position and a local mechanical indicator.

Solenoid valves:
The solenoid valves shall have 24 Vdc operating voltage and shall be low-power consumption type.
Control valves
Control valves will be sized in compliance with ISA-S75.01 code. Globe type control valve with top and bottom guided plug will normally be used.

Particular applications may call for the use of one of the following type of valves:

a) Butterfly valves for low pressure drop application, whenever no tight shut-off is required.
b) Characterized ball valves (i.e. V-ball type for solid-entraining fluids, or fluids which are likely to either polymerize or crystallize).
c) Angle valves dedicated to high pressure drops or in erosive fluid applications.
d) Three-way valves, where more than one process stream is to be controlled.

Special type valves (e.g. angle valves, multi-step type, with labyrinth, cage type, etc.) will be used for very high pressure drops, for high fluid velocity, to reduce the noise level, etc.
Also special type valves with calibrated flow through orifices for separators level on/off control will be used.
The body material will be selected in compliance with the line specification and process fluid characteristics.
The trim characteristic selection will be based on the following criteria:

- equal percentage:
  - if the maximum valve pressure drop is lower than 2/3 of the pressure drop of the system
  - non-linear variable control
  - high rangeability
- linear in all other cases

The control valves will generally be equipped with a pneumatic actuator having a 3-15 psig range spring diaphragm.

Switches:
Limit switches shall be of proximity type. The selection of position switches is subject to company approval.
Field process switches shall have hermetically sealed SPDT contact. Mercury type switches are not allowed.
They shall be explosion proof type (Ex-d) with ATEX Certification and Ex-Agencia's approval.
Fitting and tubing:
Tubing material for marine installation shall be stainless steel AISI 316 L; fittings material shall be stainless steel AISI 316.

Alarm & Trip Input:
Separate instruments from control functions shall be used where shutdown input is required. These instruments and relevant input shall not be used for any function other than shutdown service.

Junction boxes:
Junction boxes shall be Ex-e type.
Conformity certificates to ATEX Code shall be provided; enclosures mechanical protection degree shall be IP 55 as minimum, in accordance with IEC 60529 Code.
Each J-box shall have an AISI 316 SS nameplate indicating the relevant tag number.

Cable entry
The multicable inlets shall be bottom side of the junction box, whereas outlets for single cables will be located on the side walls, the single cables and the multicable shall have the armour clamped to the cable gland. The earthing of the armour will be realized through internal connection to the grounding bulkhead.
Cable glands

- Execution: Ex-d / Ex-e (EN 50014÷19 / IEC 60079-0 to IEC 60079-2 and IEC 60079-7) and Ex-Agencija approval.
- Type: suitable for armoured cables
- Threads: shall comply with the Reference Std and with the installation on the Ex-e J-box resin material; generally shall be use NPT for instruments and ISO metric for JB.
- Material: AISI 316

Cables:

Flame retardant cables according to IEC-60332 shall be used for instruments while fire resistant cables according to IEC-60331 and IEC-60332 shall be used for safety systems (ESD, F&G signal).

Cable Trays:

Materials for cable trays/cover and fittings included the bolts, nuts and assembling shall be AISI 316. The cable tray will be equipped with supports.

14 STRUCTURES

14.1 Air Gap and Minimum Deck Elevation

All the elevations shall be referred to Lowest Astronomical Tide (LAT), considered as elevation 0.0 m. Elevations above LAT shall be positive (+) values, elevations below LAT shall be negative (-) values.
The air gap to the lowest deck structure steel elevation shall be positive with respect to the 10000 years wave crest, as per ISO 19902 requirement.

Being the 10000 years return period wave crest elevation equal to 15.400 m LAT, assuming a beam height of 1 m the minimum top of steel elevation shall be not less than +16.400 m LAT.

On such basis, the new top-of-steel deck elevations are shown in the following table and compared with the previous ones:

	LEVEL	TOPSIDE ELEVATIONS TOS [m]
DECK	1	16.500
	2	22.500
	3	29.500
	1	35.500
	2	41.500

In general, no platform components, piping or equipment should be located below the lower deck in the designated air gap.

14.2 Substructure Configuration

A preliminary evaluation of substructures has been carried out. It will be a skirt piles four legged jacket.

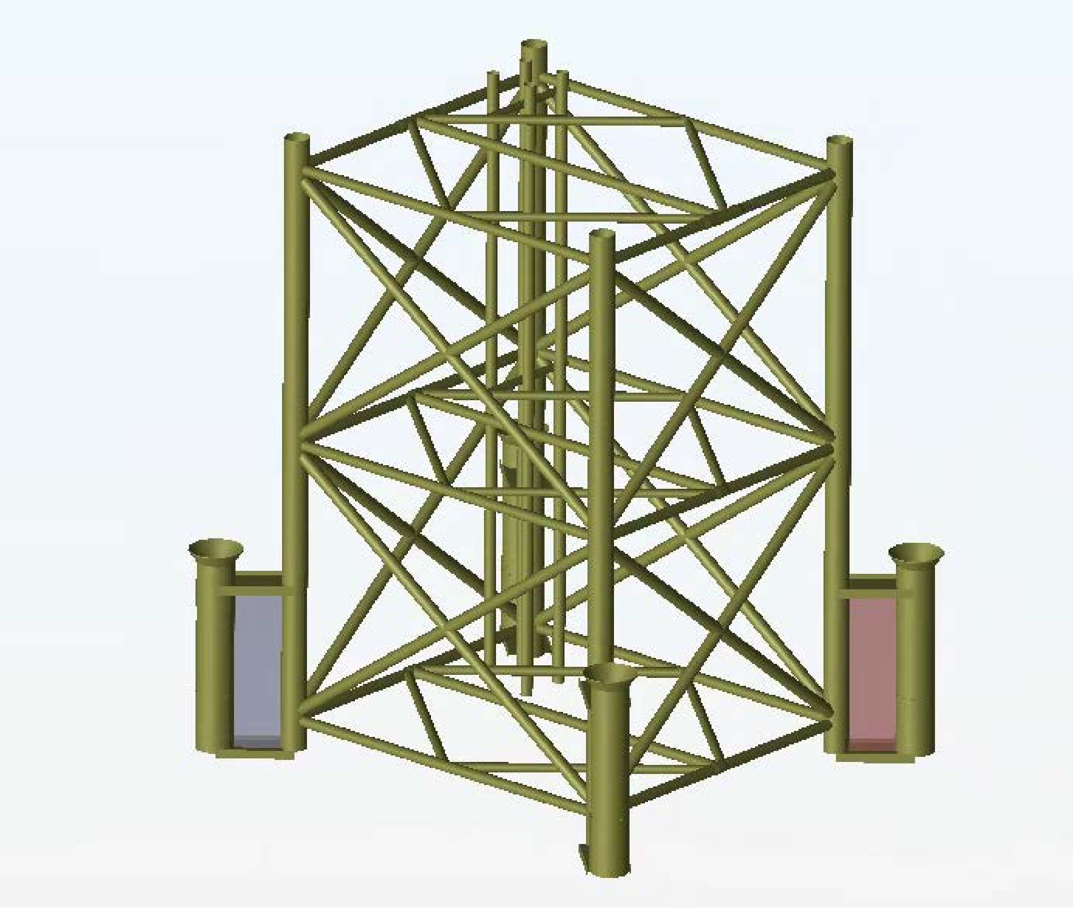
Leg spacing is 22 m x 25 m. Jacket will present three main framing plan at El. +8 m LAT, -10 m LAT and -28 m LAT.
It will accommodate six conductors.

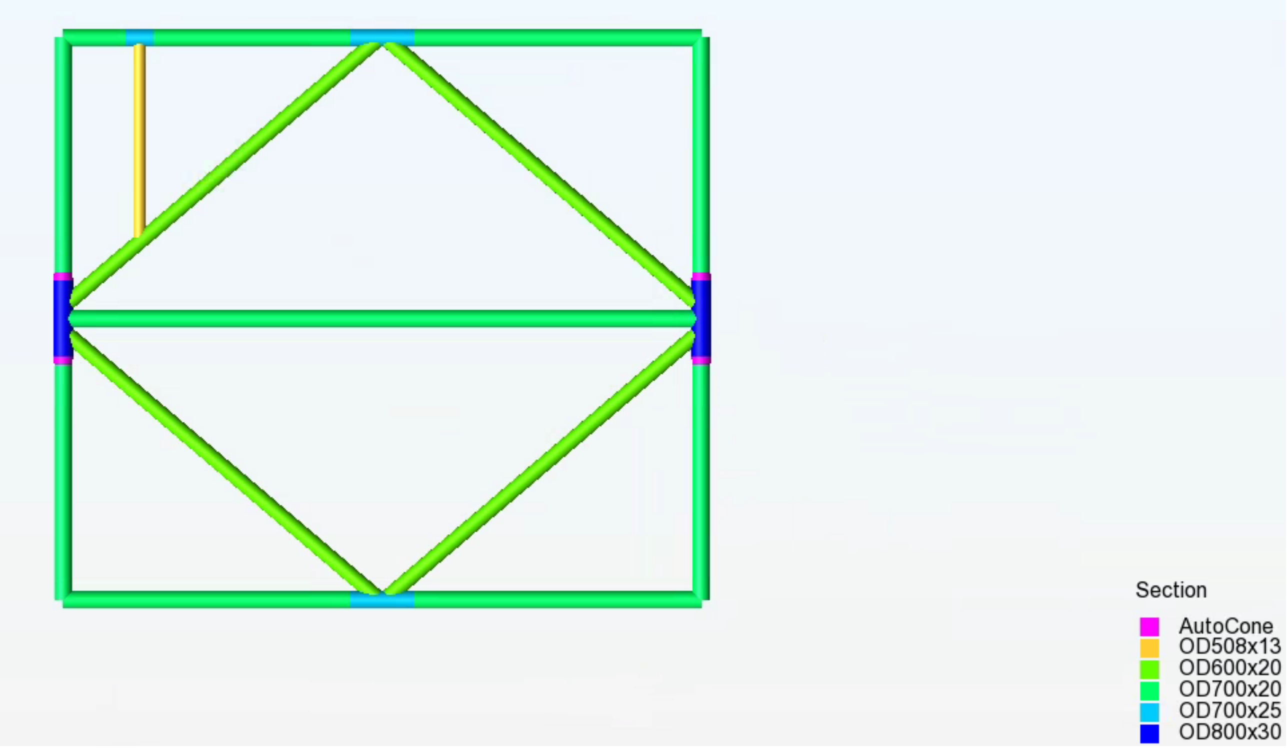
Four 84” OD foundation piles will be installed through sleeves. Space between sleeves and pile will be filled with grout to guarantee load transfer. Foundation piles will be driven to reach 50 m penetration.

Preliminary estimate of jacket weight is as follows:

- Overall jacket weight: 1350 t
  - Main Structure: 1000 t
  - Permanent Appurtenances: (risers, j-tubes, anodes, walkways etc.): 350 t.
- Foundation Piles Weight: 1150 t.

View of the jacket structures are provided in the following figures.

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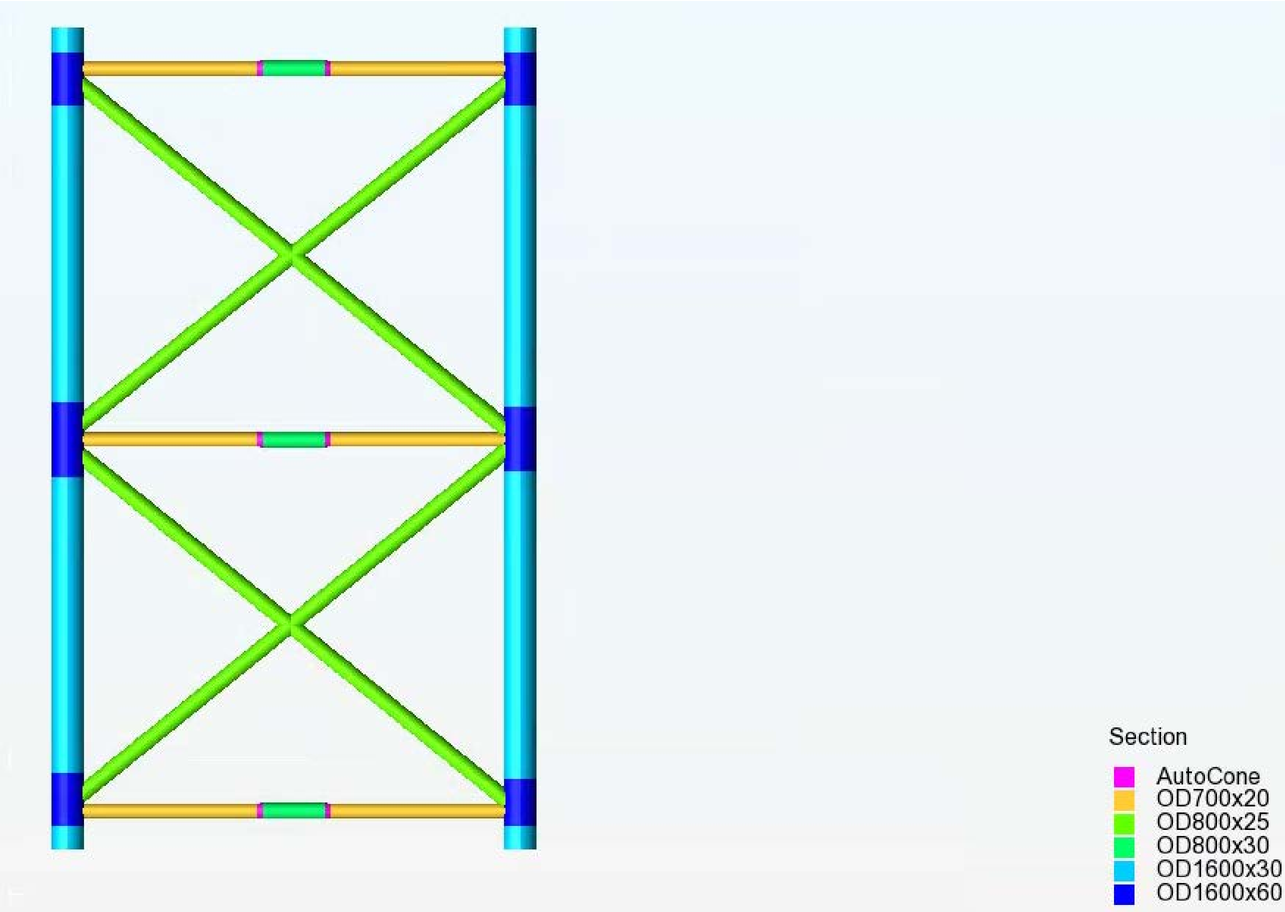
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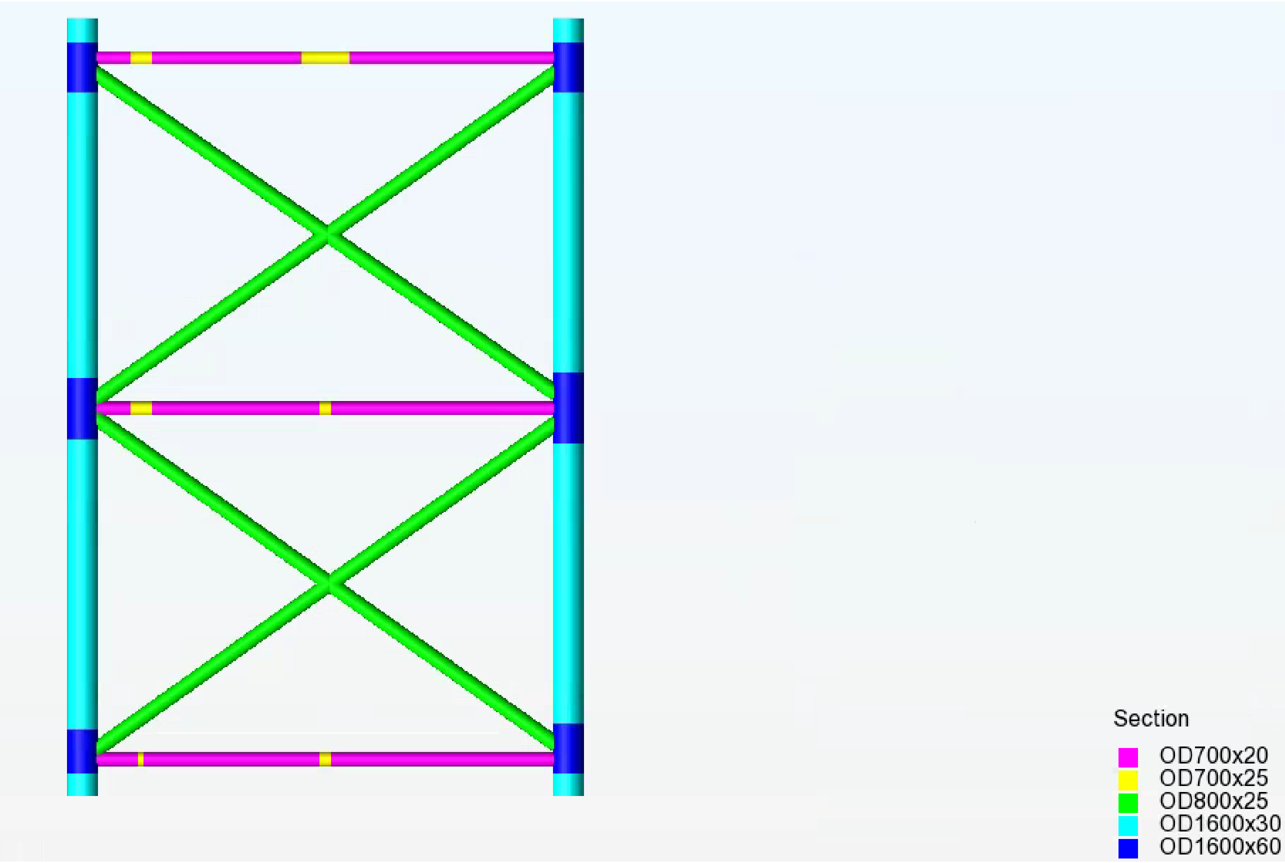
Section
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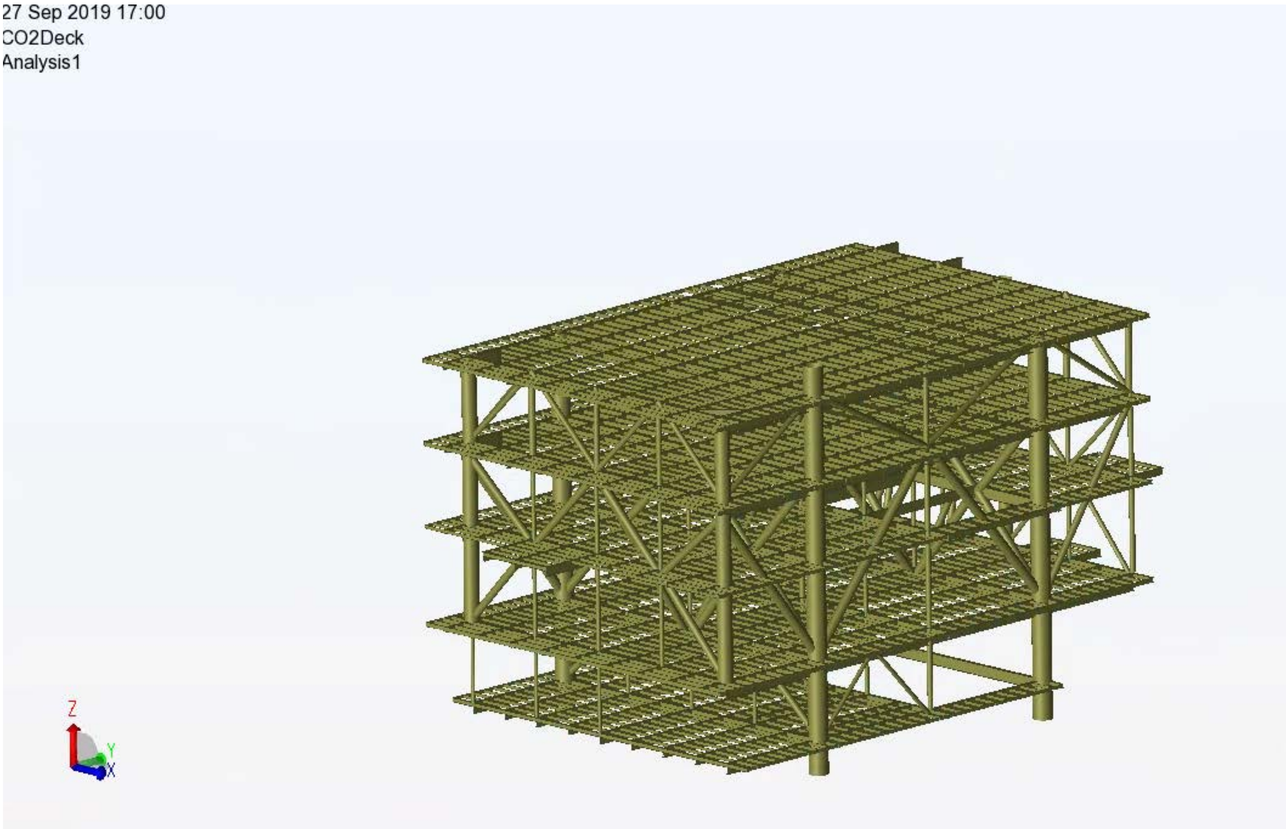
OD700x25
OD800x25
OD1600x30
OD1600x60

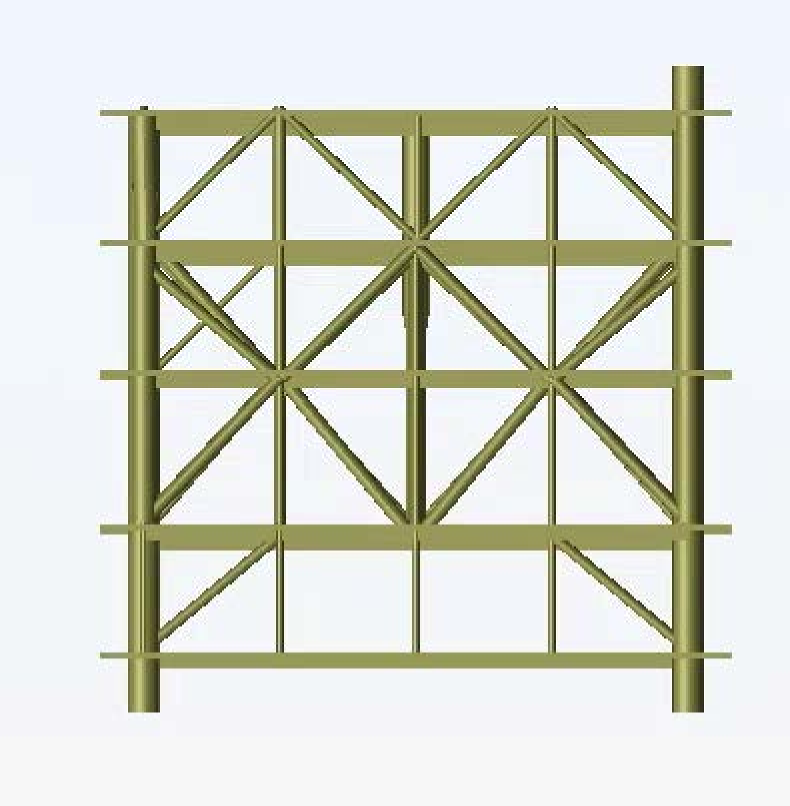
14.3 Topside Structures (*)

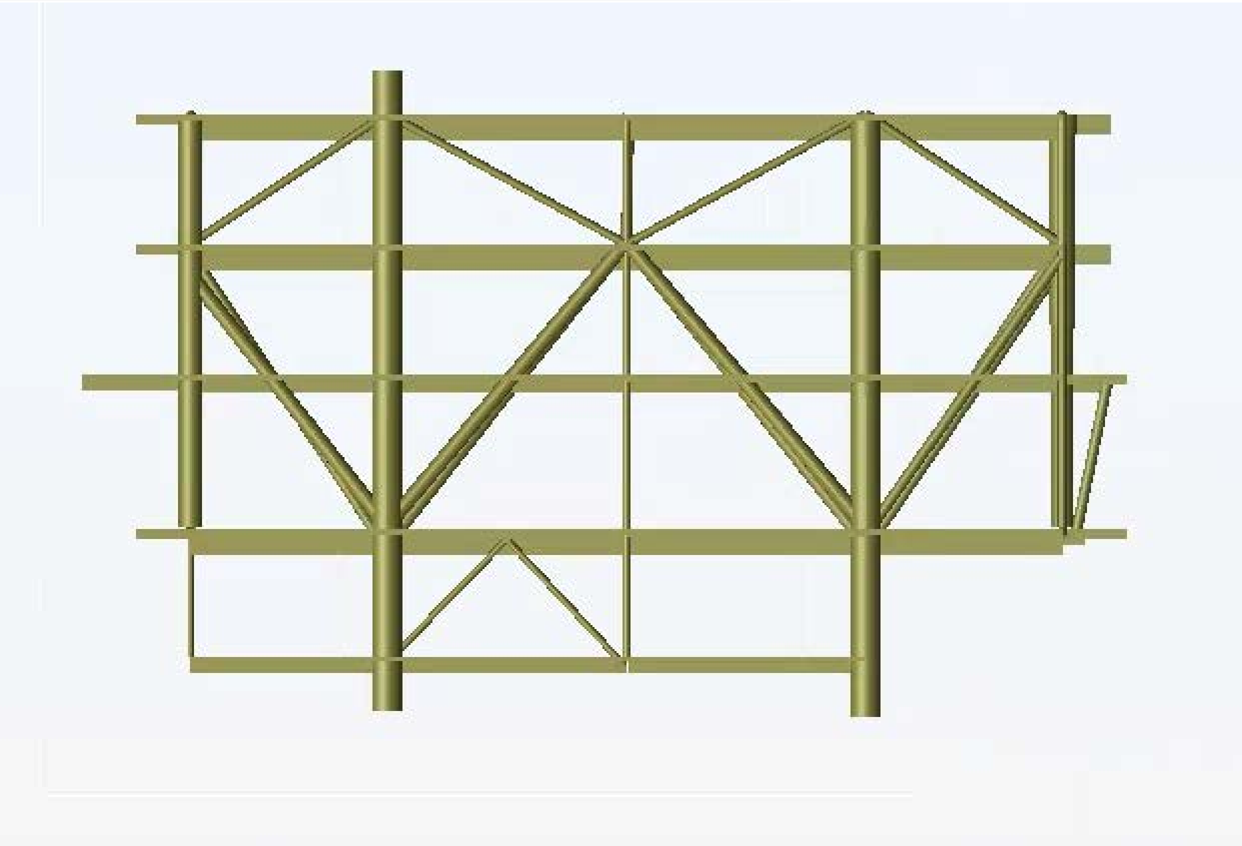
Topside of the platform will be an integrated deck with five levels. A view of the structure of the topside is provided here below.

Estimated weight of the topside structure is 2200 t with:
- 1400 t of primary structures and,
- 800 t of secondary structures.



(*) Topside structure to be implemented in order to integrate Helideck and Purge Burner System.





14.4 Overall Weight

STRUCTURE	WEIGHT (ton)
Substructure	
Jacket	
- Main structure	1000
- Permanent Appurtenances: (risers, j-tubes, anodes, walkways etc.)	350
Foundation Piles	1150
Topside Structure (*)	
- Primary Structures	1400
- Secondary Structures	800
Topside Facilities	1610
TOTAL	**6310**

(*) Topside structure to be implemented in order to integrate Helideck and Purge Burner System.

15 PLOT PLAN

The plot plans for the platform decks (*) are shown in the following attachments:

[3] “PLOT PLAN +16500.pdf”
[4] “PLOT PLAN +22500.pdf”
[5] “PLOT PLAN +29500.pdf”
[6] “PLOT PLAN +35500.pdf”
[7] “PLOT PLAN +41500 plus Hldk.pdf”

(*) Topside structure to be finalized in order to fully integrate Helideck and Purge Burner System.

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1635, 1636, 1637, 1638,\
1639, 1640, 1641, 1642, 1643) h,\
SOURCETYPE=MASS, PIPE="Pipe-001", SECTION=1, TEMPERATURE=(1644:50) C,\
MASSFLOW=(60, 52:77.40, 52:116.10, 52:154.80, 1487:190.26) kg/s,\
PHASE=GAS

TRENDDATA PIPE="PIPE-002", SECTION=1, VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h,
HOL, PT bara, QG, QGST MMscf/d, QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3,
ROL kg/m3)
TRENDDATA PIPE="PIPE-550", SECTION=1, VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h,
HOL, PT bara, QG, QGST MMscf/d, QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3,
ROL kg/m3)

HEATTRANSFER LABEL="HEATTRANS-subsea", PIPE=ALL, INTERPOLATION=VERTICAL,
HOUTEROPTION=WATER,  INTAMBIENT=4 C, OUTTAMBIENT=4 C
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INITIALCONDITIONS INTEMPERATURE=4 C, OUTTEMPERATURE=4 C, INPRESSURE=30 bara,
OUTPRESSURE=12 bara, VOIDFRACTION=0 -

GEOMETRY LABEL="LongLine1", XSTART=0 m, YSTART=1 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-001",       WALL="Wall-infield",
NSEGMENT=1,      XEND=0.0000 m, YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-002",       WALL="Wall-infield",
NSEGMENT=1,      XEND=520.7158 m,       YEND=+0.42900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-003",       WALL="Wall-infield",
NSEGMENT=1,      XEND=1041.4317 m,      YEND=+0.42900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-004",       WALL="Wall-infield",
NSEGMENT=1,      XEND=1562.1475 m,      YEND=+0.42900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-005",       WALL="Wall-infield",
NSEGMENT=1,      XEND=2082.8634 m,      YEND=+0.42900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-006",       WALL="Wall-infield",
NSEGMENT=1,      XEND=2603.5792 m,      YEND=+0.42900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-007",       WALL="Wall-infield",
NSEGMENT=1,      XEND=3124.2951 m,      YEND=-2.73600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-008",       WALL="Wall-infield",
NSEGMENT=1,      XEND=3645.0109 m,      YEND=-2.91300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-009",       WALL="Wall-infield",
NSEGMENT=1,      XEND=4165.7268 m,      YEND=-5.74200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-010",       WALL="Wall-infield",
NSEGMENT=1,      XEND=4686.4426 m,      YEND=-7.86300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-011",       WALL="Wall-infield",
NSEGMENT=1,      XEND=5207.1585 m,      YEND=-09.9220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-012",       WALL="Wall-infield",
NSEGMENT=1,      XEND=5727.8743 m,      YEND=-13.1770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-013",       WALL="Wall-infield",
NSEGMENT=1,      XEND=6248.5902 m,      YEND=-17.0130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-014",       WALL="Wall-infield",
NSEGMENT=1,      XEND=6769.3060 m,      YEND=-23.1790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-015",       WALL="Wall-infield",
NSEGMENT=1,      XEND=7290.0219 m,      YEND=-26.2940 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-016",       WALL="Wall-infield",
NSEGMENT=1,      XEND=7810.7377 m,      YEND=-28.6310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-017",       WALL="Wall-infield",
NSEGMENT=1,      XEND=8331.4536 m,      YEND=-29.8190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-018",       WALL="Wall-infield",
NSEGMENT=1,      XEND=8852.1694 m,      YEND=-29.6490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-019",       WALL="Wall-infield",
NSEGMENT=1,      XEND=9372.8852 m,      YEND=-33.4560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-020",       WALL="Wall-infield",
NSEGMENT=1,      XEND=9893.6011 m,      YEND=-31.5570 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-021",       WALL="Wall-infield",
NSEGMENT=1,      XEND=10414.3169 m,     YEND=-31.6120 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-022",       WALL="Wall-infield",
NSEGMENT=1,      XEND=10935.0328 m,     YEND=-35.7500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-023",       WALL="Wall-infield",
NSEGMENT=1,      XEND=11455.7486 m,     YEND=-37.5600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-024",       WALL="Wall-infield",
NSEGMENT=1,      XEND=11976.4645 m,     YEND=-38.9020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-357",       WALL="Wall-infield",
NSEGMENT=1,      XEND=12497.1804 m,     YEND=-39.6360 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-368",       WALL="Wall-infield",
NSEGMENT=1,      XEND=13017.8963 m,     YEND=-39.6090 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-373",       WALL="Wall-infield",
NSEGMENT=1,      XEND=13538.6122 m,     YEND=-38.5200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-374",       WALL="Wall-infield",
NSEGMENT=1,      XEND=14059.3281 m,     YEND=-38.1520 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-375",       WALL="Wall-infield",
NSEGMENT=1,      XEND=14580.0440 m,     YEND=-37.3440 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-376",       WALL="Wall-infield",
NSEGMENT=1,      XEND=15100.7599 m,     YEND=-35.9290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-377",       WALL="Wall-infield",
NSEGMENT=1,      XEND=15621.4758 m,     YEND=-36.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-378",       WALL="Wall-infield",
NSEGMENT=1,      XEND=16142.1917 m,     YEND=-35.0830 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-379",       WALL="Wall-infield",
NSEGMENT=1,      XEND=16662.9076 m,     YEND=-35.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-380",       WALL="Wall-infield",
NSEGMENT=1,      XEND=17183.6235 m,     YEND=-35.5450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-381",       WALL="Wall-infield",
NSEGMENT=1,      XEND=17704.3394 m,     YEND=-36.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-382",       WALL="Wall-infield",
NSEGMENT=1,      XEND=18225.0553 m,     YEND=-36.2200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-383",       WALL="Wall-infield",
NSEGMENT=1,      XEND=18745.7712 m,     YEND=-36.1200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-384",       WALL="Wall-infield",
NSEGMENT=1,      XEND=19266.4871 m,     YEND=-35.5050 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-385",       WALL="Wall-infield",
NSEGMENT=1,      XEND=19787.2030 m,     YEND=-34.6750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-386",       WALL="Wall-infield",
NSEGMENT=1,      XEND=20307.9189 m,     YEND=-33.7450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-387",       WALL="Wall-infield",
NSEGMENT=1,      XEND=20828.6348 m,     YEND=-32.9040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-388",       WALL="Wall-infield",
NSEGMENT=1,      XEND=21349.3507 m,     YEND=-33.0130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-389",       WALL="Wall-infield",
NSEGMENT=1,      XEND=21870.0666 m,     YEND=-31.5290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-390",       WALL="Wall-infield",
NSEGMENT=1,      XEND=22390.7825 m,     YEND=-30.0220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-391",       WALL="Wall-infield",
NSEGMENT=1,      XEND=22911.4984 m,     YEND=-30.4130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-392",       WALL="Wall-infield",
NSEGMENT=1,      XEND=23432.2143 m,     YEND=-31.2370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-399",       WALL="Wall-infield",
NSEGMENT=1,      XEND=23952.9302 m,     YEND=-30.3640 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-400",       WALL="Wall-infield",
NSEGMENT=1,      XEND=24473.6461 m,     YEND=-30.1790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-401",       WALL="Wall-infield",
NSEGMENT=1,      XEND=24994.3620 m,     YEND=-29.6260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-402",       WALL="Wall-infield",
NSEGMENT=1,      XEND=25515.0779 m,     YEND=-29.2730 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-403",       WALL="Wall-infield",
NSEGMENT=1,      XEND=26035.7938 m,     YEND=-28.4590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-518",       WALL="Wall-infield",
NSEGMENT=1,      XEND=26556.5097 m,     YEND=-28.8990 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-519",       WALL="Wall-infield",
NSEGMENT=1,      XEND=27077.2256 m,     YEND=-29.3310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-520",       WALL="Wall-infield",
NSEGMENT=1,      XEND=27597.9415 m,     YEND=-28.6380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-521",       WALL="Wall-infield",
NSEGMENT=1,      XEND=28118.6574 m,     YEND=-26.6510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-522",       WALL="Wall-infield",
NSEGMENT=1,      XEND=28639.3733 m,     YEND=-25.0470 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-523",       WALL="Wall-infield",
NSEGMENT=1,      XEND=29160.0892 m,     YEND=-25.2930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-524",       WALL="Wall-infield",
NSEGMENT=1,      XEND=29680.8051 m,     YEND=-25.6620 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-525",       WALL="Wall-infield",
NSEGMENT=1,      XEND=30201.5210 m,     YEND=-25.8810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-526",       WALL="Wall-infield",
NSEGMENT=1,      XEND=30722.2369 m,     YEND=-26.9510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-527",       WALL="Wall-infield",
NSEGMENT=1,      XEND=31242.9528 m,     YEND=-27.0660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-528",       WALL="Wall-infield",
NSEGMENT=1,      XEND=31763.6687 m,     YEND=-26.7060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-529",       WALL="Wall-infield",
NSEGMENT=1,      XEND=32284.3846 m,     YEND=-26.4360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-530",       WALL="Wall-infield",
NSEGMENT=1,      XEND=32805.1005 m,     YEND=-26.2550 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-531",       WALL="Wall-infield",
NSEGMENT=1,      XEND=33325.8164 m,     YEND=-27.0040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-532",       WALL="Wall-infield",
NSEGMENT=1,      XEND=33846.5323 m,     YEND=-27.7770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-533",       WALL="Wall-infield",
NSEGMENT=1,      XEND=34367.2482 m,     YEND=-27.0280 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-534",       WALL="Wall-infield",
NSEGMENT=1,      XEND=34887.9641 m,     YEND=-27.7420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-535",       WALL="Wall-infield",
NSEGMENT=1,      XEND=35408.6800 m,     YEND=-27.4650 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-536",       WALL="Wall-infield",
NSEGMENT=1,      XEND=35929.3959 m,     YEND=-27.1700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-537",       WALL="Wall-infield",
NSEGMENT=1,      XEND=36450.1118 m,     YEND=-27.3480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-538",       WALL="Wall-infield",
NSEGMENT=1,      XEND=36970.8277 m,     YEND=-28.0600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-539",       WALL="Wall-infield",
NSEGMENT=1,      XEND=37491.5436 m,     YEND=-31.1020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-540",       WALL="Wall-infield",
NSEGMENT=1,      XEND=38012.2595 m,     YEND=-30.0880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-541",       WALL="Wall-infield",
NSEGMENT=1,      XEND=38532.9754 m,     YEND=-28.2370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-542",       WALL="Wall-infield",
NSEGMENT=1,      XEND=39053.6913 m,     YEND=-29.4360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-543",       WALL="Wall-infield",
NSEGMENT=1,      XEND=39574.4072 m,     YEND=-31.8320 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-544",       WALL="Wall-infield",
NSEGMENT=1,      XEND=40095.1231 m,     YEND=-31.9360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-545",       WALL="Wall-infield",
NSEGMENT=1,      XEND=40615.8390 m,     YEND=-33.3630 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-546",       WALL="Wall-infield",
NSEGMENT=1,      XEND=41136.5549 m,     YEND=-35.1800 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-547",       WALL="Wall-infield",
NSEGMENT=1,      XEND=41657.2708 m,     YEND=-33.6020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-548",       WALL="Wall-infield",
NSEGMENT=1,      XEND=42177.9867 m,     YEND=-34.4300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-549",       WALL="Wall-infield",
NSEGMENT=1,      XEND=42698.7026 m,     YEND=-31.9990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-550",       WALL="Wall-infield",
NSEGMENT=1,      XEND=43219.4185 m,     YEND=+17.4900 m,        DIAMETER=0.711 m
ENDNETWORKCOMPONENT


!********************************************************************************
*******
! Network Component
!********************************************************************************
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NETWORKCOMPONENT TYPE=FLOWPATH, TAG="HEWETT_WELLS_LB"
  PARAMETERS LABEL=HEWETT_WELLS_LB
  BRANCH FLUID=Fluid1
  GEOMETRY LABEL=WELL2, XSTART=-40 ft, YSTART=17.49 m
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-AIR", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=100.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-000", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=000.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-001", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-40.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-002", WALL="SEC_30-in",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-80.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-003", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-120.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-004", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-160.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-005", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-200.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-006", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-240.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-007", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-280.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-008", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-320.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-009", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-360.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-010", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-400.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-011", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-440.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-012", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-480.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-013", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-520.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-014", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-560.000 ft, DIAMETER=219.0 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-015", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-600.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-016", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-640.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-017", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.102672 ft,  YEND=-680.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-018", WALL="SEC_7-in",
NSEGMENT=1, XEND=0.646604 ft,  YEND=-719.996 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-019", WALL="SEC_7-in",
NSEGMENT=1, XEND=1.26007 ft,  YEND=-759.991 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-020", WALL="SEC_7-in",
NSEGMENT=1, XEND=2.14582 ft,  YEND=-799.982 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-021", WALL="SEC_7-in",
NSEGMENT=1, XEND=3.43897 ft,  YEND=-839.961 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-022", WALL="SEC_7-in",
NSEGMENT=1, XEND=4.73212 ft,  YEND=-879.94 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-023", WALL="SEC_7-in",
NSEGMENT=1, XEND=6.63223 ft,  YEND=-919.895 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-024", WALL="SEC_7-in",
NSEGMENT=1, XEND=8.61737 ft,  YEND=-959.845 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-025", WALL="SEC_7-in",
NSEGMENT=1, XEND=10.9013 ft,  YEND=-999.78 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-026", WALL="SEC_7-in",
NSEGMENT=1, XEND=13.5807 ft,  YEND=-1039.69 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-027", WALL="SEC_7-in",
NSEGMENT=1, XEND=16.2601 ft,  YEND=-1079.6 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-028", WALL="SEC_7-in",
NSEGMENT=1, XEND=19.5921 ft,  YEND=-1119.46 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-029", WALL="SEC_7-in",
NSEGMENT=1, XEND=22.9661 ft,  YEND=-1159.32 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-030", WALL="SEC_7-in",
NSEGMENT=1, XEND=26.6843 ft,  YEND=-1199.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-031", WALL="SEC_7-in",
NSEGMENT=1, XEND=30.7523 ft,  YEND=-1238.94 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-032", WALL="SEC_7-in",
NSEGMENT=1, XEND=34.8292 ft,  YEND=-1278.73 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-033", WALL="SEC_7-in",
NSEGMENT=1, XEND=39.5904 ft,  YEND=-1318.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-034", WALL="SEC_7-in",
NSEGMENT=1, XEND=44.3515 ft,  YEND=-1358.16 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-035", WALL="SEC_7-in",
NSEGMENT=1, XEND=49.5057 ft,  YEND=-1397.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-036", WALL="SEC_7-in",
NSEGMENT=1, XEND=54.9588 ft,  YEND=-1437.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-037", WALL="SEC_7-in",
NSEGMENT=1, XEND=60.4779 ft,  YEND=-1477.07 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-038", WALL="SEC_7-in",
NSEGMENT=1, XEND=66.6213 ft,  YEND=-1516.6 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-039", WALL="SEC_7-in",
NSEGMENT=1, XEND=72.7647 ft,  YEND=-1556.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-040", WALL="SEC_7-in",
NSEGMENT=1, XEND=79.3504 ft,  YEND=-1595.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-041", WALL="SEC_7-in",
NSEGMENT=1, XEND=86.1823 ft,  YEND=-1634.99 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-042", WALL="SEC_7-in",
NSEGMENT=1, XEND=93.1082 ft,  YEND=-1674.38 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-043", WALL="SEC_7-in",
NSEGMENT=1, XEND=100.477 ft,  YEND=-1713.7 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-044", WALL="SEC_7-in",
NSEGMENT=1, XEND=107.998 ft,  YEND=-1752.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-045", WALL="SEC_7-in",
NSEGMENT=1, XEND=115.562 ft,  YEND=-1792.27 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-046", WALL="SEC_7-in",
NSEGMENT=1, XEND=123.429 ft,  YEND=-1831.48 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-047", WALL="SEC_7-in",
NSEGMENT=1, XEND=131.694 ft,  YEND=-1870.62 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-048", WALL="SEC_7-in",
NSEGMENT=1, XEND=140.768 ft,  YEND=-1909.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-049", WALL="SEC_7-in",
NSEGMENT=1, XEND=149.843 ft,  YEND=-1948.53 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-050", WALL="SEC_7-in",
NSEGMENT=1, XEND=159.999 ft,  YEND=-1987.22 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-051", WALL="SEC_7-in",
NSEGMENT=1, XEND=170.426 ft,  YEND=-2025.84 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-052", WALL="SEC_7-in",
NSEGMENT=1, XEND=181.311 ft,  YEND=-2064.33 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-053", WALL="SEC_7-in",
NSEGMENT=1, XEND=193.079 ft,  YEND=-2102.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-054", WALL="SEC_7-in",
NSEGMENT=1, XEND=204.847 ft,  YEND=-2140.79 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-055", WALL="SEC_7-in",
NSEGMENT=1, XEND=217.773 ft,  YEND=-2178.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-056", WALL="SEC_7-in",
NSEGMENT=1, XEND=230.867 ft,  YEND=-2216.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-057", WALL="SEC_7-in",
NSEGMENT=1, XEND=244.510 ft,  YEND=-2254.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-058", WALL="SEC_7-in",
NSEGMENT=1, XEND=258.915 ft,  YEND=-2291.36 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-059", WALL="SEC_7-in",
NSEGMENT=1, XEND=273.319 ft,  YEND=-2328.68 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-060", WALL="SEC_7-in",
NSEGMENT=1, XEND=288.949 ft,  YEND=-2365.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-061", WALL="SEC_7-in",
NSEGMENT=1, XEND=304.647 ft,  YEND=-2402.29 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-062", WALL="SEC_7-in",
NSEGMENT=1, XEND=320.977 ft,  YEND=-2438.8 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-063", WALL="SEC_7-in",
NSEGMENT=1, XEND=337.949 ft,  YEND=-2475.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-064", WALL="SEC_7-in",
NSEGMENT=1, XEND=354.952 ft,  YEND=-2511.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-065", WALL="SEC_7-in",
NSEGMENT=1, XEND=373.177 ft,  YEND=-2546.84 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-066", WALL="SEC_7-in",
NSEGMENT=1, XEND=391.402 ft,  YEND=-2582.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-067", WALL="SEC_7-in",
NSEGMENT=1, XEND=410.333 ft,  YEND=-2617.68 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-068", WALL="SEC_7-in",
NSEGMENT=1, XEND=429.790 ft,  YEND=-2652.63 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-069", WALL="SEC_7-in",
NSEGMENT=1, XEND=449.375 ft,  YEND=-2687.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-070", WALL="SEC_7-in",
NSEGMENT=1, XEND=470.039 ft,  YEND=-2721.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-071", WALL="SEC_7-in",
NSEGMENT=1, XEND=490.703 ft,  YEND=-2756.00 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-072", WALL="SEC_7-in",
NSEGMENT=1, XEND=512.137 ft,  YEND=-2789.78 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-073", WALL="SEC_7-in",
NSEGMENT=1, XEND=533.983 ft,  YEND=-2823.28 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-074", WALL="SEC_7-in",
NSEGMENT=1, XEND=556.046 ft,  YEND=-2856.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-075", WALL="SEC_7-in",
NSEGMENT=1, XEND=579.049 ft,  YEND=-2889.37 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-076", WALL="SEC_7-in",
NSEGMENT=1, XEND=602.051 ft,  YEND=-2922.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-077", WALL="SEC_7-in",
NSEGMENT=1, XEND=625.582 ft,  YEND=-2954.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-078", WALL="SEC_7-in",
NSEGMENT=1, XEND=649.453 ft,  YEND=-2986.54 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-079", WALL="SEC_7-in",
NSEGMENT=1, XEND=673.325 ft,  YEND=-3018.64 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-080", WALL="SEC_7-in",
NSEGMENT=1, XEND=697.196 ft,  YEND=-3050.73 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-081", WALL="SEC_7-in",
NSEGMENT=1, XEND=721.068 ft,  YEND=-3082.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-082", WALL="SEC_7-in",
NSEGMENT=1, XEND=744.939 ft,  YEND=-3114.92 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-083", WALL="SEC_7-in",
NSEGMENT=1, XEND=768.810 ft,  YEND=-3147.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-084", WALL="SEC_7-in",
NSEGMENT=1, XEND=792.682 ft,  YEND=-3179.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-085", WALL="SEC_7-in",
NSEGMENT=1, XEND=816.553 ft,  YEND=-3211.21 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-086", WALL="SEC_7-in",
NSEGMENT=1, XEND=840.425 ft,  YEND=-3243.31 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-087", WALL="SEC_7-in",
NSEGMENT=1, XEND=864.296 ft,  YEND=-3275.4 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-088", WALL="SEC_7-in",
NSEGMENT=1, XEND=888.167 ft,  YEND=-3307.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-089", WALL="SEC_7-in",
NSEGMENT=1, XEND=912.039 ft,  YEND=-3339.6 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-090", WALL="SEC_7-in",
NSEGMENT=1, XEND=936.566 ft,  YEND=-3371.19 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-091", WALL="SEC_7-in",
NSEGMENT=1, XEND=961.269 ft,  YEND=-3402.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-092", WALL="SEC_7-in",
NSEGMENT=1, XEND=987.767 ft,  YEND=-3432.62 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-093", WALL="SEC_7-in",
NSEGMENT=1, XEND=1014.34 ft,  YEND=-3462.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-094", WALL="SEC_7-in",
NSEGMENT=1, XEND=1041.95 ft,  YEND=-3491.46 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-095", WALL="SEC_7-in",
NSEGMENT=1, XEND=1070.55 ft,  YEND=-3519.43 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-096", WALL="SEC_7-in",
NSEGMENT=1, XEND=1099.21 ft,  YEND=-3547.32 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-097", WALL="SEC_7-in",
NSEGMENT=1, XEND=1129.69 ft,  YEND=-3573.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-098", WALL="SEC_7-in",
NSEGMENT=1, XEND=1160.16 ft,  YEND=-3599.14 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-099", WALL="SEC_7-in",
NSEGMENT=1, XEND=1191.66 ft,  YEND=-3623.79 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-100", WALL="SEC_7-in",
NSEGMENT=1, XEND=1223.87 ft,  YEND=-3647.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-101", WALL="SEC_7-in",
NSEGMENT=1, XEND=1256.27 ft,  YEND=-3670.97 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-102", WALL="SEC_7-in",
NSEGMENT=1, XEND=1290.05 ft,  YEND=-3692.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-103", WALL="SEC_7-in",
NSEGMENT=1, XEND=1323.84 ft,  YEND=-3713.81 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-104", WALL="SEC_7-in",
NSEGMENT=1, XEND=1358.57 ft,  YEND=-3733.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-105", WALL="SEC_7-in",
NSEGMENT=1, XEND=1393.76 ft,  YEND=-3752.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-106", WALL="SEC_7-in",
NSEGMENT=1, XEND=1429.21 ft,  YEND=-3771.18 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-107", WALL="SEC_7-in",
NSEGMENT=1, XEND=1465.65 ft,  YEND=-3787.69 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-108", WALL="SEC_7-in",
NSEGMENT=1, XEND=1502.08 ft,  YEND=-3804.2 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-109", WALL="SEC_7-in",
NSEGMENT=1, XEND=1539.32 ft,  YEND=-3818.82 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-110", WALL="SEC_7-in",
NSEGMENT=1, XEND=1576.81 ft,  YEND=-3832.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-111", WALL="SEC_7-in",
NSEGMENT=1, XEND=1614.57 ft,  YEND=-3845.95 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-112", WALL="SEC_7-in",
NSEGMENT=1, XEND=1652.95 ft,  YEND=-3857.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-113", WALL="SEC_7-in",
NSEGMENT=1, XEND=1691.33 ft,  YEND=-3868.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-114", WALL="SEC_7-in",
NSEGMENT=1, XEND=1730.30 ft,  YEND=-3877.49 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-115", WALL="SEC_7-in",
NSEGMENT=1, XEND=1769.40 ft,  YEND=-3885.93 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-116", WALL="SEC_7-in",
NSEGMENT=1, XEND=1808.54 ft,  YEND=-3894.21 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-117", WALL="SEC_7-in",
NSEGMENT=1, XEND=1847.93 ft,  YEND=-3901.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-118", WALL="SEC_7-in",
NSEGMENT=1, XEND=1887.32 ft,  YEND=-3908.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-119", WALL="SEC_7-in",
NSEGMENT=1, XEND=1926.71 ft,  YEND=-3915.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-120", WALL="SEC_7-in",
NSEGMENT=1, XEND=1966.11 ft,  YEND=-3921.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-121", WALL="SEC_7-in",
NSEGMENT=1, XEND=2005.50 ft,  YEND=-3928.94 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-122", WALL="SEC_7-in",
NSEGMENT=1, XEND=2044.89 ft,  YEND=-3935.88 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-123", WALL="SEC_7-in",
NSEGMENT=1, XEND=2084.28 ft,  YEND=-3942.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-124", WALL="SEC_7-in",
NSEGMENT=1, XEND=2123.68 ft,  YEND=-3949.77 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-125", WALL="SEC_7-in",
NSEGMENT=1, XEND=2163.07 ft,  YEND=-3956.72 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-126", WALL="SEC_7-in",
NSEGMENT=1, XEND=2202.46 ft,  YEND=-3963.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-127", WALL="SEC_7-in",
NSEGMENT=1, XEND=2241.85 ft,  YEND=-3970.61 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-128", WALL="SEC_7-in",
NSEGMENT=1, XEND=2281.25 ft,  YEND=-3977.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-129", WALL="SEC_7-in",
NSEGMENT=1, XEND=2320.64 ft,  YEND=-3984.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-130", WALL="SEC_7-in",
NSEGMENT=1, XEND=2360.03 ft,  YEND=-3991.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-131", WALL="SEC_7-in",
NSEGMENT=1, XEND=2399.42 ft,  YEND=-3998.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-132", WALL="SEC_7-in",
NSEGMENT=1, XEND=2438.81 ft,  YEND=-4005.34 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-133", WALL="SEC_7-in",
NSEGMENT=1, XEND=2478.21 ft,  YEND=-4012.29 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-134", WALL="SEC_7-in",
NSEGMENT=1, XEND=2517.60 ft,  YEND=-4019.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-135", WALL="SEC_7-in",
NSEGMENT=1, XEND=2556.99 ft,  YEND=-4026.18 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-136", WALL="SEC_7-in",
NSEGMENT=1, XEND=2596.38 ft,  YEND=-4033.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-137", WALL="SEC_7-in",
NSEGMENT=1, XEND=2635.78 ft,  YEND=-4040.07 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-138", WALL="SEC_7-in",
NSEGMENT=1, XEND=2675.17 ft,  YEND=-4047.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-139", WALL="SEC_7-in",
NSEGMENT=1, XEND=2714.56 ft,  YEND=-4053.96 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-140", WALL="SEC_7-in",
NSEGMENT=1, XEND=2753.95 ft,  YEND=-4060.91 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-141", WALL="SEC_7-in",
NSEGMENT=1, XEND=2793.35 ft,  YEND=-4067.85 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-142", WALL="SEC_7-in",
NSEGMENT=1, XEND=2832.74 ft,  YEND=-4074.8 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-143", WALL="SEC_7-in",
NSEGMENT=1, XEND=2872.13 ft,  YEND=-4081.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-144", WALL="SEC_7-in",
NSEGMENT=1, XEND=2911.52 ft,  YEND=-4088.69 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-145", WALL="SEC_7-in",
NSEGMENT=1, XEND=2950.91 ft,  YEND=-4095.64 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-146", WALL="SEC_7-in",
NSEGMENT=1, XEND=2990.31 ft,  YEND=-4102.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-147", WALL="SEC_7-in",
NSEGMENT=1, XEND=3029.70 ft,  YEND=-4109.53 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-148", WALL="SEC_7-in",
NSEGMENT=1, XEND=3069.09 ft,  YEND=-4116.48 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-149", WALL="SEC_7-in",
NSEGMENT=1, XEND=3108.48 ft,  YEND=-4123.42 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-150", WALL="SEC_7-in",
NSEGMENT=1, XEND=3147.88 ft,  YEND=-4130.37 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-151", WALL="SEC_7-in",
NSEGMENT=1, XEND=3187.27 ft,  YEND=-4137.31 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-152", WALL="SEC_7-in",
NSEGMENT=1, XEND=3226.66 ft,  YEND=-4144.26 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-153", WALL="SEC_7-in",
NSEGMENT=1, XEND=3266.05 ft,  YEND=-4151.2 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-154", WALL="SEC_7-in",
NSEGMENT=1, XEND=3305.45 ft,  YEND=-4158.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-155", WALL="SEC_7-in",
NSEGMENT=1, XEND=3344.84 ft,  YEND=-4165.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-156", WALL="SEC_7-in",
NSEGMENT=1, XEND=3384.23 ft,  YEND=-4172.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-157", WALL="SEC_7-in",
NSEGMENT=1, XEND=3423.62 ft,  YEND=-4178.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-158", WALL="SEC_7-in",
NSEGMENT=1, XEND=3463.01 ft,  YEND=-4185.93 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-159", WALL="SEC_7-in",
NSEGMENT=1, XEND=3502.41 ft,  YEND=-4192.88 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-160", WALL="SEC_7-in",
NSEGMENT=1, XEND=3541.80 ft,  YEND=-4199.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-161", WALL="SEC_7-in",
NSEGMENT=1, XEND=3581.19 ft,  YEND=-4206.77 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-162", WALL="SEC_7-in",
NSEGMENT=1, XEND=3620.58 ft,  YEND=-4213.72 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-163", WALL="SEC_7-in",
NSEGMENT=1, XEND=3659.98 ft,  YEND=-4220.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-164", WALL="SEC_7-in",
NSEGMENT=1, XEND=3699.37 ft,  YEND=-4227.61 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-165", WALL="SEC_7-in",
NSEGMENT=1, XEND=3738.76 ft,  YEND=-4234.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-166", WALL="SEC_7-in",
NSEGMENT=1, XEND=3778.15 ft,  YEND=-4241.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-167", WALL="SEC_7-in",
NSEGMENT=1, XEND=3817.55 ft,  YEND=-4248.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-168", WALL="SEC_7-in",
NSEGMENT=1, XEND=3856.94 ft,  YEND=-4255.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-169", WALL="SEC_7-in",
NSEGMENT=1, XEND=3896.33 ft,  YEND=-4262.34 ft, DIAMETER=157.1 mm
  HEATTRANSFER LABEL=HT_well_2_00, PIPE="PIPE-AIR", HOUTEROPTION=AIR,
TAMBIENT=5.00 C,  VELOCITY=1.0 m/s
  HEATTRANSFER LABEL=HT_well_2_01, PIPE="PIPE-000", HOUTEROPTION=WATER,
TAMBIENT=7.00 C,  VELOCITY=1.0 m/s
  HEATTRANSFER LABEL=HT_well_2_02, PIPE="3-171", INTAMBIENT=7.00 C,
OUTTAMBIENT=52 C,  HAMBIENT=1000000 W/m2-C
  TRENDDATA VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h, HOL, PT bara, QG, QGST
MMscf/d,  QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3, ROL kg/m3),
PIPE="PIPE-000",  SECTION=1
  TRENDDATA VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h, HOL, PT bara, QG, QGST
MMscf/d,  QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3, ROL kg/m3),
PIPE="PIPE-169",  SECTION=1
  INITIALCONDITIONS INTEMPERATURE=10 C, OUTTEMPERATURE=30 C, INPRESSURE=15.4
bara,  OUTPRESSURE=9 bara, VOIDFRACTION=1 -
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  VALVE LABEL=WELL_MASTER_2, TIME=0 s, PIPE="PIPE-001", SECTIONBOUNDARY=1,
EQUILIBRIUMMODEL=EQUILIBRIUM,  OPENING=1, DIAMETER=4 IN
  POSITION LABEL="WELL_RES-POS_2", PIPE="Pipe-169", SECTION=1
  RESERVOIRCONTACT LABEL=WELL_RES_2, TIME=(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10,
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ENDNETWORKCOMPONENT


NETWORKCOMPONENT TYPE=NODE, TAG=OFFSHORE_MAN
  PARAMETERS LABEL=OFFSHORE_MAN, TYPE=INTERNAL
ENDNETWORKCOMPONENT

NETWORKCOMPONENT TYPE=NODE, TAG=NODE_BH_LB
 PARAMETERS LABEL=NODE_BH_LB, TYPE=PRESSURE, TEMPERATURE=(1644:4) C,\
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 95.744, 95.766, 95.797, 95.822, 95.845, 95.872) bara
ENDNETWORKCOMPONENT

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! Connections
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CONNECTION TERMINALS = (LONG_LINE_1 INLET, ONSHORE_MAN FLOWTERM_1)
CONNECTION TERMINALS = (LONG_LINE_1 OUTLET, OFFSHORE_MAN FLOWTERM_1)
CONNECTION TERMINALS = (OFFSHORE_MAN FLOWTERM_2, "HEWETT_WELLS_LB" INLET)
CONNECTION TERMINALS = ("HEWETT_WELLS_LB" OUTLET, NODE_BH_LB FLOWTERM_1)
ENDCASE
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! Global keywords
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CASE AUTHOR=TEFA, PROJECT=OLGA, TITLE="ExportLineSens"
OPTIONS TEMPERATURE=WALL, STEADYSTATE=ON, DEBUG=OFF, FLOWMODEL=OLGAHD,
COMPOSITIONAL=SINGLE
SINGLEOPTIONS COMPONENT=CO2, MINPRESSURE=0.1 bara, MAXPRESSURE=350 bara,
MINTEMPERATURE=-150 C, MAXTEMPERATURE=150 C, FLASHFORMULATION=PH

INTEGRATION ENDTIME=1600 h, MAXDT=10 s, MINDT=0.0000001 s, STARTTIME=0 s,
DTSTART=0.1 s
OUTPUT DTOUT=10 h
TREND DTPLOT=1 m
PROFILE DTPLOT=1 h

TRENDDATA VARIABLE=(HT, SPEED, VOLGBL)
TRENDDATA VARIABLE=(GGSOUR, GLHLMA, GLSOUR, GLWTMA, GTSOUR, ICRIT, QGSTSOUR,
QLSTSOUR, QOSTSOUR, QWSTSOUR, QGSTWELL, QLSTWELL, QOSTWELL, QWSTWELL)
TRENDDATA VARIABLE=(TVALVE, VALVDP bara, VALVOP, PVALVE bara)
TRENDDATA VARIABLE=(DPBR bara, DPFBR bara, DPGBR bara, DPABR bara)
TRENDDATA VARIABLE=(WATC, LIQC, OILC, GASC)
TRENDDATA VARIABLE=(MAXTMBRCT, MINTMBRCT, MAXPTBRCT, MINPTBRCT)

PROFILEDATA VARIABLE=(GG kg/s, GLT kg/s, GLTWT kg/s, GT kg/s, QGST MMscf/d, QLST
MMscf/d)
PROFILEDATA VARIABLE=(EVR, HOL, HOLWT, HOLHL, ID)
PROFILEDATA VARIABLE=(PT bara, Q2, QG, ROG kg/m3, ROL kg/m3, TM, TWS, UG, UL)
PROFILEDATA VARIABLE=(SIG, GD, TAUWG, TAUWGA, RS, DPZF, DPZG, HTK, ESTRESTIMEW,
VISL, VISG, TU)

RESTART WRITE=APPEND, DTWRITE=10 h  !

!******************************************************************************
*******
! Library keywords
!******************************************************************************
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MATERIAL LABEL=3LHDPE, CAPACITY=2300 J/kg-K, CONDUCTIVITY=0.3 W/m-K, DENSITY=950
kg/m3
MATERIAL LABEL=3LPP, CAPACITY=1000 J/kg-C, CONDUCTIVITY=0.22 W/m-K, DENSITY=900
kg/m3
MATERIAL LABEL=carbonsteel, CAPACITY=434 J/kg-C, CONDUCTIVITY=45 W/m-K,
DENSITY=7832 kg/m3
MATERIAL LABEL=concrete, CAPACITY=960 J/kg-C, CONDUCTIVITY=0.8 W/m-K,
DENSITY=2400 kg/m3
MATERIAL LABEL=inconel625, CAPACITY=410 J/kg-C, CONDUCTIVITY=9.8 W/m-C,
DENSITY=8440 kg/m3
MATERIAL LABEL=SuperDuplex, CAPACITY=500 J/kg-C, CONDUCTIVITY=15 W/m-K,
DENSITY=7750 kg/m3

MATERIAL LABEL=Steel, CAPACITY=470 J/kg-K, CONDUCTIVITY=45 W/m-K, DENSITY=7850
kg/m3
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MATERIAL LABEL=Cement, CAPACITY=900 J/kg-K, CONDUCTIVITY=5.88 W/m-K,
DENSITY=2400 kg/m3
MATERIAL LABEL=Formation, CAPACITY=1257 J/kg-K, CONDUCTIVITY=3 W/m-K,
DENSITY=2100 kg/m3
MATERIAL LABEL=Brine, CAPACITY=4300 J/kg-K, CONDUCTIVITY=2.6 W/m-K, DENSITY=1250
kg/m3

WALL LABEL="SEC_7-in", THICKNESS=(7.7, 16.4, 10.4, 35.0, 60.0, 110.0, 210.0,
300.0,  590.0, 1100.0, 1630.0) mm, MATERIAL=(Steel, Brine, Steel, Cement,
Formation,  Formation, Formation, Formation, Formation, Formation, Formation)
WALL LABEL="SEC_9-5/8", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 35.0, 60.0,
110.0,  210.0, 300.0, 590.0, 1100.0, 1630.0) mm, MATERIAL=(Steel, Brine, Steel,
Cement, Steel, Cement, Formation, Formation, Formation, Formation, Formation,
Formation, Formation)
WALL LABEL="SEC_13-3/8", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 51.8, 9.7,
35.0,  60.0, 110.0, 210.0, 300.0, 590.0, 1100.0, 1630.0) mm, MATERIAL=(Steel,
Brine, Steel, Cement, Steel, Cement, Steel, Cement, Formation, Formation,
Formation, Formation, Formation, Formation, Formation)
WALL LABEL="SEC_30-in", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 51.8, 9.7,
195.4,  25.4, 35.0, 60.0, 110.0, 210.0, 300.0, 590.0, 1100.0, 1630.0) mm,
MATERIAL=(Steel,  Brine, Steel, Cement, Steel, Cement, Steel, Cement, Steel,
Cement, Formation,  Formation, Formation, Formation, Formation, Formation,
Formation)
WALL LABEL="SEC_30-wt", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 51.8, 9.7,
195.4,  25.4) mm, MATERIAL=(Steel, Brine, Steel, Cement, Steel, Cement, Steel,
Cement, Steel)

WALL LABEL="Wall-infield", THICKNESS=(3, 5, 7, 50, 100) mm,
MATERIAL=(inconel625, carbonsteel, carbonsteel, 3LPP, concrete)

TABLE LABEL="WELL-IPR", POINT=(0, 0, 1, 64), XVARIABLE=DELTAP bar,
YVARIABLE=FLOW kg/s
TABULAR LABEL="WELL_PRD-TAB", TABLE="WELL-IPR"
TABULAR LABEL="WELL_INJ-TAB", TABLE="WELL-IPR"


!********************************************************************************
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! Network Component
!********************************************************************************
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NETWORKCOMPONENT TYPE=NODE, TAG=ONSHORE_MAN
PARAMETERS LABEL=ONSHORE_MAN, TYPE=CLOSED
ENDNETWORKCOMPONENT

!********************************************************************************
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! Network Component
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NETWORKCOMPONENT TYPE=FLOWPATH, TAG=LONG_LINE_1
PARAMETERS LABEL=LONG_LINE_1

SOURCE LABEL="CO2",\
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1635, 1636, 1637, 1638,\
1639, 1640, 1641, 1642, 1643) h,\
SOURCETYPE=MASS, PIPE="Pipe-001", SECTION=1, TEMPERATURE=(1644:50) C,\
MASSFLOW=(60, 52:77.40, 52:116.10, 52:154.80, 1487:190.26) kg/s,\
PHASE=GAS

TRENDDATA PIPE="PIPE-002", SECTION=1, VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h,
HOL, PT bara, QG, QGST MMscf/d, QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3,
ROL kg/m3)
TRENDDATA PIPE="PIPE-550", SECTION=1, VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h,
HOL, PT bara, QG, QGST MMscf/d, QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3,
ROL kg/m3)

HEATTRANSFER LABEL="HEATTRANS-subsea", PIPE=ALL, INTERPOLATION=VERTICAL,
HOUTEROPTION=WATER,  INTAMBIENT=4 C, OUTTAMBIENT=4 C
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INITIALCONDITIONS INTEMPERATURE=4 C, OUTTEMPERATURE=4 C, INPRESSURE=30 bara,
OUTPRESSURE=12 bara, VOIDFRACTION=0 -

GEOMETRY LABEL="LongLine1", XSTART=0 m, YSTART=1 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-001",       WALL="Wall-infield",
NSEGMENT=1,      XEND=0 m,      YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-002",       WALL="Wall-infield",
NSEGMENT=1,      XEND=550 m,    YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-003",       WALL="Wall-infield",
NSEGMENT=1,      XEND=1100 m,   YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-004",       WALL="Wall-infield",
NSEGMENT=1,      XEND=1650 m,   YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-005",       WALL="Wall-infield",
NSEGMENT=1,      XEND=2200 m,   YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-006",       WALL="Wall-infield",
NSEGMENT=1,      XEND=2750 m,   YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-007",       WALL="Wall-infield",
NSEGMENT=1,      XEND=3300 m,   YEND=-2.7360 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-008",       WALL="Wall-infield",
NSEGMENT=1,      XEND=3850 m,   YEND=-2.9130 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-009",       WALL="Wall-infield",
NSEGMENT=1,      XEND=4400 m,   YEND=-5.7420 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-010",       WALL="Wall-infield",
NSEGMENT=1,      XEND=4950 m,   YEND=-7.8630 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-011",       WALL="Wall-infield",
NSEGMENT=1,      XEND=5500 m,   YEND=-09.9220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-012",       WALL="Wall-infield",
NSEGMENT=1,      XEND=6050 m,   YEND=-13.1770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-013",       WALL="Wall-infield",
NSEGMENT=1,      XEND=6600 m,   YEND=-17.0130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-014",       WALL="Wall-infield",
NSEGMENT=1,      XEND=7150 m,   YEND=-23.1790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-015",       WALL="Wall-infield",
NSEGMENT=1,      XEND=7700 m,   YEND=-26.2940 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-016",       WALL="Wall-infield",
NSEGMENT=1,      XEND=8250 m,   YEND=-28.6310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-017",       WALL="Wall-infield",
NSEGMENT=1,      XEND=8800 m,   YEND=-29.8190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-018",       WALL="Wall-infield",
NSEGMENT=1,      XEND=9350 m,   YEND=-29.6490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-019",       WALL="Wall-infield",
NSEGMENT=1,      XEND=9900 m,   YEND=-33.4560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-020",       WALL="Wall-infield",
NSEGMENT=1,      XEND=10450 m,  YEND=-31.5570 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-021",       WALL="Wall-infield",
NSEGMENT=1,      XEND=11000 m,  YEND=-31.6120 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-022",       WALL="Wall-infield",
NSEGMENT=1,      XEND=11550 m,  YEND=-35.7500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-023",       WALL="Wall-infield",
NSEGMENT=1,      XEND=12100 m,  YEND=-37.5600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-024",       WALL="Wall-infield",
NSEGMENT=1,      XEND=12650 m,  YEND=-38.9020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-025",       WALL="Wall-infield",
NSEGMENT=1,      XEND=13200 m,  YEND=-41.1370 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-026",        WALL="Wall-infield",
NSEGMENT=1,      XEND=13750 m,  YEND=-43.4980 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-027",        WALL="Wall-infield",
NSEGMENT=1,      XEND=14300 m,  YEND=-43.0630 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-028",        WALL="Wall-infield",
NSEGMENT=1,      XEND=14850 m,  YEND=-43.5410 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-029",        WALL="Wall-infield",
NSEGMENT=1,      XEND=15400 m,  YEND=-44.0200 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-030",        WALL="Wall-infield",
NSEGMENT=1,      XEND=15950 m,  YEND=-42.4000 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-031",        WALL="Wall-infield",
NSEGMENT=1,      XEND=16500 m,  YEND=-43.9440 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-032",        WALL="Wall-infield",
NSEGMENT=1,      XEND=17050 m,  YEND=-46.4390 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-033",        WALL="Wall-infield",
NSEGMENT=1,      XEND=17600 m,  YEND=-44.6580 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-034",        WALL="Wall-infield",
NSEGMENT=1,      XEND=18150 m,  YEND=-42.8310 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-035",        WALL="Wall-infield",
NSEGMENT=1,      XEND=18700 m,  YEND=-43.9020 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-036",        WALL="Wall-infield",
NSEGMENT=1,      XEND=19250 m,  YEND=-44.2720 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-037",        WALL="Wall-infield",
NSEGMENT=1,      XEND=19800 m,  YEND=-45.6470 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-038",        WALL="Wall-infield",
NSEGMENT=1,      XEND=20350 m,  YEND=-46.9960 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-039",        WALL="Wall-infield",
NSEGMENT=1,      XEND=20900 m,  YEND=-46.8460 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-325",        WALL="Wall-infield",
NSEGMENT=1,      XEND=21450 m,  YEND=-49.9360 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-326",        WALL="Wall-infield",
NSEGMENT=1,      XEND=22000 m,  YEND=-50.2090 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-327",        WALL="Wall-infield",
NSEGMENT=1,      XEND=22550 m,  YEND=-50.1630 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-328",        WALL="Wall-infield",
NSEGMENT=1,      XEND=23100 m,  YEND=-50.1480 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-329",        WALL="Wall-infield",
NSEGMENT=1,      XEND=23650 m,  YEND=-49.3660 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-330",        WALL="Wall-infield",
NSEGMENT=1,      XEND=24200 m,  YEND=-49.4720 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-331",        WALL="Wall-infield",
NSEGMENT=1,      XEND=24750 m,  YEND=-48.2750 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-332",        WALL="Wall-infield",
NSEGMENT=1,      XEND=25300 m,  YEND=-48.6140 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-333",        WALL="Wall-infield",
NSEGMENT=1,      XEND=25850 m,  YEND=-48.1580 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-334",        WALL="Wall-infield",
NSEGMENT=1,      XEND=26400 m,  YEND=-47.7530 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-335",        WALL="Wall-infield",
NSEGMENT=1,      XEND=26950 m,  YEND=-47.2530 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-336",        WALL="Wall-infield",
NSEGMENT=1,      XEND=27500 m,  YEND=-47.3140 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-337",        WALL="Wall-infield",
NSEGMENT=1,      XEND=28050 m,  YEND=-47.1200 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-338",        WALL="Wall-infield",
NSEGMENT=1,      XEND=28600 m,  YEND=-46.4370 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-339",        WALL="Wall-infield",
NSEGMENT=1,      XEND=29150 m,  YEND=-46.0990 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-340",        WALL="Wall-infield",
NSEGMENT=1,      XEND=29700 m,  YEND=-45.6500 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-341",        WALL="Wall-infield",
NSEGMENT=1,      XEND=30250 m,  YEND=-45.1670 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-342",        WALL="Wall-infield",
NSEGMENT=1,      XEND=30800 m,  YEND=-45.1000 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-343",        WALL="Wall-infield",
NSEGMENT=1,      XEND=31350 m,  YEND=-44.8740 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-344",        WALL="Wall-infield",
NSEGMENT=1,      XEND=31900 m,  YEND=-44.0700 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-345",        WALL="Wall-infield",
NSEGMENT=1,      XEND=32450 m,  YEND=-43.2510 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-346",        WALL="Wall-infield",
NSEGMENT=1,      XEND=33000 m,  YEND=-43.0880 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-347",        WALL="Wall-infield",
NSEGMENT=1,      XEND=33550 m,  YEND=-42.2610 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-348",        WALL="Wall-infield",
NSEGMENT=1,      XEND=34100 m,  YEND=-42.1030 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-349",        WALL="Wall-infield",
NSEGMENT=1,      XEND=34650 m,  YEND=-41.6960 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-350",        WALL="Wall-infield",
NSEGMENT=1,      XEND=35200 m,  YEND=-41.0700 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-351",        WALL="Wall-infield",
NSEGMENT=1,      XEND=35750 m,  YEND=-41.0700 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-352",        WALL="Wall-infield",
NSEGMENT=1,      XEND=36300 m,  YEND=-40.5080 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-353",        WALL="Wall-infield",
NSEGMENT=1,      XEND=36850 m,  YEND=-40.0700 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-354",        WALL="Wall-infield",
NSEGMENT=1,      XEND=37400 m,  YEND=-40.0500 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-355",        WALL="Wall-infield",
NSEGMENT=1,      XEND=37950 m,  YEND=-40.0500 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-356",        WALL="Wall-infield",
NSEGMENT=1,      XEND=38500 m,  YEND=-40.0600 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-357",        WALL="Wall-infield",
NSEGMENT=1,      XEND=39050 m,  YEND=-39.6360 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-358",        WALL="Wall-infield",
NSEGMENT=1,      XEND=39600 m,  YEND=-39.0820 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-359",        WALL="Wall-infield",
NSEGMENT=1,      XEND=40150 m,  YEND=-39.0400 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-360",        WALL="Wall-infield",
NSEGMENT=1,      XEND=40700 m,  YEND=-39.0400 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-361",        WALL="Wall-infield",
NSEGMENT=1,      XEND=41250 m,  YEND=-39.0400 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-362",        WALL="Wall-infield",
NSEGMENT=1,      XEND=41800 m,  YEND=-39.0660 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-363",        WALL="Wall-infield",
NSEGMENT=1,      XEND=42350 m,  YEND=-39.6750 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-364",        WALL="Wall-infield",
NSEGMENT=1,      XEND=42900 m,  YEND=-39.9300 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-365",        WALL="Wall-infield",
NSEGMENT=1,      XEND=43450 m,  YEND=-40.0600 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-366",        WALL="Wall-infield",
NSEGMENT=1,      XEND=44000 m,  YEND=-39.7530 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-367",        WALL="Wall-infield",
NSEGMENT=1,      XEND=44550 m,  YEND=-40.0110 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-368",        WALL="Wall-infield",
NSEGMENT=1,      XEND=45100 m,  YEND=-39.6090 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-369",        WALL="Wall-infield",
NSEGMENT=1,      XEND=45650 m,  YEND=-39.3380 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-370",        WALL="Wall-infield",
NSEGMENT=1,      XEND=46200 m,  YEND=-39.0750 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-371",        WALL="Wall-infield",
NSEGMENT=1,      XEND=46750 m,  YEND=-39.5180 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-372",        WALL="Wall-infield",
NSEGMENT=1,      XEND=47300 m,  YEND=-39.1230 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-373",        WALL="Wall-infield",
NSEGMENT=1,      XEND=47850 m,  YEND=-38.5200 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-374",        WALL="Wall-infield",
NSEGMENT=1,      XEND=48400 m,  YEND=-38.1520 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-375",        WALL="Wall-infield",
NSEGMENT=1,      XEND=48950 m,  YEND=-37.3440 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-376",        WALL="Wall-infield",
NSEGMENT=1,      XEND=49500 m,  YEND=-35.9290 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-377",        WALL="Wall-infield",
NSEGMENT=1,      XEND=50050 m,  YEND=-36.1000 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-378",        WALL="Wall-infield",
NSEGMENT=1,      XEND=50600 m,  YEND=-35.0830 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-379",        WALL="Wall-infield",
NSEGMENT=1,      XEND=51150 m,  YEND=-35.1000 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-380",        WALL="Wall-infield",
NSEGMENT=1,      XEND=51700 m,  YEND=-35.5450 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-381",        WALL="Wall-infield",
NSEGMENT=1,      XEND=52250 m,  YEND=-36.1000 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-382",        WALL="Wall-infield",
NSEGMENT=1,      XEND=52800 m,  YEND=-36.2200 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-383",        WALL="Wall-infield",
NSEGMENT=1,      XEND=53350 m,  YEND=-36.1200 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-384",        WALL="Wall-infield",
NSEGMENT=1,      XEND=53900 m,  YEND=-35.5050 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-385",        WALL="Wall-infield",
NSEGMENT=1,      XEND=54450 m,  YEND=-34.6750 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-386",        WALL="Wall-infield",
NSEGMENT=1,      XEND=55000 m,  YEND=-33.7450 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-387",        WALL="Wall-infield",
NSEGMENT=1,      XEND=55550 m,  YEND=-32.9040 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-388",        WALL="Wall-infield",
NSEGMENT=1,      XEND=56100 m,  YEND=-33.0130 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-389",        WALL="Wall-infield",
NSEGMENT=1,      XEND=56650 m,  YEND=-31.5290 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-390",        WALL="Wall-infield",
NSEGMENT=1,      XEND=57200 m,  YEND=-30.0220 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-391",        WALL="Wall-infield",
NSEGMENT=1,      XEND=57750 m,  YEND=-30.4130 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-392",        WALL="Wall-infield",
NSEGMENT=1,      XEND=58300 m,  YEND=-31.2370 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-393",        WALL="Wall-infield",
NSEGMENT=1,      XEND=58850 m,  YEND=-31.5850 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-394",        WALL="Wall-infield",
NSEGMENT=1,      XEND=59400 m,  YEND=-31.3930 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-395",        WALL="Wall-infield",
NSEGMENT=1,      XEND=59950 m,  YEND=-31.4500 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-396",        WALL="Wall-infield",
NSEGMENT=1,      XEND=60500 m,  YEND=-31.2060 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-397",        WALL="Wall-infield",
NSEGMENT=1,      XEND=61050 m,  YEND=-31.5430 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-398",        WALL="Wall-infield",
NSEGMENT=1,      XEND=61600 m,  YEND=-31.2030 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-399",        WALL="Wall-infield",
NSEGMENT=1,      XEND=62150 m,  YEND=-30.3640 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-400",        WALL="Wall-infield",
NSEGMENT=1,      XEND=62700 m,  YEND=-30.1790 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-401",        WALL="Wall-infield",
NSEGMENT=1,      XEND=63250 m,  YEND=-29.6260 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-402",        WALL="Wall-infield",
NSEGMENT=1,      XEND=63800 m,  YEND=-29.2730 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-403",        WALL="Wall-infield",
NSEGMENT=1,      XEND=64350 m,  YEND=-28.4590 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-404",        WALL="Wall-infield",
NSEGMENT=1,      XEND=64900 m,  YEND=-29.0220 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-405",        WALL="Wall-infield",
NSEGMENT=1,      XEND=65450 m,  YEND=-29.2030 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-406",        WALL="Wall-infield",
NSEGMENT=1,      XEND=66000 m,  YEND=-30.7930 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-407",        WALL="Wall-infield",
NSEGMENT=1,      XEND=66550 m,  YEND=-31.8160 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-408",        WALL="Wall-infield",
NSEGMENT=1,      XEND=67100 m,  YEND=-33.8070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-409",        WALL="Wall-infield",
NSEGMENT=1,      XEND=67650 m,  YEND=-35.5070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-410",        WALL="Wall-infield",
NSEGMENT=1,      XEND=68200 m,  YEND=-38.1260 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-411",        WALL="Wall-infield",
NSEGMENT=1,      XEND=68750 m,  YEND=-36.9760 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-412",        WALL="Wall-infield",
NSEGMENT=1,      XEND=69300 m,  YEND=-39.5430 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-413",        WALL="Wall-infield",
NSEGMENT=1,      XEND=69850 m,  YEND=-38.4480 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-414",        WALL="Wall-infield",
NSEGMENT=1,      XEND=70400 m,  YEND=-54.2030 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-415",        WALL="Wall-infield",
NSEGMENT=1,      XEND=70950 m,  YEND=-51.6360 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-416",        WALL="Wall-infield",
NSEGMENT=1,      XEND=71500 m,  YEND=-40.2930 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-417",        WALL="Wall-infield",
NSEGMENT=1,      XEND=72050 m,  YEND=-38.4310 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-418",        WALL="Wall-infield",
NSEGMENT=1,      XEND=72600 m,  YEND=-32.0340 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-419",       WALL="Wall-infield",
NSEGMENT=1,      XEND=73150 m,  YEND=-29.8450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-420",       WALL="Wall-infield",
NSEGMENT=1,      XEND=73700 m,  YEND=-29.0910 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-421",       WALL="Wall-infield",
NSEGMENT=1,      XEND=74250 m,  YEND=-28.4070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-422",       WALL="Wall-infield",
NSEGMENT=1,      XEND=74800 m,  YEND=-28.4760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-423",       WALL="Wall-infield",
NSEGMENT=1,      XEND=75350 m,  YEND=-28.2560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-424",       WALL="Wall-infield",
NSEGMENT=1,      XEND=75900 m,  YEND=-28.5440 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-425",       WALL="Wall-infield",
NSEGMENT=1,      XEND=76450 m,  YEND=-28.8670 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-426",       WALL="Wall-infield",
NSEGMENT=1,      XEND=77000 m,  YEND=-28.5630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-427",       WALL="Wall-infield",
NSEGMENT=1,      XEND=77550 m,  YEND=-28.4910 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-428",       WALL="Wall-infield",
NSEGMENT=1,      XEND=78100 m,  YEND=-28.3750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-429",       WALL="Wall-infield",
NSEGMENT=1,      XEND=78650 m,  YEND=-27.7070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-430",       WALL="Wall-infield",
NSEGMENT=1,      XEND=79200 m,  YEND=-27.8590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-431",       WALL="Wall-infield",
NSEGMENT=1,      XEND=79750 m,  YEND=-27.3680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-432",       WALL="Wall-infield",
NSEGMENT=1,      XEND=80300 m,  YEND=-26.7670 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-433",       WALL="Wall-infield",
NSEGMENT=1,      XEND=80850 m,  YEND=-26.5300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-434",       WALL="Wall-infield",
NSEGMENT=1,      XEND=81400 m,  YEND=-26.1460 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-435",       WALL="Wall-infield",
NSEGMENT=1,      XEND=81950 m,  YEND=-24.5190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-436",       WALL="Wall-infield",
NSEGMENT=1,      XEND=82500 m,  YEND=-24.6200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-437",       WALL="Wall-infield",
NSEGMENT=1,      XEND=83050 m,  YEND=-24.3880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-438",       WALL="Wall-infield",
NSEGMENT=1,      XEND=83600 m,  YEND=-24.3230 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-439",       WALL="Wall-infield",
NSEGMENT=1,      XEND=84150 m,  YEND=-24.9240 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-440",       WALL="Wall-infield",
NSEGMENT=1,      XEND=84700 m,  YEND=-24.6190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-441",       WALL="Wall-infield",
NSEGMENT=1,      XEND=85250 m,  YEND=-23.7350 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-442",       WALL="Wall-infield",
NSEGMENT=1,      XEND=85800 m,  YEND=-23.2680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-443",       WALL="Wall-infield",
NSEGMENT=1,      XEND=86350 m,  YEND=-22.5470 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-444",       WALL="Wall-infield",
NSEGMENT=1,      XEND=86900 m,  YEND=-23.2580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-445",       WALL="Wall-infield",
NSEGMENT=1,      XEND=87450 m,  YEND=-22.7360 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-446",        WALL="Wall-infield",
NSEGMENT=1,      XEND=88000 m,  YEND=-22.8960 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-447",        WALL="Wall-infield",
NSEGMENT=1,      XEND=88550 m,  YEND=-23.2070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-448",        WALL="Wall-infield",
NSEGMENT=1,      XEND=89100 m,  YEND=-23.3850 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-449",        WALL="Wall-infield",
NSEGMENT=1,      XEND=89650 m,  YEND=-24.3810 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-450",        WALL="Wall-infield",
NSEGMENT=1,      XEND=90200 m,  YEND=-24.7160 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-451",        WALL="Wall-infield",
NSEGMENT=1,      XEND=90750 m,  YEND=-23.9950 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-452",        WALL="Wall-infield",
NSEGMENT=1,      XEND=91300 m,  YEND=-23.5480 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-453",        WALL="Wall-infield",
NSEGMENT=1,      XEND=91850 m,  YEND=-22.8560 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-454",        WALL="Wall-infield",
NSEGMENT=1,      XEND=92400 m,  YEND=-21.7050 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-455",        WALL="Wall-infield",
NSEGMENT=1,      XEND=92950 m,  YEND=-20.3060 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-456",        WALL="Wall-infield",
NSEGMENT=1,      XEND=93500 m,  YEND=-20.2680 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-457",        WALL="Wall-infield",
NSEGMENT=1,      XEND=94050 m,  YEND=-20.8400 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-458",        WALL="Wall-infield",
NSEGMENT=1,      XEND=94600 m,  YEND=-19.1840 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-459",        WALL="Wall-infield",
NSEGMENT=1,      XEND=95150 m,  YEND=-18.7580 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-460",        WALL="Wall-infield",
NSEGMENT=1,      XEND=95700 m,  YEND=-20.4450 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-461",        WALL="Wall-infield",
NSEGMENT=1,      XEND=96250 m,  YEND=-22.1120 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-462",        WALL="Wall-infield",
NSEGMENT=1,      XEND=96800 m,  YEND=-21.8580 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-463",        WALL="Wall-infield",
NSEGMENT=1,      XEND=97350 m,  YEND=-21.7380 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-464",        WALL="Wall-infield",
NSEGMENT=1,      XEND=97900 m,  YEND=-20.8810 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-465",        WALL="Wall-infield",
NSEGMENT=1,      XEND=98450 m,  YEND=-21.6700 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-466",        WALL="Wall-infield",
NSEGMENT=1,      XEND=99000 m,  YEND=-21.2360 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-467",        WALL="Wall-infield",
NSEGMENT=1,      XEND=99550 m,  YEND=-15.3160 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-468",        WALL="Wall-infield",
NSEGMENT=1,      XEND=100100 m, YEND=-14.1550 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-469",        WALL="Wall-infield",
NSEGMENT=1,      XEND=100650 m, YEND=-15.5720 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-470",        WALL="Wall-infield",
NSEGMENT=1,      XEND=101200 m, YEND=-16.8760 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-471",        WALL="Wall-infield",
NSEGMENT=1,      XEND=101750 m, YEND=-19.2520 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-472",        WALL="Wall-infield",
NSEGMENT=1,      XEND=102300 m, YEND=-21.2300 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-473",        WALL="Wall-infield",
NSEGMENT=1,      XEND=102850 m, YEND=-22.3480 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-474",        WALL="Wall-infield",
NSEGMENT=1,      XEND=103400 m, YEND=-23.5630 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-475",        WALL="Wall-infield",
NSEGMENT=1,      XEND=103950 m, YEND=-23.9140 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-476",        WALL="Wall-infield",
NSEGMENT=1,      XEND=104500 m, YEND=-23.7570 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-477",        WALL="Wall-infield",
NSEGMENT=1,      XEND=105050 m, YEND=-23.4870 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-478",        WALL="Wall-infield",
NSEGMENT=1,      XEND=105600 m, YEND=-23.3070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-479",        WALL="Wall-infield",
NSEGMENT=1,      XEND=106150 m, YEND=-23.1320 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-480",        WALL="Wall-infield",
NSEGMENT=1,      XEND=106700 m, YEND=-23.5520 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-481",        WALL="Wall-infield",
NSEGMENT=1,      XEND=107250 m, YEND=-22.0330 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-482",        WALL="Wall-infield",
NSEGMENT=1,      XEND=107800 m, YEND=-21.5500 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-483",        WALL="Wall-infield",
NSEGMENT=1,      XEND=108350 m, YEND=-20.1780 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-484",        WALL="Wall-infield",
NSEGMENT=1,      XEND=108900 m, YEND=-22.0100 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-485",        WALL="Wall-infield",
NSEGMENT=1,      XEND=109450 m, YEND=-18.7720 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-486",        WALL="Wall-infield",
NSEGMENT=1,      XEND=110000 m, YEND=-18.1080 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-487",        WALL="Wall-infield",
NSEGMENT=1,      XEND=110550 m, YEND=-17.9710 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-488",        WALL="Wall-infield",
NSEGMENT=1,      XEND=111100 m, YEND=-16.7010 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-489",        WALL="Wall-infield",
NSEGMENT=1,      XEND=111650 m, YEND=-16.5310 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-490",        WALL="Wall-infield",
NSEGMENT=1,      XEND=112200 m, YEND=-17.4430 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-491",        WALL="Wall-infield",
NSEGMENT=1,      XEND=112750 m, YEND=-19.4420 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-492",        WALL="Wall-infield",
NSEGMENT=1,      XEND=113300 m, YEND=-21.5970 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-493",        WALL="Wall-infield",
NSEGMENT=1,      XEND=113850 m, YEND=-22.8990 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-494",        WALL="Wall-infield",
NSEGMENT=1,      XEND=114400 m, YEND=-24.3070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-495",        WALL="Wall-infield",
NSEGMENT=1,      XEND=114950 m, YEND=-25.9820 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-496",        WALL="Wall-infield",
NSEGMENT=1,      XEND=115500 m, YEND=-29.5400 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-497",        WALL="Wall-infield",
NSEGMENT=1,      XEND=116050 m, YEND=-31.1460 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-498",        WALL="Wall-infield",
NSEGMENT=1,      XEND=116600 m, YEND=-30.3780 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,        LABEL="Pipe-499",        WALL="Wall-infield",
NSEGMENT=1,      XEND=117150 m, YEND=-25.6660 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-500",        WALL="Wall-infield",
NSEGMENT=1,      XEND=117700 m, YEND=-21.9720 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-501",        WALL="Wall-infield",
NSEGMENT=1,      XEND=118250 m, YEND=-17.7300 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-502",        WALL="Wall-infield",
NSEGMENT=1,      XEND=118800 m, YEND=-18.4990 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-503",        WALL="Wall-infield",
NSEGMENT=1,      XEND=119350 m, YEND=-20.9070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-504",        WALL="Wall-infield",
NSEGMENT=1,      XEND=119900 m, YEND=-22.1170 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-505",        WALL="Wall-infield",
NSEGMENT=1,      XEND=120450 m, YEND=-23.6160 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-506",        WALL="Wall-infield",
NSEGMENT=1,      XEND=121000 m, YEND=-24.1470 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-507",        WALL="Wall-infield",
NSEGMENT=1,      XEND=121550 m, YEND=-24.9730 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-508",        WALL="Wall-infield",
NSEGMENT=1,      XEND=122100 m, YEND=-25.2610 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-509",        WALL="Wall-infield",
NSEGMENT=1,      XEND=122650 m, YEND=-25.7640 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-510",        WALL="Wall-infield",
NSEGMENT=1,      XEND=123200 m, YEND=-26.6070 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-511",        WALL="Wall-infield",
NSEGMENT=1,      XEND=123750 m, YEND=-26.7710 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-512",        WALL="Wall-infield",
NSEGMENT=1,      XEND=124300 m, YEND=-26.5020 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-513",        WALL="Wall-infield",
NSEGMENT=1,      XEND=124850 m, YEND=-27.3600 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-514",        WALL="Wall-infield",
NSEGMENT=1,      XEND=125400 m, YEND=-28.2330 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-515",        WALL="Wall-infield",
NSEGMENT=1,      XEND=125950 m, YEND=-28.7060 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-516",        WALL="Wall-infield",
NSEGMENT=1,      XEND=126500 m, YEND=-29.1270 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-517",        WALL="Wall-infield",
NSEGMENT=1,      XEND=127050 m, YEND=-28.4750 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-518",        WALL="Wall-infield",
NSEGMENT=1,      XEND=127600 m, YEND=-28.8990 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-519",        WALL="Wall-infield",
NSEGMENT=1,      XEND=128150 m, YEND=-29.3310 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-520",        WALL="Wall-infield",
NSEGMENT=1,      XEND=128700 m, YEND=-28.6380 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-521",        WALL="Wall-infield",
NSEGMENT=1,      XEND=129250 m, YEND=-26.6510 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-522",        WALL="Wall-infield",
NSEGMENT=1,      XEND=129800 m, YEND=-25.0470 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-523",        WALL="Wall-infield",
NSEGMENT=1,      XEND=130350 m, YEND=-25.2930 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-524",        WALL="Wall-infield",
NSEGMENT=1,      XEND=130900 m, YEND=-25.6620 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-525",        WALL="Wall-infield",
NSEGMENT=1,      XEND=131450 m, YEND=-25.8810 m,         DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-526",        WALL="Wall-infield",
NSEGMENT=1,      XEND=132000 m, YEND=-26.9510 m,         DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-527",       WALL="Wall-infield",
NSEGMENT=1,      XEND=132550 m, YEND=-27.0660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-528",       WALL="Wall-infield",
NSEGMENT=1,      XEND=133100 m, YEND=-26.7060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-529",       WALL="Wall-infield",
NSEGMENT=1,      XEND=133650 m, YEND=-26.4360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-530",       WALL="Wall-infield",
NSEGMENT=1,      XEND=134200 m, YEND=-26.2550 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-531",       WALL="Wall-infield",
NSEGMENT=1,      XEND=134750 m, YEND=-27.0040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-532",       WALL="Wall-infield",
NSEGMENT=1,      XEND=135300 m, YEND=-27.7770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-533",       WALL="Wall-infield",
NSEGMENT=1,      XEND=135850 m, YEND=-27.0280 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-534",       WALL="Wall-infield",
NSEGMENT=1,      XEND=136400 m, YEND=-27.7420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-535",       WALL="Wall-infield",
NSEGMENT=1,      XEND=136950 m, YEND=-27.4650 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-536",       WALL="Wall-infield",
NSEGMENT=1,      XEND=137500 m, YEND=-27.1700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-537",       WALL="Wall-infield",
NSEGMENT=1,      XEND=138050 m, YEND=-27.3480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-538",       WALL="Wall-infield",
NSEGMENT=1,      XEND=138600 m, YEND=-28.0600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-539",       WALL="Wall-infield",
NSEGMENT=1,      XEND=139150 m, YEND=-31.1020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-540",       WALL="Wall-infield",
NSEGMENT=1,      XEND=139700 m, YEND=-30.0880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-541",       WALL="Wall-infield",
NSEGMENT=1,      XEND=140250 m, YEND=-28.2370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-542",       WALL="Wall-infield",
NSEGMENT=1,      XEND=140800 m, YEND=-29.4360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-543",       WALL="Wall-infield",
NSEGMENT=1,      XEND=141350 m, YEND=-31.8320 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-544",       WALL="Wall-infield",
NSEGMENT=1,      XEND=141900 m, YEND=-31.9360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-545",       WALL="Wall-infield",
NSEGMENT=1,      XEND=142450 m, YEND=-33.3630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-546",       WALL="Wall-infield",
NSEGMENT=1,      XEND=143000 m, YEND=-35.1800 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-547",       WALL="Wall-infield",
NSEGMENT=1,      XEND=143550 m, YEND=-33.6020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-548",       WALL="Wall-infield",
NSEGMENT=1,      XEND=144100 m, YEND=-34.4300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-549",       WALL="Wall-infield",
NSEGMENT=1,      XEND=144650 m, YEND=-31.9990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-550",       WALL="Wall-infield",
NSEGMENT=1,      XEND=145200 m, YEND=+17.4900 m,        DIAMETER=0.711 m
ENDNETWORKCOMPONENT


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! Network Component
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NETWORKCOMPONENT TYPE=FLOWPATH, TAG="HEWETT_WELLS_LB"
  PARAMETERS LABEL=HEWETT_WELLS_LB
  BRANCH FLUID=Fluid1
  GEOMETRY LABEL=WELL2, XSTART=-40 ft, YSTART=17.49 m
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-AIR", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=100.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-000", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=000.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-001", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-40.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-002", WALL="SEC_30-in",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-80.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-003", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-120.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-004", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-160.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-005", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-200.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-006", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-240.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-007", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-280.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-008", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-320.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-009", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-360.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-010", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-400.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-011", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-440.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-012", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-480.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-013", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-520.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-014", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-560.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-015", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-600.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-016", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-640.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-017", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.102672 ft,  YEND=-680.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-018", WALL="SEC_7-in",
NSEGMENT=1, XEND=0.646604 ft,  YEND=-719.996 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-019", WALL="SEC_7-in",
NSEGMENT=1, XEND=1.26007 ft,  YEND=-759.991 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-020", WALL="SEC_7-in",
NSEGMENT=1, XEND=2.14582 ft,  YEND=-799.982 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-021", WALL="SEC_7-in",
NSEGMENT=1, XEND=3.43897 ft,  YEND=-839.961 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-022", WALL="SEC_7-in",
NSEGMENT=1, XEND=4.73212 ft,  YEND=-879.94 ft, DIAMETER=219.0 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-023", WALL="SEC_7-in",
NSEGMENT=1, XEND=6.63223 ft,  YEND=-919.895 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-024", WALL="SEC_7-in",
NSEGMENT=1, XEND=8.61737 ft,  YEND=-959.845 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-025", WALL="SEC_7-in",
NSEGMENT=1, XEND=10.9013 ft,  YEND=-999.78 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-026", WALL="SEC_7-in",
NSEGMENT=1, XEND=13.5807 ft,  YEND=-1039.69 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-027", WALL="SEC_7-in",
NSEGMENT=1, XEND=16.2601 ft,  YEND=-1079.6 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-028", WALL="SEC_7-in",
NSEGMENT=1, XEND=19.5921 ft,  YEND=-1119.46 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-029", WALL="SEC_7-in",
NSEGMENT=1, XEND=22.9661 ft,  YEND=-1159.32 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-030", WALL="SEC_7-in",
NSEGMENT=1, XEND=26.6843 ft,  YEND=-1199.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-031", WALL="SEC_7-in",
NSEGMENT=1, XEND=30.7523 ft,  YEND=-1238.94 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-032", WALL="SEC_7-in",
NSEGMENT=1, XEND=34.8292 ft,  YEND=-1278.73 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-033", WALL="SEC_7-in",
NSEGMENT=1, XEND=39.5904 ft,  YEND=-1318.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-034", WALL="SEC_7-in",
NSEGMENT=1, XEND=44.3515 ft,  YEND=-1358.16 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-035", WALL="SEC_7-in",
NSEGMENT=1, XEND=49.5057 ft,  YEND=-1397.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-036", WALL="SEC_7-in",
NSEGMENT=1, XEND=54.9588 ft,  YEND=-1437.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-037", WALL="SEC_7-in",
NSEGMENT=1, XEND=60.4779 ft,  YEND=-1477.07 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-038", WALL="SEC_7-in",
NSEGMENT=1, XEND=66.6213 ft,  YEND=-1516.6 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-039", WALL="SEC_7-in",
NSEGMENT=1, XEND=72.7647 ft,  YEND=-1556.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-040", WALL="SEC_7-in",
NSEGMENT=1, XEND=79.3504 ft,  YEND=-1595.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-041", WALL="SEC_7-in",
NSEGMENT=1, XEND=86.1823 ft,  YEND=-1634.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-042", WALL="SEC_7-in",
NSEGMENT=1, XEND=93.1082 ft,  YEND=-1674.38 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-043", WALL="SEC_7-in",
NSEGMENT=1, XEND=100.477 ft,  YEND=-1713.7 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-044", WALL="SEC_7-in",
NSEGMENT=1, XEND=107.998 ft,  YEND=-1752.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-045", WALL="SEC_7-in",
NSEGMENT=1, XEND=115.562 ft,  YEND=-1792.27 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-046", WALL="SEC_7-in",
NSEGMENT=1, XEND=123.429 ft,  YEND=-1831.48 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-047", WALL="SEC_7-in",
NSEGMENT=1, XEND=131.694 ft,  YEND=-1870.62 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-048", WALL="SEC_7-in",
NSEGMENT=1, XEND=140.768 ft,  YEND=-1909.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-049", WALL="SEC_7-in",
NSEGMENT=1, XEND=149.843 ft,  YEND=-1948.53 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-050", WALL="SEC_7-in",
NSEGMENT=1, XEND=159.999 ft,  YEND=-1987.22 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-051", WALL="SEC_7-in",
NSEGMENT=1, XEND=170.426 ft,  YEND=-2025.84 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-052", WALL="SEC_7-in",
NSEGMENT=1, XEND=181.311 ft,  YEND=-2064.33 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-053", WALL="SEC_7-in",
NSEGMENT=1, XEND=193.079 ft,  YEND=-2102.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-054", WALL="SEC_7-in",
NSEGMENT=1, XEND=204.847 ft,  YEND=-2140.79 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-055", WALL="SEC_7-in",
NSEGMENT=1, XEND=217.773 ft,  YEND=-2178.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-056", WALL="SEC_7-in",
NSEGMENT=1, XEND=230.867 ft,  YEND=-2216.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-057", WALL="SEC_7-in",
NSEGMENT=1, XEND=244.510 ft,  YEND=-2254.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-058", WALL="SEC_7-in",
NSEGMENT=1, XEND=258.915 ft,  YEND=-2291.36 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-059", WALL="SEC_7-in",
NSEGMENT=1, XEND=273.319 ft,  YEND=-2328.68 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-060", WALL="SEC_7-in",
NSEGMENT=1, XEND=288.949 ft,  YEND=-2365.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-061", WALL="SEC_7-in",
NSEGMENT=1, XEND=304.647 ft,  YEND=-2402.29 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-062", WALL="SEC_7-in",
NSEGMENT=1, XEND=320.977 ft,  YEND=-2438.8 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-063", WALL="SEC_7-in",
NSEGMENT=1, XEND=337.949 ft,  YEND=-2475.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-064", WALL="SEC_7-in",
NSEGMENT=1, XEND=354.952 ft,  YEND=-2511.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-065", WALL="SEC_7-in",
NSEGMENT=1, XEND=373.177 ft,  YEND=-2546.84 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-066", WALL="SEC_7-in",
NSEGMENT=1, XEND=391.402 ft,  YEND=-2582.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-067", WALL="SEC_7-in",
NSEGMENT=1, XEND=410.333 ft,  YEND=-2617.68 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-068", WALL="SEC_7-in",
NSEGMENT=1, XEND=429.790 ft,  YEND=-2652.63 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-069", WALL="SEC_7-in",
NSEGMENT=1, XEND=449.375 ft,  YEND=-2687.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-070", WALL="SEC_7-in",
NSEGMENT=1, XEND=470.039 ft,  YEND=-2721.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-071", WALL="SEC_7-in",
NSEGMENT=1, XEND=490.703 ft,  YEND=-2756.00 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-072", WALL="SEC_7-in",
NSEGMENT=1, XEND=512.137 ft,  YEND=-2789.78 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-073", WALL="SEC_7-in",
NSEGMENT=1, XEND=533.983 ft,  YEND=-2823.28 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-074", WALL="SEC_7-in",
NSEGMENT=1, XEND=556.046 ft,  YEND=-2856.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-075", WALL="SEC_7-in",
NSEGMENT=1, XEND=579.049 ft,  YEND=-2889.37 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-076", WALL="SEC_7-in",
NSEGMENT=1, XEND=602.051 ft,  YEND=-2922.1 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-077", WALL="SEC_7-in",
NSEGMENT=1, XEND=625.582 ft,  YEND=-2954.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-078", WALL="SEC_7-in",
NSEGMENT=1, XEND=649.453 ft,  YEND=-2986.54 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-079", WALL="SEC_7-in",
NSEGMENT=1, XEND=673.325 ft,  YEND=-3018.64 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-080", WALL="SEC_7-in",
NSEGMENT=1, XEND=697.196 ft,  YEND=-3050.73 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-081", WALL="SEC_7-in",
NSEGMENT=1, XEND=721.068 ft,  YEND=-3082.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-082", WALL="SEC_7-in",
NSEGMENT=1, XEND=744.939 ft,  YEND=-3114.92 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-083", WALL="SEC_7-in",
NSEGMENT=1, XEND=768.810 ft,  YEND=-3147.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-084", WALL="SEC_7-in",
NSEGMENT=1, XEND=792.682 ft,  YEND=-3179.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-085", WALL="SEC_7-in",
NSEGMENT=1, XEND=816.553 ft,  YEND=-3211.21 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-086", WALL="SEC_7-in",
NSEGMENT=1, XEND=840.425 ft,  YEND=-3243.31 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-087", WALL="SEC_7-in",
NSEGMENT=1, XEND=864.296 ft,  YEND=-3275.4 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-088", WALL="SEC_7-in",
NSEGMENT=1, XEND=888.167 ft,  YEND=-3307.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-089", WALL="SEC_7-in",
NSEGMENT=1, XEND=912.039 ft,  YEND=-3339.6 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-090", WALL="SEC_7-in",
NSEGMENT=1, XEND=936.566 ft,  YEND=-3371.19 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-091", WALL="SEC_7-in",
NSEGMENT=1, XEND=961.269 ft,  YEND=-3402.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-092", WALL="SEC_7-in",
NSEGMENT=1, XEND=987.767 ft,  YEND=-3432.62 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-093", WALL="SEC_7-in",
NSEGMENT=1, XEND=1014.34 ft,  YEND=-3462.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-094", WALL="SEC_7-in",
NSEGMENT=1, XEND=1041.95 ft,  YEND=-3491.46 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-095", WALL="SEC_7-in",
NSEGMENT=1, XEND=1070.55 ft,  YEND=-3519.43 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-096", WALL="SEC_7-in",
NSEGMENT=1, XEND=1099.21 ft,  YEND=-3547.32 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-097", WALL="SEC_7-in",
NSEGMENT=1, XEND=1129.69 ft,  YEND=-3573.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-098", WALL="SEC_7-in",
NSEGMENT=1, XEND=1160.16 ft,  YEND=-3599.14 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-099", WALL="SEC_7-in",
NSEGMENT=1, XEND=1191.66 ft,  YEND=-3623.79 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-100", WALL="SEC_7-in",
NSEGMENT=1, XEND=1223.87 ft,  YEND=-3647.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-101", WALL="SEC_7-in",
NSEGMENT=1, XEND=1256.27 ft,  YEND=-3670.97 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-102", WALL="SEC_7-in",
NSEGMENT=1, XEND=1290.05 ft,  YEND=-3692.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-103", WALL="SEC_7-in",
NSEGMENT=1, XEND=1323.84 ft,  YEND=-3713.81 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-104", WALL="SEC_7-in",
NSEGMENT=1, XEND=1358.57 ft,  YEND=-3733.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-105", WALL="SEC_7-in",
NSEGMENT=1, XEND=1393.76 ft,  YEND=-3752.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-106", WALL="SEC_7-in",
NSEGMENT=1, XEND=1429.21 ft,  YEND=-3771.18 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-107", WALL="SEC_7-in",
NSEGMENT=1, XEND=1465.65 ft,  YEND=-3787.69 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-108", WALL="SEC_7-in",
NSEGMENT=1, XEND=1502.08 ft,  YEND=-3804.2 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-109", WALL="SEC_7-in",
NSEGMENT=1, XEND=1539.32 ft,  YEND=-3818.82 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-110", WALL="SEC_7-in",
NSEGMENT=1, XEND=1576.81 ft,  YEND=-3832.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-111", WALL="SEC_7-in",
NSEGMENT=1, XEND=1614.57 ft,  YEND=-3845.95 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-112", WALL="SEC_7-in",
NSEGMENT=1, XEND=1652.95 ft,  YEND=-3857.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-113", WALL="SEC_7-in",
NSEGMENT=1, XEND=1691.33 ft,  YEND=-3868.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-114", WALL="SEC_7-in",
NSEGMENT=1, XEND=1730.30 ft,  YEND=-3877.49 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-115", WALL="SEC_7-in",
NSEGMENT=1, XEND=1769.40 ft,  YEND=-3885.93 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-116", WALL="SEC_7-in",
NSEGMENT=1, XEND=1808.54 ft,  YEND=-3894.21 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-117", WALL="SEC_7-in",
NSEGMENT=1, XEND=1847.93 ft,  YEND=-3901.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-118", WALL="SEC_7-in",
NSEGMENT=1, XEND=1887.32 ft,  YEND=-3908.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-119", WALL="SEC_7-in",
NSEGMENT=1, XEND=1926.71 ft,  YEND=-3915.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-120", WALL="SEC_7-in",
NSEGMENT=1, XEND=1966.11 ft,  YEND=-3921.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-121", WALL="SEC_7-in",
NSEGMENT=1, XEND=2005.50 ft,  YEND=-3928.94 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-122", WALL="SEC_7-in",
NSEGMENT=1, XEND=2044.89 ft,  YEND=-3935.88 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-123", WALL="SEC_7-in",
NSEGMENT=1, XEND=2084.28 ft,  YEND=-3942.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-124", WALL="SEC_7-in",
NSEGMENT=1, XEND=2123.68 ft,  YEND=-3949.77 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-125", WALL="SEC_7-in",
NSEGMENT=1, XEND=2163.07 ft,  YEND=-3956.72 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-126", WALL="SEC_7-in",
NSEGMENT=1, XEND=2202.46 ft,  YEND=-3963.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-127", WALL="SEC_7-in",
NSEGMENT=1, XEND=2241.85 ft,  YEND=-3970.61 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-128", WALL="SEC_7-in",
NSEGMENT=1, XEND=2281.25 ft,  YEND=-3977.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-129", WALL="SEC_7-in",
NSEGMENT=1, XEND=2320.64 ft,  YEND=-3984.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-130", WALL="SEC_7-in",
NSEGMENT=1, XEND=2360.03 ft,  YEND=-3991.45 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-131", WALL="SEC_7-in",
NSEGMENT=1, XEND=2399.42 ft,  YEND=-3998.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-132", WALL="SEC_7-in",
NSEGMENT=1, XEND=2438.81 ft,  YEND=-4005.34 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-133", WALL="SEC_7-in",
NSEGMENT=1, XEND=2478.21 ft,  YEND=-4012.29 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-134", WALL="SEC_7-in",
NSEGMENT=1, XEND=2517.60 ft,  YEND=-4019.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-135", WALL="SEC_7-in",
NSEGMENT=1, XEND=2556.99 ft,  YEND=-4026.18 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-136", WALL="SEC_7-in",
NSEGMENT=1, XEND=2596.38 ft,  YEND=-4033.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-137", WALL="SEC_7-in",
NSEGMENT=1, XEND=2635.78 ft,  YEND=-4040.07 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-138", WALL="SEC_7-in",
NSEGMENT=1, XEND=2675.17 ft,  YEND=-4047.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-139", WALL="SEC_7-in",
NSEGMENT=1, XEND=2714.56 ft,  YEND=-4053.96 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-140", WALL="SEC_7-in",
NSEGMENT=1, XEND=2753.95 ft,  YEND=-4060.91 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-141", WALL="SEC_7-in",
NSEGMENT=1, XEND=2793.35 ft,  YEND=-4067.85 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-142", WALL="SEC_7-in",
NSEGMENT=1, XEND=2832.74 ft,  YEND=-4074.8 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-143", WALL="SEC_7-in",
NSEGMENT=1, XEND=2872.13 ft,  YEND=-4081.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-144", WALL="SEC_7-in",
NSEGMENT=1, XEND=2911.52 ft,  YEND=-4088.69 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-145", WALL="SEC_7-in",
NSEGMENT=1, XEND=2950.91 ft,  YEND=-4095.64 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-146", WALL="SEC_7-in",
NSEGMENT=1, XEND=2990.31 ft,  YEND=-4102.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-147", WALL="SEC_7-in",
NSEGMENT=1, XEND=3029.70 ft,  YEND=-4109.53 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-148", WALL="SEC_7-in",
NSEGMENT=1, XEND=3069.09 ft,  YEND=-4116.48 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-149", WALL="SEC_7-in",
NSEGMENT=1, XEND=3108.48 ft,  YEND=-4123.42 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-150", WALL="SEC_7-in",
NSEGMENT=1, XEND=3147.88 ft,  YEND=-4130.37 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-151", WALL="SEC_7-in",
NSEGMENT=1, XEND=3187.27 ft,  YEND=-4137.31 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-152", WALL="SEC_7-in",
NSEGMENT=1, XEND=3226.66 ft,  YEND=-4144.26 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-153", WALL="SEC_7-in",
NSEGMENT=1, XEND=3266.05 ft,  YEND=-4151.2 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-154", WALL="SEC_7-in",
NSEGMENT=1, XEND=3305.45 ft,  YEND=-4158.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-155", WALL="SEC_7-in",
NSEGMENT=1, XEND=3344.84 ft,  YEND=-4165.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-156", WALL="SEC_7-in",
NSEGMENT=1, XEND=3384.23 ft,  YEND=-4172.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-157", WALL="SEC_7-in",
NSEGMENT=1, XEND=3423.62 ft,  YEND=-4178.99 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-158", WALL="SEC_7-in",
NSEGMENT=1, XEND=3463.01 ft,  YEND=-4185.93 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-159", WALL="SEC_7-in",
NSEGMENT=1, XEND=3502.41 ft,  YEND=-4192.88 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-160", WALL="SEC_7-in",
NSEGMENT=1, XEND=3541.80 ft,  YEND=-4199.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-161", WALL="SEC_7-in",
NSEGMENT=1, XEND=3581.19 ft,  YEND=-4206.77 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-162", WALL="SEC_7-in",
NSEGMENT=1, XEND=3620.58 ft,  YEND=-4213.72 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-163", WALL="SEC_7-in",
NSEGMENT=1, XEND=3659.98 ft,  YEND=-4220.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-164", WALL="SEC_7-in",
NSEGMENT=1, XEND=3699.37 ft,  YEND=-4227.61 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-165", WALL="SEC_7-in",
NSEGMENT=1, XEND=3738.76 ft,  YEND=-4234.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-166", WALL="SEC_7-in",
NSEGMENT=1, XEND=3778.15 ft,  YEND=-4241.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-167", WALL="SEC_7-in",
NSEGMENT=1, XEND=3817.55 ft,  YEND=-4248.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-168", WALL="SEC_7-in",
NSEGMENT=1, XEND=3856.94 ft,  YEND=-4255.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-169", WALL="SEC_7-in",
NSEGMENT=1, XEND=3896.33 ft,  YEND=-4262.34 ft, DIAMETER=157.1 mm
  HEATTRANSFER LABEL=HT_well_2_00, PIPE="PIPE-AIR", HOUTEROPTION=AIR,
TAMBIENT=5.00 C,  VELOCITY=1.0 m/s
  HEATTRANSFER LABEL=HT_well_2_01, PIPE="PIPE-000", HOUTEROPTION=WATER,
TAMBIENT=7.00 C,  VELOCITY=1.0 m/s
  HEATTRANSFER LABEL=HT_well_2_02, PIPE="3-171", INTAMBIENT=7.00 C,
OUTTAMBIENT=52 C,  HAMBIENT=1000000 W/m2-C
  TRENDDATA VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h, HOL, PT bara, QG, QGST
MMscf/d,  QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3, ROL kg/m3),
PIPE="PIPE-000",  SECTION=1
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MMscf/d,  QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3, ROL kg/m3),
PIPE="PIPE-169",  SECTION=1
  INITIALCONDITIONS INTEMPERATURE=10 C, OUTTEMPERATURE=30 C, INPRESSURE=15.4
bara,  OUTPRESSURE=9 bara, VOIDFRACTION=1 -
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ENDNETWORKCOMPONENT


NETWORKCOMPONENT TYPE=NODE, TAG=OFFSHORE_MAN
  PARAMETERS LABEL=OFFSHORE_MAN, TYPE=INTERNAL
ENDNETWORKCOMPONENT

NETWORKCOMPONENT TYPE=NODE, TAG=NODE_BH_LB
 PARAMETERS LABEL=NODE_BH_LB, TYPE=PRESSURE, TEMPERATURE=(1644:4) C,\
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980, 981, 982,\
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1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028,
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PRESSURE=(7.397, 8.449, 8.705, 8.911, 9.093, 9.259, 9.413, 9.557, 9.694,\
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 18.656, 18.784, 18.908, 19.032, 19.153, 19.278, 19.398, 19.804, 20.009,\
 20.199, 20.379, 20.552, 20.724, 20.887, 21.044, 21.206, 21.359, 21.511,\
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 33.524, 33.624, 33.727, 33.831, 33.934, 34.031, 34.134, 34.236, 34.337,\
 34.437, 34.538, 34.637, 34.738, 34.834, 34.932, 35.031, 35.130, 35.230,\
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 37.047, 37.140, 37.236, 37.326, 37.419, 37.510, 37.604, 37.698, 37.788,\
 37.882, 37.973, 38.061, 38.153, 38.245, 38.335, 38.426, 38.517, 38.609,\
 38.698, 38.788, 38.876, 38.965, 39.054, 39.143, 39.232, 39.321, 39.410,\
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 95.511, 95.535, 95.559, 95.589, 95.609, 95.638, 95.663, 95.690, 95.712,\
 95.744, 95.766, 95.797, 95.822, 95.845, 95.872) bara
ENDNETWORKCOMPONENT


!*****************************************************************************
*******
! Connections
!*****************************************************************************
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CONNECTION TERMINALS = (LONG_LINE_1 INLET, ONSHORE_MAN FLOWTERM_1)
CONNECTION TERMINALS = (LONG_LINE_1 OUTLET, OFFSHORE_MAN FLOWTERM_1)
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CONNECTION TERMINALS = (OFFSHORE_MAN FLOWTERM_2, "HEWETT_WELLS_LB" INLET)
CONNECTION TERMINALS = ("HEWETT_WELLS_LB" OUTLET, NODE_BH_LB FLOWTERM_1)
ENDCASE
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! Global keywords
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CASE AUTHOR=TEFA, PROJECT=OLGA, TITLE="ExportLineSens"
OPTIONS TEMPERATURE=WALL, STEADYSTATE=ON, DEBUG=OFF, FLOWMODEL=OLGAHD,
COMPOSITIONAL=SINGLE
SINGLEOPTIONS COMPONENT=CO2, MINPRESSURE=0.1 bara, MAXPRESSURE=350 bara,
MINTEMPERATURE=-150 C, MAXTEMPERATURE=150 C, FLASHFORMULATION=PH

INTEGRATION ENDTIME=1644 h, MAXDT=10 s, MINDT=0.0000001 s, STARTTIME=0 s,
DTSTART=0.1 s
OUTPUT DTOUT=10 h
TREND DTPLOT=1 m
PROFILE DTPLOT=1 h

TRENDDATA VARIABLE=(HT, SPEED, VOLGBL)
TRENDDATA VARIABLE=(GGSOUR, GLHLMA, GLSOUR, GLWTMA, GTSOUR, ICRIT, QGSTSOUR,
QLSTSOUR, QOSTSOUR, QWSTSOUR, QGSTWELL, QLSTWELL, QOSTWELL, QWSTWELL)
TRENDDATA VARIABLE=(TVALVE, VALVDP bara, VALVOP, PVALVE bara)
TRENDDATA VARIABLE=(DPBR bara, DPFBR bara, DPGBR bara, DPABR bara)
TRENDDATA VARIABLE=(WATC, LIQC, OILC, GASC)
TRENDDATA VARIABLE=(MAXTMBRCT, MINTMBRCT, MAXPTBRCT, MINPTBRCT)

PROFILEDATA VARIABLE=(GG kg/s, GLT kg/s, GLTWT kg/s, GT kg/s, QGST MMscf/d, QLST
MMscf/d)
PROFILEDATA VARIABLE=(EVR, HOL, HOLWT, HOLHL, ID)
PROFILEDATA VARIABLE=(PT bara, Q2, QG, ROG kg/m3, ROL kg/m3, TM, TWS, UG, UL)
PROFILEDATA VARIABLE=(SIG, GD, TAUWG, TAUWGA, RS, DPZF, DPZG, HTK, ESTRESTIMEW,
VISL, VISG, TU)

RESTART WRITE=APPEND, DTWRITE=10 h  !

!*******************************************************************************
*******
! Library keywords
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MATERIAL LABEL=3LHDPE, CAPACITY=2300 J/kg-K, CONDUCTIVITY=0.3 W/m-K, DENSITY=950
kg/m3
MATERIAL LABEL=3LPP, CAPACITY=1000 J/kg-C, CONDUCTIVITY=0.22 W/m-K, DENSITY=900
kg/m3
MATERIAL LABEL=carbonsteel, CAPACITY=434 J/kg-C, CONDUCTIVITY=45 W/m-K,
DENSITY=7832 kg/m3
MATERIAL LABEL=concrete, CAPACITY=960 J/kg-C, CONDUCTIVITY=0.8 W/m-K,
DENSITY=2400 kg/m3
MATERIAL LABEL=inconel625, CAPACITY=410 J/kg-C, CONDUCTIVITY=9.8 W/m-C,
DENSITY=8440 kg/m3
MATERIAL LABEL=SuperDuplex, CAPACITY=500 J/kg-C, CONDUCTIVITY=15 W/m-K,
DENSITY=7750 kg/m3

MATERIAL LABEL=Steel, CAPACITY=470 J/kg-K, CONDUCTIVITY=45 W/m-K, DENSITY=7850
kg/m3
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MATERIAL LABEL=Cement, CAPACITY=900 J/kg-K, CONDUCTIVITY=5.88 W/m-K,
DENSITY=2400 kg/m3
MATERIAL LABEL=Formation, CAPACITY=1257 J/kg-K, CONDUCTIVITY=3 W/m-K,
DENSITY=2100 kg/m3
MATERIAL LABEL=Brine, CAPACITY=4300 J/kg-K, CONDUCTIVITY=2.6 W/m-K, DENSITY=1250
kg/m3

WALL LABEL="SEC_7-in", THICKNESS=(7.7, 16.4, 10.4, 35.0, 60.0, 110.0, 210.0,
300.0,  590.0, 1100.0, 1630.0) mm, MATERIAL=(Steel, Brine, Steel, Cement,
Formation,  Formation, Formation, Formation, Formation, Formation, Formation)
WALL LABEL="SEC_9-5/8", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 35.0, 60.0,
110.0,  210.0, 300.0, 590.0, 1100.0, 1630.0) mm, MATERIAL=(Steel, Brine, Steel,
Cement, Steel, Cement, Formation, Formation, Formation, Formation, Formation,
Formation, Formation)
WALL LABEL="SEC_13-3/8", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 51.8, 9.7,
35.0,  60.0, 110.0, 210.0, 300.0, 590.0, 1100.0, 1630.0) mm, MATERIAL=(Steel,
Brine, Steel, Cement, Steel, Cement, Steel, Cement, Formation, Formation,
Formation, Formation, Formation, Formation, Formation)
WALL LABEL="SEC_30-in", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 51.8, 9.7,
195.4,  25.4, 35.0, 60.0, 110.0, 210.0, 300.0, 590.0, 1100.0, 1630.0) mm,
MATERIAL=(Steel,  Brine, Steel, Cement, Steel, Cement, Steel, Cement, Steel,
Cement, Formation,  Formation, Formation, Formation, Formation, Formation,
Formation)
WALL LABEL="SEC_30-wt", THICKNESS=(7.7, 16.4, 10.4, 29.9, 13.8, 51.8, 9.7,
195.4,  25.4) mm, MATERIAL=(Steel, Brine, Steel, Cement, Steel, Cement, Steel,
Cement, Steel)

WALL LABEL="Wall-infield", THICKNESS=(3, 5, 7, 50, 100) mm,
MATERIAL=(inconel625, carbonsteel, carbonsteel, 3LPP, concrete)

TABLE LABEL="WELL-IPR", POINT=(0, 0, 1, 64), XVARIABLE=DELTAP bar,
YVARIABLE=FLOW kg/s
TABULAR LABEL="WELL_PRD-TAB", TABLE="WELL-IPR"
TABULAR LABEL="WELL_INJ-TAB", TABLE="WELL-IPR"


!*******************************************************************************
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! Network Component
!*******************************************************************************
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NETWORKCOMPONENT TYPE=NODE, TAG=ONSHORE_MAN
PARAMETERS LABEL=ONSHORE_MAN, TYPE=CLOSED
ENDNETWORKCOMPONENT

!*******************************************************************************
*******
! Network Component
!*******************************************************************************
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NETWORKCOMPONENT TYPE=FLOWPATH, TAG=LONG_LINE_1
PARAMETERS LABEL=LONG_LINE_1

SOURCE LABEL="CO2",\
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TIME=(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
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1639, 1640, 1641, 1642, 1643) h,\
SOURCETYPE=MASS, PIPE="Pipe-001", SECTION=1, TEMPERATURE=(1644:50) C,\
MASSFLOW=(63.12, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40,
77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40, 77.40,
77.40, 77.40, 77.40, 77.40,\
77.40, 77.40, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10,
116.10, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10, 116.10,
116.10, 116.10, 116.10,\
116.10, 116.10, 116.10, 116.10, 116.10, 154.80, 154.80, 154.80, 154.80, 154.80,
154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 154.80,
154.80, 154.80, 154.80,\
154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 154.80, 1565:190.26)
kg/s,\
PHASE=GAS
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TRENDDATA PIPE="PIPE-002", SECTION=1, VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h,
HOL, PT bara, QG, QGST MMscf/d, QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3,
ROL kg/m3)
TRENDDATA PIPE="PIPE-550", SECTION=1, VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h,
HOL, PT bara, QG, QGST MMscf/d, QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3,
ROL kg/m3)

HEATTRANSFER LABEL="HEATTRANS-subsea", PIPE=ALL, INTERPOLATION=VERTICAL,
HOUTEROPTION=WATER,  INTAMBIENT=4 C, OUTTAMBIENT=4 C

INITIALCONDITIONS INTEMPERATURE=4 C, OUTTEMPERATURE=4 C, INPRESSURE=30 bara,
OUTPRESSURE=12 bara, VOIDFRACTION=0 -

GEOMETRY LABEL="LongLine1", XSTART=0 m, YSTART=1 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-001",       WALL="Wall-infield",
NSEGMENT=1,      XEND=0.0000 m, YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-002",       WALL="Wall-infield",
NSEGMENT=1,      XEND=520.7158 m,       YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-003",       WALL="Wall-infield",
NSEGMENT=1,      XEND=1041.4317 m,      YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-004",       WALL="Wall-infield",
NSEGMENT=1,      XEND=1562.1475 m,      YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-005",       WALL="Wall-infield",
NSEGMENT=1,      XEND=2082.8634 m,      YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-006",       WALL="Wall-infield",
NSEGMENT=1,      XEND=2603.5792 m,      YEND=0.4290 m,  DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-007",       WALL="Wall-infield",
NSEGMENT=1,      XEND=3124.2951 m,      YEND=-2.7360 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-008",       WALL="Wall-infield",
NSEGMENT=1,      XEND=3645.0109 m,      YEND=-2.9130 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-009",       WALL="Wall-infield",
NSEGMENT=1,      XEND=4165.7268 m,      YEND=-5.7420 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-010",       WALL="Wall-infield",
NSEGMENT=1,      XEND=4686.4426 m,      YEND=-7.8630 m, DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-011",       WALL="Wall-infield",
NSEGMENT=1,      XEND=5207.1585 m,      YEND=-09.9220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-012",       WALL="Wall-infield",
NSEGMENT=1,      XEND=5727.8743 m,      YEND=-13.1770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-013",       WALL="Wall-infield",
NSEGMENT=1,      XEND=6248.5902 m,      YEND=-17.0130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-014",       WALL="Wall-infield",
NSEGMENT=1,      XEND=6769.3060 m,      YEND=-23.1790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-015",       WALL="Wall-infield",
NSEGMENT=1,      XEND=7290.0219 m,      YEND=-26.2940 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-016",       WALL="Wall-infield",
NSEGMENT=1,      XEND=7810.7377 m,      YEND=-28.6310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-017",       WALL="Wall-infield",
NSEGMENT=1,      XEND=8331.4536 m,      YEND=-29.8190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-018",       WALL="Wall-infield",
NSEGMENT=1,      XEND=8852.1694 m,      YEND=-29.6490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-019",       WALL="Wall-infield",
NSEGMENT=1,      XEND=9372.8852 m,      YEND=-33.4560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-020",       WALL="Wall-infield",
NSEGMENT=1,      XEND=9893.6011 m,      YEND=-31.5570 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-021",       WALL="Wall-infield",
NSEGMENT=1,      XEND=10414.3169 m,     YEND=-31.6120 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-022",       WALL="Wall-infield",
NSEGMENT=1,      XEND=10935.0328 m,     YEND=-35.7500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-023",       WALL="Wall-infield",
NSEGMENT=1,      XEND=11455.7486 m,     YEND=-37.5600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-024",       WALL="Wall-infield",
NSEGMENT=1,      XEND=11976.4645 m,     YEND=-38.9020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-025",       WALL="Wall-infield",
NSEGMENT=1,      XEND=12497.1803 m,     YEND=-41.1370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-026",       WALL="Wall-infield",
NSEGMENT=1,      XEND=13017.8962 m,     YEND=-43.4980 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-027",       WALL="Wall-infield",
NSEGMENT=1,      XEND=13538.6120 m,     YEND=-43.0630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-028",       WALL="Wall-infield",
NSEGMENT=1,      XEND=14059.3279 m,     YEND=-43.5410 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-029",       WALL="Wall-infield",
NSEGMENT=1,      XEND=14580.0437 m,     YEND=-44.0200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-030",       WALL="Wall-infield",
NSEGMENT=1,      XEND=15100.7596 m,     YEND=-42.4000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-031",       WALL="Wall-infield",
NSEGMENT=1,      XEND=15621.4754 m,     YEND=-43.9440 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-032",       WALL="Wall-infield",
NSEGMENT=1,      XEND=16142.1913 m,     YEND=-46.4390 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-033",       WALL="Wall-infield",
NSEGMENT=1,      XEND=16662.9071 m,     YEND=-44.6580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-034",       WALL="Wall-infield",
NSEGMENT=1,      XEND=17183.6230 m,     YEND=-42.8310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-035",       WALL="Wall-infield",
NSEGMENT=1,      XEND=17704.3388 m,     YEND=-43.9020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-036",       WALL="Wall-infield",
NSEGMENT=1,      XEND=18225.0546 m,     YEND=-44.2720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-037",       WALL="Wall-infield",
NSEGMENT=1,      XEND=18745.7705 m,     YEND=-45.6470 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-038",       WALL="Wall-infield",
NSEGMENT=1,      XEND=19266.4863 m,     YEND=-46.9960 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-039",       WALL="Wall-infield",
NSEGMENT=1,      XEND=19787.2022 m,     YEND=-46.8460 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-040",       WALL="Wall-infield",
NSEGMENT=1,      XEND=20307.9180 m,     YEND=-46.5680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-041",       WALL="Wall-infield",
NSEGMENT=1,      XEND=20828.6339 m,     YEND=-46.6600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-042",       WALL="Wall-infield",
NSEGMENT=1,      XEND=21349.3497 m,     YEND=-47.2290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-043",       WALL="Wall-infield",
NSEGMENT=1,      XEND=21870.0656 m,     YEND=-48.1380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-044",       WALL="Wall-infield",
NSEGMENT=1,      XEND=22390.7814 m,     YEND=-47.9550 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-045",       WALL="Wall-infield",
NSEGMENT=1,      XEND=22911.4973 m,     YEND=-48.2840 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-046",       WALL="Wall-infield",
NSEGMENT=1,      XEND=23432.2131 m,     YEND=-48.9650 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-047",       WALL="Wall-infield",
NSEGMENT=1,      XEND=23952.9290 m,     YEND=-49.3090 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-048",       WALL="Wall-infield",
NSEGMENT=1,      XEND=24473.6448 m,     YEND=-48.6850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-049",       WALL="Wall-infield",
NSEGMENT=1,      XEND=24994.3607 m,     YEND=-47.9120 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-050",       WALL="Wall-infield",
NSEGMENT=1,      XEND=25515.0765 m,     YEND=-47.8210 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-051",       WALL="Wall-infield",
NSEGMENT=1,      XEND=26035.7923 m,     YEND=-47.9770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-052",       WALL="Wall-infield",
NSEGMENT=1,      XEND=26556.5082 m,     YEND=-48.2150 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-053",       WALL="Wall-infield",
NSEGMENT=1,      XEND=27077.2240 m,     YEND=-48.3990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-054",       WALL="Wall-infield",
NSEGMENT=1,      XEND=27597.9399 m,     YEND=-49.0270 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-055",       WALL="Wall-infield",
NSEGMENT=1,      XEND=28118.6557 m,     YEND=-49.1940 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-056",       WALL="Wall-infield",
NSEGMENT=1,      XEND=28639.3716 m,     YEND=-49.3530 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-057",       WALL="Wall-infield",
NSEGMENT=1,      XEND=29160.0874 m,     YEND=-49.6470 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-058",       WALL="Wall-infield",
NSEGMENT=1,      XEND=29680.8033 m,     YEND=-49.5390 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-059",       WALL="Wall-infield",
NSEGMENT=1,      XEND=30201.5191 m,     YEND=-49.6820 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-060",       WALL="Wall-infield",
NSEGMENT=1,      XEND=30722.2350 m,     YEND=-50.0500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-061",       WALL="Wall-infield",
NSEGMENT=1,      XEND=31242.9508 m,     YEND=-50.4790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-062",       WALL="Wall-infield",
NSEGMENT=1,      XEND=31763.6667 m,     YEND=-51.2190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-063",       WALL="Wall-infield",
NSEGMENT=1,      XEND=32284.3825 m,     YEND=-52.1330 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-064",       WALL="Wall-infield",
NSEGMENT=1,      XEND=32805.0984 m,     YEND=-52.5220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-065",       WALL="Wall-infield",
NSEGMENT=1,      XEND=33325.8142 m,     YEND=-53.3510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-066",       WALL="Wall-infield",
NSEGMENT=1,      XEND=33846.5301 m,     YEND=-54.4690 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-067",       WALL="Wall-infield",
NSEGMENT=1,      XEND=34367.2459 m,     YEND=-54.8300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-068",       WALL="Wall-infield",
NSEGMENT=1,      XEND=34887.9617 m,     YEND=-55.0040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-069",       WALL="Wall-infield",
NSEGMENT=1,      XEND=35408.6776 m,     YEND=-55.1420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-070",       WALL="Wall-infield",
NSEGMENT=1,      XEND=35929.3934 m,     YEND=-55.5090 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-071",       WALL="Wall-infield",
NSEGMENT=1,      XEND=36450.1093 m,     YEND=-55.5590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-072",       WALL="Wall-infield",
NSEGMENT=1,      XEND=36970.8251 m,     YEND=-55.6080 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-073",       WALL="Wall-infield",
NSEGMENT=1,      XEND=37491.5410 m,     YEND=-53.4920 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-074",       WALL="Wall-infield",
NSEGMENT=1,      XEND=38012.2568 m,     YEND=-51.6350 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-075",       WALL="Wall-infield",
NSEGMENT=1,      XEND=38532.9727 m,     YEND=-52.7700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-076",       WALL="Wall-infield",
NSEGMENT=1,      XEND=39053.6885 m,     YEND=-55.3440 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-077",       WALL="Wall-infield",
NSEGMENT=1,      XEND=39574.4044 m,     YEND=-55.8730 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-078",       WALL="Wall-infield",
NSEGMENT=1,      XEND=40095.1202 m,     YEND=-57.3490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-079",       WALL="Wall-infield",
NSEGMENT=1,      XEND=40615.8361 m,     YEND=-57.2880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-080",       WALL="Wall-infield",
NSEGMENT=1,      XEND=41136.5519 m,     YEND=-55.7400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-081",       WALL="Wall-infield",
NSEGMENT=1,      XEND=41657.2678 m,     YEND=-56.9880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-082",       WALL="Wall-infield",
NSEGMENT=1,      XEND=42177.9836 m,     YEND=-57.3100 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-083",       WALL="Wall-infield",
NSEGMENT=1,      XEND=42698.6995 m,     YEND=-57.3100 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-084",       WALL="Wall-infield",
NSEGMENT=1,      XEND=43219.4153 m,     YEND=-57.2220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-085",       WALL="Wall-infield",
NSEGMENT=1,      XEND=43740.1311 m,     YEND=-57.9720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-086",       WALL="Wall-infield",
NSEGMENT=1,      XEND=44260.8470 m,     YEND=-57.5200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-087",       WALL="Wall-infield",
NSEGMENT=1,      XEND=44781.5628 m,     YEND=-57.9020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-088",       WALL="Wall-infield",
NSEGMENT=1,      XEND=45302.2787 m,     YEND=-57.7840 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-089",       WALL="Wall-infield",
NSEGMENT=1,      XEND=45822.9945 m,     YEND=-57.9330 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-090",       WALL="Wall-infield",
NSEGMENT=1,      XEND=46343.7104 m,     YEND=-58.5520 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-091",       WALL="Wall-infield",
NSEGMENT=1,      XEND=46864.4262 m,     YEND=-58.4380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-092",       WALL="Wall-infield",
NSEGMENT=1,      XEND=47385.1421 m,     YEND=-58.4390 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-093",       WALL="Wall-infield",
NSEGMENT=1,      XEND=47905.8579 m,     YEND=-57.7700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-094",       WALL="Wall-infield",
NSEGMENT=1,      XEND=48426.5738 m,     YEND=-58.7700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-095",       WALL="Wall-infield",
NSEGMENT=1,      XEND=48947.2896 m,     YEND=-57.7700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-096",       WALL="Wall-infield",
NSEGMENT=1,      XEND=49468.0055 m,     YEND=-58.3240 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-097",       WALL="Wall-infield",
NSEGMENT=1,      XEND=49988.7213 m,     YEND=-58.3490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-098",       WALL="Wall-infield",
NSEGMENT=1,      XEND=50509.4372 m,     YEND=-58.6220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-099",       WALL="Wall-infield",
NSEGMENT=1,      XEND=51030.1530 m,     YEND=-57.4230 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-100",       WALL="Wall-infield",
NSEGMENT=1,      XEND=51550.8689 m,     YEND=-56.6560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-101",       WALL="Wall-infield",
NSEGMENT=1,      XEND=52071.5847 m,     YEND=-56.7700 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-102",       WALL="Wall-infield",
NSEGMENT=1,      XEND=52592.3005 m,     YEND=-56.7700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-103",       WALL="Wall-infield",
NSEGMENT=1,      XEND=53113.0164 m,     YEND=-56.7700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-104",       WALL="Wall-infield",
NSEGMENT=1,      XEND=53633.7322 m,     YEND=-56.7500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-105",       WALL="Wall-infield",
NSEGMENT=1,      XEND=54154.4481 m,     YEND=-58.3380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-106",       WALL="Wall-infield",
NSEGMENT=1,      XEND=54675.1639 m,     YEND=-58.0030 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-107",       WALL="Wall-infield",
NSEGMENT=1,      XEND=55195.8798 m,     YEND=-59.4220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-108",       WALL="Wall-infield",
NSEGMENT=1,      XEND=55716.5956 m,     YEND=-59.5260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-109",       WALL="Wall-infield",
NSEGMENT=1,      XEND=56237.3115 m,     YEND=-58.1210 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-110",       WALL="Wall-infield",
NSEGMENT=1,      XEND=56758.0273 m,     YEND=-58.4180 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-111",       WALL="Wall-infield",
NSEGMENT=1,      XEND=57278.7432 m,     YEND=-58.5870 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-112",       WALL="Wall-infield",
NSEGMENT=1,      XEND=57799.4590 m,     YEND=-59.7030 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-113",       WALL="Wall-infield",
NSEGMENT=1,      XEND=58320.1749 m,     YEND=-58.7200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-114",       WALL="Wall-infield",
NSEGMENT=1,      XEND=58840.8907 m,     YEND=-60.3430 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-115",       WALL="Wall-infield",
NSEGMENT=1,      XEND=59361.6066 m,     YEND=-60.6410 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-116",       WALL="Wall-infield",
NSEGMENT=1,      XEND=59882.3224 m,     YEND=-60.7430 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-117",       WALL="Wall-infield",
NSEGMENT=1,      XEND=60403.0383 m,     YEND=-60.4940 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-118",       WALL="Wall-infield",
NSEGMENT=1,      XEND=60923.7541 m,     YEND=-60.5110 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-119",       WALL="Wall-infield",
NSEGMENT=1,      XEND=61444.4699 m,     YEND=-60.6720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-120",       WALL="Wall-infield",
NSEGMENT=1,      XEND=61965.1858 m,     YEND=-59.1950 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-121",       WALL="Wall-infield",
NSEGMENT=1,      XEND=62485.9016 m,     YEND=-58.8960 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-122",       WALL="Wall-infield",
NSEGMENT=1,      XEND=63006.6175 m,     YEND=-59.0010 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-123",       WALL="Wall-infield",
NSEGMENT=1,      XEND=63527.3333 m,     YEND=-58.8400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-124",       WALL="Wall-infield",
NSEGMENT=1,      XEND=64048.0492 m,     YEND=-59.1150 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-125",       WALL="Wall-infield",
NSEGMENT=1,      XEND=64568.7650 m,     YEND=-59.2690 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-126",       WALL="Wall-infield",
NSEGMENT=1,      XEND=65089.4809 m,     YEND=-59.6700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-127",       WALL="Wall-infield",
NSEGMENT=1,      XEND=65610.1967 m,     YEND=-59.1900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-128",       WALL="Wall-infield",
NSEGMENT=1,      XEND=66130.9126 m,     YEND=-58.8080 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-129",       WALL="Wall-infield",
NSEGMENT=1,      XEND=66651.6284 m,     YEND=-58.8250 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-130",       WALL="Wall-infield",
NSEGMENT=1,      XEND=67172.3443 m,     YEND=-58.8920 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-131",       WALL="Wall-infield",
NSEGMENT=1,      XEND=67693.0601 m,     YEND=-59.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-132",       WALL="Wall-infield",
NSEGMENT=1,      XEND=68213.7760 m,     YEND=-59.5610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-133",       WALL="Wall-infield",
NSEGMENT=1,      XEND=68734.4918 m,     YEND=-60.0560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-134",       WALL="Wall-infield",
NSEGMENT=1,      XEND=69255.2077 m,     YEND=-60.3760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-135",       WALL="Wall-infield",
NSEGMENT=1,      XEND=69775.9235 m,     YEND=-61.3350 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-136",       WALL="Wall-infield",
NSEGMENT=1,      XEND=70296.6393 m,     YEND=-60.4320 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-137",       WALL="Wall-infield",
NSEGMENT=1,      XEND=70817.3552 m,     YEND=-60.6580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-138",       WALL="Wall-infield",
NSEGMENT=1,      XEND=71338.0710 m,     YEND=-60.9730 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-139",       WALL="Wall-infield",
NSEGMENT=1,      XEND=71858.7869 m,     YEND=-61.2850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-140",       WALL="Wall-infield",
NSEGMENT=1,      XEND=72379.5027 m,     YEND=-60.8850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-141",       WALL="Wall-infield",
NSEGMENT=1,      XEND=72900.2186 m,     YEND=-61.8590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-142",       WALL="Wall-infield",
NSEGMENT=1,      XEND=73420.9344 m,     YEND=-62.1490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-143",       WALL="Wall-infield",
NSEGMENT=1,      XEND=73941.6503 m,     YEND=-62.7640 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-144",       WALL="Wall-infield",
NSEGMENT=1,      XEND=74462.3661 m,     YEND=-62.4770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-145",       WALL="Wall-infield",
NSEGMENT=1,      XEND=74983.0820 m,     YEND=-63.4600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-146",       WALL="Wall-infield",
NSEGMENT=1,      XEND=75503.7978 m,     YEND=-63.6510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-147",       WALL="Wall-infield",
NSEGMENT=1,      XEND=76024.5137 m,     YEND=-64.2810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-148",       WALL="Wall-infield",
NSEGMENT=1,      XEND=76545.2295 m,     YEND=-64.1420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-149",       WALL="Wall-infield",
NSEGMENT=1,      XEND=77065.9454 m,     YEND=-64.3130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-150",       WALL="Wall-infield",
NSEGMENT=1,      XEND=77586.6612 m,     YEND=-64.8660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-151",       WALL="Wall-infield",
NSEGMENT=1,      XEND=78107.3770 m,     YEND=-65.2890 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-152",       WALL="Wall-infield",
NSEGMENT=1,      XEND=78628.0929 m,     YEND=-65.2220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-153",       WALL="Wall-infield",
NSEGMENT=1,      XEND=79148.8087 m,     YEND=-65.8120 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-154",       WALL="Wall-infield",
NSEGMENT=1,      XEND=79669.5246 m,     YEND=-65.8610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-155",       WALL="Wall-infield",
NSEGMENT=1,      XEND=80190.2404 m,     YEND=-66.5720 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-156",       WALL="Wall-infield",
NSEGMENT=1,      XEND=80710.9563 m,     YEND=-66.1890 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-157",       WALL="Wall-infield",
NSEGMENT=1,      XEND=81231.6721 m,     YEND=-65.9400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-158",       WALL="Wall-infield",
NSEGMENT=1,      XEND=81752.3880 m,     YEND=-65.5960 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-159",       WALL="Wall-infield",
NSEGMENT=1,      XEND=82273.1038 m,     YEND=-65.4130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-160",       WALL="Wall-infield",
NSEGMENT=1,      XEND=82793.8197 m,     YEND=-65.4810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-161",       WALL="Wall-infield",
NSEGMENT=1,      XEND=83314.5355 m,     YEND=-66.0360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-162",       WALL="Wall-infield",
NSEGMENT=1,      XEND=83835.2514 m,     YEND=-66.9410 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-163",       WALL="Wall-infield",
NSEGMENT=1,      XEND=84355.9672 m,     YEND=-67.5100 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-164",       WALL="Wall-infield",
NSEGMENT=1,      XEND=84876.6831 m,     YEND=-67.3000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-165",       WALL="Wall-infield",
NSEGMENT=1,      XEND=85397.3989 m,     YEND=-67.1770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-166",       WALL="Wall-infield",
NSEGMENT=1,      XEND=85918.1148 m,     YEND=-66.3800 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-167",       WALL="Wall-infield",
NSEGMENT=1,      XEND=86438.8306 m,     YEND=-66.0900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-168",       WALL="Wall-infield",
NSEGMENT=1,      XEND=86959.5464 m,     YEND=-66.0900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-169",       WALL="Wall-infield",
NSEGMENT=1,      XEND=87480.2623 m,     YEND=-65.6110 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-170",       WALL="Wall-infield",
NSEGMENT=1,      XEND=88000.9781 m,     YEND=-65.2110 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-171",       WALL="Wall-infield",
NSEGMENT=1,      XEND=88521.6940 m,     YEND=-66.3540 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-172",       WALL="Wall-infield",
NSEGMENT=1,      XEND=89042.4098 m,     YEND=-67.1270 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-173",       WALL="Wall-infield",
NSEGMENT=1,      XEND=89563.1257 m,     YEND=-68.4170 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-174",       WALL="Wall-infield",
NSEGMENT=1,      XEND=90083.8415 m,     YEND=-68.0890 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-175",       WALL="Wall-infield",
NSEGMENT=1,      XEND=90604.5574 m,     YEND=-67.4990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-176",       WALL="Wall-infield",
NSEGMENT=1,      XEND=91125.2732 m,     YEND=-66.7570 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-177",       WALL="Wall-infield",
NSEGMENT=1,      XEND=91645.9891 m,     YEND=-66.2420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-178",       WALL="Wall-infield",
NSEGMENT=1,      XEND=92166.7049 m,     YEND=-65.8450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-179",       WALL="Wall-infield",
NSEGMENT=1,      XEND=92687.4208 m,     YEND=-65.5700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-180",       WALL="Wall-infield",
NSEGMENT=1,      XEND=93208.1366 m,     YEND=-66.1250 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-181",       WALL="Wall-infield",
NSEGMENT=1,      XEND=93728.8525 m,     YEND=-65.8180 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-182",       WALL="Wall-infield",
NSEGMENT=1,      XEND=94249.5683 m,     YEND=-65.0150 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-183",       WALL="Wall-infield",
NSEGMENT=1,      XEND=94770.2842 m,     YEND=-64.8650 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-184",       WALL="Wall-infield",
NSEGMENT=1,      XEND=95291.0000 m,     YEND=-64.6850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-185",       WALL="Wall-infield",
NSEGMENT=1,      XEND=95811.7158 m,     YEND=-64.1480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-186",       WALL="Wall-infield",
NSEGMENT=1,      XEND=96332.4317 m,     YEND=-63.8590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-187",       WALL="Wall-infield",
NSEGMENT=1,      XEND=96853.1475 m,     YEND=-64.5670 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-188",       WALL="Wall-infield",
NSEGMENT=1,      XEND=97373.8634 m,     YEND=-64.4020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-189",       WALL="Wall-infield",
NSEGMENT=1,      XEND=97894.5792 m,     YEND=-64.1970 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-190",       WALL="Wall-infield",
NSEGMENT=1,      XEND=98415.2951 m,     YEND=-63.0070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-191",       WALL="Wall-infield",
NSEGMENT=1,      XEND=98936.0109 m,     YEND=-61.4400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-192",       WALL="Wall-infield",
NSEGMENT=1,      XEND=99456.7268 m,     YEND=-61.1700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-193",       WALL="Wall-infield",
NSEGMENT=1,      XEND=99977.4426 m,     YEND=-61.2700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-194",       WALL="Wall-infield",
NSEGMENT=1,      XEND=100498.1585 m,    YEND=-59.9230 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-195",       WALL="Wall-infield",
NSEGMENT=1,      XEND=101018.8743 m,    YEND=-60.1850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-196",       WALL="Wall-infield",
NSEGMENT=1,      XEND=101539.5902 m,    YEND=-60.2320 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-197",       WALL="Wall-infield",
NSEGMENT=1,      XEND=102060.3060 m,    YEND=-59.1230 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-198",       WALL="Wall-infield",
NSEGMENT=1,      XEND=102581.0219 m,    YEND=-59.2900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-199",       WALL="Wall-infield",
NSEGMENT=1,      XEND=103101.7377 m,    YEND=-60.2840 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-200",       WALL="Wall-infield",
NSEGMENT=1,      XEND=103622.4536 m,    YEND=-60.3410 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-201",       WALL="Wall-infield",
NSEGMENT=1,      XEND=104143.1694 m,    YEND=-60.5240 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-202",       WALL="Wall-infield",
NSEGMENT=1,      XEND=104663.8852 m,    YEND=-59.6250 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-203",       WALL="Wall-infield",
NSEGMENT=1,      XEND=105184.6011 m,    YEND=-60.4300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-204",       WALL="Wall-infield",
NSEGMENT=1,      XEND=105705.3169 m,    YEND=-62.8340 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-205",       WALL="Wall-infield",
NSEGMENT=1,      XEND=106226.0328 m,    YEND=-63.9770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-206",       WALL="Wall-infield",
NSEGMENT=1,      XEND=106746.7486 m,    YEND=-64.6060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-207",       WALL="Wall-infield",
NSEGMENT=1,      XEND=107267.4645 m,    YEND=-64.0760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-208",       WALL="Wall-infield",
NSEGMENT=1,      XEND=107788.1803 m,    YEND=-63.6300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-209",       WALL="Wall-infield",
NSEGMENT=1,      XEND=108308.8962 m,    YEND=-64.3800 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-210",       WALL="Wall-infield",
NSEGMENT=1,      XEND=108829.6120 m,    YEND=-65.4510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-211",       WALL="Wall-infield",
NSEGMENT=1,      XEND=109350.3279 m,    YEND=-65.9590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-212",       WALL="Wall-infield",
NSEGMENT=1,      XEND=109871.0437 m,    YEND=-66.6930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-213",       WALL="Wall-infield",
NSEGMENT=1,      XEND=110391.7596 m,    YEND=-66.8530 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-214",       WALL="Wall-infield",
NSEGMENT=1,      XEND=110912.4754 m,    YEND=-67.1510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-215",       WALL="Wall-infield",
NSEGMENT=1,      XEND=111433.1913 m,    YEND=-67.0610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-216",       WALL="Wall-infield",
NSEGMENT=1,      XEND=111953.9071 m,    YEND=-67.4640 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-217",       WALL="Wall-infield",
NSEGMENT=1,      XEND=112474.6230 m,    YEND=-67.6390 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-218",       WALL="Wall-infield",
NSEGMENT=1,      XEND=112995.3388 m,    YEND=-67.4810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-219",       WALL="Wall-infield",
NSEGMENT=1,      XEND=113516.0546 m,    YEND=-67.6790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-220",       WALL="Wall-infield",
NSEGMENT=1,      XEND=114036.7705 m,    YEND=-67.5500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-221",       WALL="Wall-infield",
NSEGMENT=1,      XEND=114557.4863 m,    YEND=-67.5480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-222",       WALL="Wall-infield",
NSEGMENT=1,      XEND=115078.2022 m,    YEND=-67.0860 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-223",       WALL="Wall-infield",
NSEGMENT=1,      XEND=115598.9180 m,    YEND=-65.9750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-224",       WALL="Wall-infield",
NSEGMENT=1,      XEND=116119.6339 m,    YEND=-65.5730 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-225",       WALL="Wall-infield",
NSEGMENT=1,      XEND=116640.3497 m,    YEND=-64.6400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-226",       WALL="Wall-infield",
NSEGMENT=1,      XEND=117161.0656 m,    YEND=-63.4090 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-227",       WALL="Wall-infield",
NSEGMENT=1,      XEND=117681.7814 m,    YEND=-62.4930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-228",       WALL="Wall-infield",
NSEGMENT=1,      XEND=118202.4973 m,    YEND=-61.3700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-229",       WALL="Wall-infield",
NSEGMENT=1,      XEND=118723.2131 m,    YEND=-60.5330 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-230",       WALL="Wall-infield",
NSEGMENT=1,      XEND=119243.9290 m,    YEND=-59.7010 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-231",       WALL="Wall-infield",
NSEGMENT=1,      XEND=119764.6448 m,    YEND=-59.3530 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-232",       WALL="Wall-infield",
NSEGMENT=1,      XEND=120285.3607 m,    YEND=-60.4830 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-233",       WALL="Wall-infield",
NSEGMENT=1,      XEND=120806.0765 m,    YEND=-60.3260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-234",       WALL="Wall-infield",
NSEGMENT=1,      XEND=121326.7923 m,    YEND=-59.9350 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-235",       WALL="Wall-infield",
NSEGMENT=1,      XEND=121847.5082 m,    YEND=-58.2540 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-236",       WALL="Wall-infield",
NSEGMENT=1,      XEND=122368.2240 m,    YEND=-52.3080 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-237",       WALL="Wall-infield",
NSEGMENT=1,      XEND=122888.9399 m,    YEND=-49.0500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-238",       WALL="Wall-infield",
NSEGMENT=1,      XEND=123409.6557 m,    YEND=-50.0150 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-239",       WALL="Wall-infield",
NSEGMENT=1,      XEND=123930.3716 m,    YEND=-51.3250 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-240",       WALL="Wall-infield",
NSEGMENT=1,      XEND=124451.0874 m,    YEND=-53.1490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-241",       WALL="Wall-infield",
NSEGMENT=1,      XEND=124971.8033 m,    YEND=-54.6620 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-242",       WALL="Wall-infield",
NSEGMENT=1,      XEND=125492.5191 m,    YEND=-53.2540 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-243",       WALL="Wall-infield",
NSEGMENT=1,      XEND=126013.2350 m,    YEND=-56.1020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-244",       WALL="Wall-infield",
NSEGMENT=1,      XEND=126533.9508 m,    YEND=-58.7130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-245",       WALL="Wall-infield",
NSEGMENT=1,      XEND=127054.6667 m,    YEND=-60.6490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-246",       WALL="Wall-infield",
NSEGMENT=1,      XEND=127575.3825 m,    YEND=-58.0680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-247",       WALL="Wall-infield",
NSEGMENT=1,      XEND=128096.0984 m,    YEND=-59.0740 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-248",       WALL="Wall-infield",
NSEGMENT=1,      XEND=128616.8142 m,    YEND=-58.9090 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-249",       WALL="Wall-infield",
NSEGMENT=1,      XEND=129137.5301 m,    YEND=-57.0170 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-250",       WALL="Wall-infield",
NSEGMENT=1,      XEND=129658.2459 m,    YEND=-55.3240 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-251",       WALL="Wall-infield",
NSEGMENT=1,      XEND=130178.9617 m,    YEND=-54.3300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-252",       WALL="Wall-infield",
NSEGMENT=1,      XEND=130699.6776 m,    YEND=-51.6290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-253",       WALL="Wall-infield",
NSEGMENT=1,      XEND=131220.3934 m,    YEND=-49.2780 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-254",       WALL="Wall-infield",
NSEGMENT=1,      XEND=131741.1093 m,    YEND=-44.7760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-255",       WALL="Wall-infield",
NSEGMENT=1,      XEND=132261.8251 m,    YEND=-43.4970 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-256",       WALL="Wall-infield",
NSEGMENT=1,      XEND=132782.5410 m,    YEND=-42.0300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-257",       WALL="Wall-infield",
NSEGMENT=1,      XEND=133303.2568 m,    YEND=-38.2570 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-258",       WALL="Wall-infield",
NSEGMENT=1,      XEND=133823.9727 m,    YEND=-40.7550 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-259",       WALL="Wall-infield",
NSEGMENT=1,      XEND=134344.6885 m,    YEND=-38.0290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-260",       WALL="Wall-infield",
NSEGMENT=1,      XEND=134865.4044 m,    YEND=-42.9420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-261",       WALL="Wall-infield",
NSEGMENT=1,      XEND=135386.1202 m,    YEND=-44.9200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-262",       WALL="Wall-infield",
NSEGMENT=1,      XEND=135906.8361 m,    YEND=-47.7050 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-263",       WALL="Wall-infield",
NSEGMENT=1,      XEND=136427.5519 m,    YEND=-49.5410 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-264",       WALL="Wall-infield",
NSEGMENT=1,      XEND=136948.2678 m,    YEND=-52.1830 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-265",       WALL="Wall-infield",
NSEGMENT=1,      XEND=137468.9836 m,    YEND=-50.7930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-266",       WALL="Wall-infield",
NSEGMENT=1,      XEND=137989.6995 m,    YEND=-55.1460 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-267",       WALL="Wall-infield",
NSEGMENT=1,      XEND=138510.4153 m,    YEND=-59.1720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-268",       WALL="Wall-infield",
NSEGMENT=1,      XEND=139031.1311 m,    YEND=-58.6390 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-269",       WALL="Wall-infield",
NSEGMENT=1,      XEND=139551.8470 m,    YEND=-59.0520 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-270",       WALL="Wall-infield",
NSEGMENT=1,      XEND=140072.5628 m,    YEND=-58.9310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-271",       WALL="Wall-infield",
NSEGMENT=1,      XEND=140593.2787 m,    YEND=-60.6500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-272",       WALL="Wall-infield",
NSEGMENT=1,      XEND=141113.9945 m,    YEND=-60.5340 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-273",       WALL="Wall-infield",
NSEGMENT=1,      XEND=141634.7104 m,    YEND=-61.0070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-274",       WALL="Wall-infield",
NSEGMENT=1,      XEND=142155.4262 m,    YEND=-61.6700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-275",       WALL="Wall-infield",
NSEGMENT=1,      XEND=142676.1421 m,    YEND=-61.5500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-276",       WALL="Wall-infield",
NSEGMENT=1,      XEND=143196.8579 m,    YEND=-61.4500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-277",       WALL="Wall-infield",
NSEGMENT=1,      XEND=143717.5738 m,    YEND=-60.8490 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-278",       WALL="Wall-infield",
NSEGMENT=1,      XEND=144238.2896 m,    YEND=-59.4600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-279",       WALL="Wall-infield",
NSEGMENT=1,      XEND=144759.0055 m,    YEND=-59.8450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-280",       WALL="Wall-infield",
NSEGMENT=1,      XEND=145279.7213 m,    YEND=-59.3110 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-281",       WALL="Wall-infield",
NSEGMENT=1,      XEND=145800.4372 m,    YEND=-60.0640 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-282",       WALL="Wall-infield",
NSEGMENT=1,      XEND=146321.1530 m,    YEND=-56.3870 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-283",       WALL="Wall-infield",
NSEGMENT=1,      XEND=146841.8689 m,    YEND=-55.7620 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-284",       WALL="Wall-infield",
NSEGMENT=1,      XEND=147362.5847 m,    YEND=-56.8280 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-285",       WALL="Wall-infield",
NSEGMENT=1,      XEND=147883.3005 m,    YEND=-56.7010 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-286",       WALL="Wall-infield",
NSEGMENT=1,      XEND=148404.0164 m,    YEND=-56.7260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-287",       WALL="Wall-infield",
NSEGMENT=1,      XEND=148924.7322 m,    YEND=-56.6260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-288",       WALL="Wall-infield",
NSEGMENT=1,      XEND=149445.4481 m,    YEND=-54.6560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-289",       WALL="Wall-infield",
NSEGMENT=1,      XEND=149966.1639 m,    YEND=-54.3250 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-290",       WALL="Wall-infield",
NSEGMENT=1,      XEND=150486.8798 m,    YEND=-55.1210 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-291",       WALL="Wall-infield",
NSEGMENT=1,      XEND=151007.5956 m,    YEND=-54.8430 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-292",       WALL="Wall-infield",
NSEGMENT=1,      XEND=151528.3115 m,    YEND=-56.1620 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-293",       WALL="Wall-infield",
NSEGMENT=1,      XEND=152049.0273 m,    YEND=-55.1500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-294",       WALL="Wall-infield",
NSEGMENT=1,      XEND=152569.7432 m,    YEND=-56.1860 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-295",       WALL="Wall-infield",
NSEGMENT=1,      XEND=153090.4590 m,    YEND=-54.0200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-296",       WALL="Wall-infield",
NSEGMENT=1,      XEND=153611.1749 m,    YEND=-54.8140 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-297",       WALL="Wall-infield",
NSEGMENT=1,      XEND=154131.8907 m,    YEND=-55.2450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-298",       WALL="Wall-infield",
NSEGMENT=1,      XEND=154652.6066 m,    YEND=-55.0720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-299",       WALL="Wall-infield",
NSEGMENT=1,      XEND=155173.3224 m,    YEND=-55.2300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-300",       WALL="Wall-infield",
NSEGMENT=1,      XEND=155694.0383 m,    YEND=-55.7840 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-301",       WALL="Wall-infield",
NSEGMENT=1,      XEND=156214.7541 m,    YEND=-56.2100 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-302",       WALL="Wall-infield",
NSEGMENT=1,      XEND=156735.4699 m,    YEND=-56.2000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-303",       WALL="Wall-infield",
NSEGMENT=1,      XEND=157256.1858 m,    YEND=-55.7900 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-304",       WALL="Wall-infield",
NSEGMENT=1,      XEND=157776.9016 m,    YEND=-55.2100 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-305",       WALL="Wall-infield",
NSEGMENT=1,      XEND=158297.6175 m,    YEND=-55.3870 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-306",       WALL="Wall-infield",
NSEGMENT=1,      XEND=158818.3333 m,    YEND=-55.1620 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-307",       WALL="Wall-infield",
NSEGMENT=1,      XEND=159339.0492 m,    YEND=-54.1800 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-308",       WALL="Wall-infield",
NSEGMENT=1,      XEND=159859.7650 m,    YEND=-54.0220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-309",       WALL="Wall-infield",
NSEGMENT=1,      XEND=160380.4809 m,    YEND=-54.2000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-310",       WALL="Wall-infield",
NSEGMENT=1,      XEND=160901.1967 m,    YEND=-53.1820 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-311",       WALL="Wall-infield",
NSEGMENT=1,      XEND=161421.9126 m,    YEND=-54.1320 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-312",       WALL="Wall-infield",
NSEGMENT=1,      XEND=161942.6284 m,    YEND=-53.2040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-313",       WALL="Wall-infield",
NSEGMENT=1,      XEND=162463.3443 m,    YEND=-52.7930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-314",       WALL="Wall-infield",
NSEGMENT=1,      XEND=162984.0601 m,    YEND=-52.5400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-315",       WALL="Wall-infield",
NSEGMENT=1,      XEND=163504.7760 m,    YEND=-54.0870 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-316",       WALL="Wall-infield",
NSEGMENT=1,      XEND=164025.4918 m,    YEND=-54.3600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-317",       WALL="Wall-infield",
NSEGMENT=1,      XEND=164546.2077 m,    YEND=-54.3610 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-318",       WALL="Wall-infield",
NSEGMENT=1,      XEND=165066.9235 m,    YEND=-54.1480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-319",       WALL="Wall-infield",
NSEGMENT=1,      XEND=165587.6393 m,    YEND=-52.6190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-320",       WALL="Wall-infield",
NSEGMENT=1,      XEND=166108.3552 m,    YEND=-52.0790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-321",       WALL="Wall-infield",
NSEGMENT=1,      XEND=166629.0710 m,    YEND=-52.6610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-322",       WALL="Wall-infield",
NSEGMENT=1,      XEND=167149.7869 m,    YEND=-52.3000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-323",       WALL="Wall-infield",
NSEGMENT=1,      XEND=167670.5027 m,    YEND=-52.1500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-324",       WALL="Wall-infield",
NSEGMENT=1,      XEND=168191.2186 m,    YEND=-51.9610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-325",       WALL="Wall-infield",
NSEGMENT=1,      XEND=168711.9344 m,    YEND=-49.9360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-326",       WALL="Wall-infield",
NSEGMENT=1,      XEND=169232.6503 m,    YEND=-50.2090 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-327",       WALL="Wall-infield",
NSEGMENT=1,      XEND=169753.3661 m,    YEND=-50.1630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-328",       WALL="Wall-infield",
NSEGMENT=1,      XEND=170274.0820 m,    YEND=-50.1480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-329",       WALL="Wall-infield",
NSEGMENT=1,      XEND=170794.7978 m,    YEND=-49.3660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-330",       WALL="Wall-infield",
NSEGMENT=1,      XEND=171315.5137 m,    YEND=-49.4720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-331",       WALL="Wall-infield",
NSEGMENT=1,      XEND=171836.2295 m,    YEND=-48.2750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-332",       WALL="Wall-infield",
NSEGMENT=1,      XEND=172356.9454 m,    YEND=-48.6140 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-333",       WALL="Wall-infield",
NSEGMENT=1,      XEND=172877.6612 m,    YEND=-48.1580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-334",       WALL="Wall-infield",
NSEGMENT=1,      XEND=173398.3770 m,    YEND=-47.7530 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-335",       WALL="Wall-infield",
NSEGMENT=1,      XEND=173919.0929 m,    YEND=-47.2530 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-336",       WALL="Wall-infield",
NSEGMENT=1,      XEND=174439.8087 m,    YEND=-47.3140 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-337",       WALL="Wall-infield",
NSEGMENT=1,      XEND=174960.5246 m,    YEND=-47.1200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-338",       WALL="Wall-infield",
NSEGMENT=1,      XEND=175481.2404 m,    YEND=-46.4370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-339",       WALL="Wall-infield",
NSEGMENT=1,      XEND=176001.9563 m,    YEND=-46.0990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-340",       WALL="Wall-infield",
NSEGMENT=1,      XEND=176522.6721 m,    YEND=-45.6500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-341",       WALL="Wall-infield",
NSEGMENT=1,      XEND=177043.3880 m,    YEND=-45.1670 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-342",       WALL="Wall-infield",
NSEGMENT=1,      XEND=177564.1038 m,    YEND=-45.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-343",       WALL="Wall-infield",
NSEGMENT=1,      XEND=178084.8197 m,    YEND=-44.8740 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-344",       WALL="Wall-infield",
NSEGMENT=1,      XEND=178605.5355 m,    YEND=-44.0700 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-345",       WALL="Wall-infield",
NSEGMENT=1,      XEND=179126.2514 m,    YEND=-43.2510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-346",       WALL="Wall-infield",
NSEGMENT=1,      XEND=179646.9672 m,    YEND=-43.0880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-347",       WALL="Wall-infield",
NSEGMENT=1,      XEND=180167.6831 m,    YEND=-42.2610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-348",       WALL="Wall-infield",
NSEGMENT=1,      XEND=180688.3989 m,    YEND=-42.1030 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-349",       WALL="Wall-infield",
NSEGMENT=1,      XEND=181209.1148 m,    YEND=-41.6960 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-350",       WALL="Wall-infield",
NSEGMENT=1,      XEND=181729.8306 m,    YEND=-41.0700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-351",       WALL="Wall-infield",
NSEGMENT=1,      XEND=182250.5464 m,    YEND=-41.0700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-352",       WALL="Wall-infield",
NSEGMENT=1,      XEND=182771.2623 m,    YEND=-40.5080 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-353",       WALL="Wall-infield",
NSEGMENT=1,      XEND=183291.9781 m,    YEND=-40.0700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-354",       WALL="Wall-infield",
NSEGMENT=1,      XEND=183812.6940 m,    YEND=-40.0500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-355",       WALL="Wall-infield",
NSEGMENT=1,      XEND=184333.4098 m,    YEND=-40.0500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-356",       WALL="Wall-infield",
NSEGMENT=1,      XEND=184854.1257 m,    YEND=-40.0600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-357",       WALL="Wall-infield",
NSEGMENT=1,      XEND=185374.8415 m,    YEND=-39.6360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-358",       WALL="Wall-infield",
NSEGMENT=1,      XEND=185895.5574 m,    YEND=-39.0820 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-359",       WALL="Wall-infield",
NSEGMENT=1,      XEND=186416.2732 m,    YEND=-39.0400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-360",       WALL="Wall-infield",
NSEGMENT=1,      XEND=186936.9891 m,    YEND=-39.0400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-361",       WALL="Wall-infield",
NSEGMENT=1,      XEND=187457.7049 m,    YEND=-39.0400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-362",       WALL="Wall-infield",
NSEGMENT=1,      XEND=187978.4208 m,    YEND=-39.0660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-363",       WALL="Wall-infield",
NSEGMENT=1,      XEND=188499.1366 m,    YEND=-39.6750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-364",       WALL="Wall-infield",
NSEGMENT=1,      XEND=189019.8525 m,    YEND=-39.9300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-365",       WALL="Wall-infield",
NSEGMENT=1,      XEND=189540.5683 m,    YEND=-40.0600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-366",       WALL="Wall-infield",
NSEGMENT=1,      XEND=190061.2842 m,    YEND=-39.7530 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-367",       WALL="Wall-infield",
NSEGMENT=1,      XEND=190582.0000 m,    YEND=-40.0110 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-368",       WALL="Wall-infield",
NSEGMENT=1,      XEND=191102.7158 m,    YEND=-39.6090 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-369",       WALL="Wall-infield",
NSEGMENT=1,      XEND=191623.4317 m,    YEND=-39.3380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-370",       WALL="Wall-infield",
NSEGMENT=1,      XEND=192144.1475 m,    YEND=-39.0750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-371",       WALL="Wall-infield",
NSEGMENT=1,      XEND=192664.8634 m,    YEND=-39.5180 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-372",       WALL="Wall-infield",
NSEGMENT=1,      XEND=193185.5792 m,    YEND=-39.1230 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-373",       WALL="Wall-infield",
NSEGMENT=1,      XEND=193706.2951 m,    YEND=-38.5200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-374",       WALL="Wall-infield",
NSEGMENT=1,      XEND=194227.0109 m,    YEND=-38.1520 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-375",       WALL="Wall-infield",
NSEGMENT=1,      XEND=194747.7268 m,    YEND=-37.3440 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-376",       WALL="Wall-infield",
NSEGMENT=1,      XEND=195268.4426 m,    YEND=-35.9290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-377",       WALL="Wall-infield",
NSEGMENT=1,      XEND=195789.1585 m,    YEND=-36.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-378",       WALL="Wall-infield",
NSEGMENT=1,      XEND=196309.8743 m,    YEND=-35.0830 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-379",       WALL="Wall-infield",
NSEGMENT=1,      XEND=196830.5902 m,    YEND=-35.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-380",       WALL="Wall-infield",
NSEGMENT=1,      XEND=197351.3060 m,    YEND=-35.5450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-381",       WALL="Wall-infield",
NSEGMENT=1,      XEND=197872.0219 m,    YEND=-36.1000 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-382",       WALL="Wall-infield",
NSEGMENT=1,      XEND=198392.7377 m,    YEND=-36.2200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-383",       WALL="Wall-infield",
NSEGMENT=1,      XEND=198913.4536 m,    YEND=-36.1200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-384",       WALL="Wall-infield",
NSEGMENT=1,      XEND=199434.1694 m,    YEND=-35.5050 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-385",       WALL="Wall-infield",
NSEGMENT=1,      XEND=199954.8852 m,    YEND=-34.6750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-386",       WALL="Wall-infield",
NSEGMENT=1,      XEND=200475.6011 m,    YEND=-33.7450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-387",       WALL="Wall-infield",
NSEGMENT=1,      XEND=200996.3169 m,    YEND=-32.9040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-388",       WALL="Wall-infield",
NSEGMENT=1,      XEND=201517.0328 m,    YEND=-33.0130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-389",       WALL="Wall-infield",
NSEGMENT=1,      XEND=202037.7486 m,    YEND=-31.5290 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-390",       WALL="Wall-infield",
NSEGMENT=1,      XEND=202558.4645 m,    YEND=-30.0220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-391",       WALL="Wall-infield",
NSEGMENT=1,      XEND=203079.1803 m,    YEND=-30.4130 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-392",       WALL="Wall-infield",
NSEGMENT=1,      XEND=203599.8962 m,    YEND=-31.2370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-393",       WALL="Wall-infield",
NSEGMENT=1,      XEND=204120.6120 m,    YEND=-31.5850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-394",       WALL="Wall-infield",
NSEGMENT=1,      XEND=204641.3279 m,    YEND=-31.3930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-395",       WALL="Wall-infield",
NSEGMENT=1,      XEND=205162.0437 m,    YEND=-31.4500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-396",       WALL="Wall-infield",
NSEGMENT=1,      XEND=205682.7596 m,    YEND=-31.2060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-397",       WALL="Wall-infield",
NSEGMENT=1,      XEND=206203.4754 m,    YEND=-31.5430 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-398",       WALL="Wall-infield",
NSEGMENT=1,      XEND=206724.1913 m,    YEND=-31.2030 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-399",       WALL="Wall-infield",
NSEGMENT=1,      XEND=207244.9071 m,    YEND=-30.3640 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-400",       WALL="Wall-infield",
NSEGMENT=1,      XEND=207765.6230 m,    YEND=-30.1790 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-401",       WALL="Wall-infield",
NSEGMENT=1,      XEND=208286.3388 m,    YEND=-29.6260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-402",       WALL="Wall-infield",
NSEGMENT=1,      XEND=208807.0546 m,    YEND=-29.2730 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-403",       WALL="Wall-infield",
NSEGMENT=1,      XEND=209327.7705 m,    YEND=-28.4590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-404",       WALL="Wall-infield",
NSEGMENT=1,      XEND=209848.4863 m,    YEND=-29.0220 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-405",       WALL="Wall-infield",
NSEGMENT=1,      XEND=210369.2022 m,    YEND=-29.2030 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-406",       WALL="Wall-infield",
NSEGMENT=1,      XEND=210889.9180 m,    YEND=-30.7930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-407",       WALL="Wall-infield",
NSEGMENT=1,      XEND=211410.6339 m,    YEND=-31.8160 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-408",       WALL="Wall-infield",
NSEGMENT=1,      XEND=211931.3497 m,    YEND=-33.8070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-409",       WALL="Wall-infield",
NSEGMENT=1,      XEND=212452.0656 m,    YEND=-35.5070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-410",       WALL="Wall-infield",
NSEGMENT=1,      XEND=212972.7814 m,    YEND=-38.1260 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-411",       WALL="Wall-infield",
NSEGMENT=1,      XEND=213493.4973 m,    YEND=-36.9760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-412",       WALL="Wall-infield",
NSEGMENT=1,      XEND=214014.2131 m,    YEND=-39.5430 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-413",       WALL="Wall-infield",
NSEGMENT=1,      XEND=214534.9290 m,    YEND=-38.4480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-414",       WALL="Wall-infield",
NSEGMENT=1,      XEND=215055.6448 m,    YEND=-54.2030 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-415",       WALL="Wall-infield",
NSEGMENT=1,      XEND=215576.3607 m,    YEND=-51.6360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-416",       WALL="Wall-infield",
NSEGMENT=1,      XEND=216097.0765 m,    YEND=-40.2930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-417",       WALL="Wall-infield",
NSEGMENT=1,      XEND=216617.7923 m,    YEND=-38.4310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-418",       WALL="Wall-infield",
NSEGMENT=1,      XEND=217138.5082 m,    YEND=-32.0340 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-419",       WALL="Wall-infield",
NSEGMENT=1,      XEND=217659.2240 m,    YEND=-29.8450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-420",       WALL="Wall-infield",
NSEGMENT=1,      XEND=218179.9399 m,    YEND=-29.0910 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-421",       WALL="Wall-infield",
NSEGMENT=1,      XEND=218700.6557 m,    YEND=-28.4070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-422",       WALL="Wall-infield",
NSEGMENT=1,      XEND=219221.3716 m,    YEND=-28.4760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-423",       WALL="Wall-infield",
NSEGMENT=1,      XEND=219742.0874 m,    YEND=-28.2560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-424",       WALL="Wall-infield",
NSEGMENT=1,      XEND=220262.8033 m,    YEND=-28.5440 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-425",       WALL="Wall-infield",
NSEGMENT=1,      XEND=220783.5191 m,    YEND=-28.8670 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-426",       WALL="Wall-infield",
NSEGMENT=1,      XEND=221304.2350 m,    YEND=-28.5630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-427",       WALL="Wall-infield",
NSEGMENT=1,      XEND=221824.9508 m,    YEND=-28.4910 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-428",       WALL="Wall-infield",
NSEGMENT=1,      XEND=222345.6667 m,    YEND=-28.3750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-429",       WALL="Wall-infield",
NSEGMENT=1,      XEND=222866.3825 m,    YEND=-27.7070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-430",       WALL="Wall-infield",
NSEGMENT=1,      XEND=223387.0984 m,    YEND=-27.8590 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-431",       WALL="Wall-infield",
NSEGMENT=1,      XEND=223907.8142 m,    YEND=-27.3680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-432",       WALL="Wall-infield",
NSEGMENT=1,      XEND=224428.5301 m,    YEND=-26.7670 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-433",       WALL="Wall-infield",
NSEGMENT=1,      XEND=224949.2459 m,    YEND=-26.5300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-434",       WALL="Wall-infield",
NSEGMENT=1,      XEND=225469.9617 m,    YEND=-26.1460 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-435",       WALL="Wall-infield",
NSEGMENT=1,      XEND=225990.6776 m,    YEND=-24.5190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-436",       WALL="Wall-infield",
NSEGMENT=1,      XEND=226511.3934 m,    YEND=-24.6200 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-437",       WALL="Wall-infield",
NSEGMENT=1,      XEND=227032.1093 m,    YEND=-24.3880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-438",       WALL="Wall-infield",
NSEGMENT=1,      XEND=227552.8251 m,    YEND=-24.3230 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-439",       WALL="Wall-infield",
NSEGMENT=1,      XEND=228073.5410 m,    YEND=-24.9240 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-440",       WALL="Wall-infield",
NSEGMENT=1,      XEND=228594.2568 m,    YEND=-24.6190 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-441",       WALL="Wall-infield",
NSEGMENT=1,      XEND=229114.9727 m,    YEND=-23.7350 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-442",       WALL="Wall-infield",
NSEGMENT=1,      XEND=229635.6885 m,    YEND=-23.2680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-443",       WALL="Wall-infield",
NSEGMENT=1,      XEND=230156.4044 m,    YEND=-22.5470 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-444",       WALL="Wall-infield",
NSEGMENT=1,      XEND=230677.1202 m,    YEND=-23.2580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-445",       WALL="Wall-infield",
NSEGMENT=1,      XEND=231197.8361 m,    YEND=-22.7360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-446",       WALL="Wall-infield",
NSEGMENT=1,      XEND=231718.5519 m,    YEND=-22.8960 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-447",       WALL="Wall-infield",
NSEGMENT=1,      XEND=232239.2678 m,    YEND=-23.2070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-448",       WALL="Wall-infield",
NSEGMENT=1,      XEND=232759.9836 m,    YEND=-23.3850 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-449",       WALL="Wall-infield",
NSEGMENT=1,      XEND=233280.6995 m,    YEND=-24.3810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-450",       WALL="Wall-infield",
NSEGMENT=1,      XEND=233801.4153 m,    YEND=-24.7160 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-451",       WALL="Wall-infield",
NSEGMENT=1,      XEND=234322.1311 m,    YEND=-23.9950 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-452",       WALL="Wall-infield",
NSEGMENT=1,      XEND=234842.8470 m,    YEND=-23.5480 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-453",       WALL="Wall-infield",
NSEGMENT=1,      XEND=235363.5628 m,    YEND=-22.8560 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-454",       WALL="Wall-infield",
NSEGMENT=1,      XEND=235884.2787 m,    YEND=-21.7050 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-455",       WALL="Wall-infield",
NSEGMENT=1,      XEND=236404.9945 m,    YEND=-20.3060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-456",       WALL="Wall-infield",
NSEGMENT=1,      XEND=236925.7104 m,    YEND=-20.2680 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-457",       WALL="Wall-infield",
NSEGMENT=1,      XEND=237446.4262 m,    YEND=-20.8400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-458",       WALL="Wall-infield",
NSEGMENT=1,      XEND=237967.1421 m,    YEND=-19.1840 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-459",       WALL="Wall-infield",
NSEGMENT=1,      XEND=238487.8579 m,    YEND=-18.7580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-460",       WALL="Wall-infield",
NSEGMENT=1,      XEND=239008.5738 m,    YEND=-20.4450 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-461",       WALL="Wall-infield",
NSEGMENT=1,      XEND=239529.2896 m,    YEND=-22.1120 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-462",       WALL="Wall-infield",
NSEGMENT=1,      XEND=240050.0055 m,    YEND=-21.8580 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-463",       WALL="Wall-infield",
NSEGMENT=1,      XEND=240570.7213 m,    YEND=-21.7380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-464",       WALL="Wall-infield",
NSEGMENT=1,      XEND=241091.4372 m,    YEND=-20.8810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-465",       WALL="Wall-infield",
NSEGMENT=1,      XEND=241612.1530 m,    YEND=-21.6700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-466",       WALL="Wall-infield",
NSEGMENT=1,      XEND=242132.8689 m,    YEND=-21.2360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-467",       WALL="Wall-infield",
NSEGMENT=1,      XEND=242653.5847 m,    YEND=-15.3160 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-468",       WALL="Wall-infield",
NSEGMENT=1,      XEND=243174.3005 m,    YEND=-14.1550 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-469",       WALL="Wall-infield",
NSEGMENT=1,      XEND=243695.0164 m,    YEND=-15.5720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-470",       WALL="Wall-infield",
NSEGMENT=1,      XEND=244215.7322 m,    YEND=-16.8760 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-471",       WALL="Wall-infield",
NSEGMENT=1,      XEND=244736.4481 m,    YEND=-19.2520 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-472",       WALL="Wall-infield",
NSEGMENT=1,      XEND=245257.1639 m,    YEND=-21.2300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-473",       WALL="Wall-infield",
NSEGMENT=1,      XEND=245777.8798 m,    YEND=-22.3480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-474",       WALL="Wall-infield",
NSEGMENT=1,      XEND=246298.5956 m,    YEND=-23.5630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-475",       WALL="Wall-infield",
NSEGMENT=1,      XEND=246819.3115 m,    YEND=-23.9140 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-476",       WALL="Wall-infield",
NSEGMENT=1,      XEND=247340.0273 m,    YEND=-23.7570 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-477",       WALL="Wall-infield",
NSEGMENT=1,      XEND=247860.7432 m,    YEND=-23.4870 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-478",       WALL="Wall-infield",
NSEGMENT=1,      XEND=248381.4590 m,    YEND=-23.3070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-479",       WALL="Wall-infield",
NSEGMENT=1,      XEND=248902.1749 m,    YEND=-23.1320 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-480",       WALL="Wall-infield",
NSEGMENT=1,      XEND=249422.8907 m,    YEND=-23.5520 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-481",       WALL="Wall-infield",
NSEGMENT=1,      XEND=249943.6066 m,    YEND=-22.0330 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-482",       WALL="Wall-infield",
NSEGMENT=1,      XEND=250464.3224 m,    YEND=-21.5500 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-483",       WALL="Wall-infield",
NSEGMENT=1,      XEND=250985.0383 m,    YEND=-20.1780 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-484",       WALL="Wall-infield",
NSEGMENT=1,      XEND=251505.7541 m,    YEND=-22.0100 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-485",       WALL="Wall-infield",
NSEGMENT=1,      XEND=252026.4699 m,    YEND=-18.7720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-486",       WALL="Wall-infield",
NSEGMENT=1,      XEND=252547.1858 m,    YEND=-18.1080 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-487",       WALL="Wall-infield",
NSEGMENT=1,      XEND=253067.9016 m,    YEND=-17.9710 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-488",       WALL="Wall-infield",
NSEGMENT=1,      XEND=253588.6175 m,    YEND=-16.7010 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-489",       WALL="Wall-infield",
NSEGMENT=1,      XEND=254109.3333 m,    YEND=-16.5310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-490",       WALL="Wall-infield",
NSEGMENT=1,      XEND=254630.0492 m,    YEND=-17.4430 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-491",       WALL="Wall-infield",
NSEGMENT=1,      XEND=255150.7650 m,    YEND=-19.4420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-492",       WALL="Wall-infield",
NSEGMENT=1,      XEND=255671.4809 m,    YEND=-21.5970 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-493",       WALL="Wall-infield",
NSEGMENT=1,      XEND=256192.1967 m,    YEND=-22.8990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-494",       WALL="Wall-infield",
NSEGMENT=1,      XEND=256712.9126 m,    YEND=-24.3070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-495",       WALL="Wall-infield",
NSEGMENT=1,      XEND=257233.6284 m,    YEND=-25.9820 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-496",       WALL="Wall-infield",
NSEGMENT=1,      XEND=257754.3443 m,    YEND=-29.5400 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-497",       WALL="Wall-infield",
NSEGMENT=1,      XEND=258275.0601 m,    YEND=-31.1460 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-498",       WALL="Wall-infield",
NSEGMENT=1,      XEND=258795.7760 m,    YEND=-30.3780 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-499",       WALL="Wall-infield",
NSEGMENT=1,      XEND=259316.4918 m,    YEND=-25.6660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-500",       WALL="Wall-infield",
NSEGMENT=1,      XEND=259837.2077 m,    YEND=-21.9720 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-501",       WALL="Wall-infield",
NSEGMENT=1,      XEND=260357.9235 m,    YEND=-17.7300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-502",       WALL="Wall-infield",
NSEGMENT=1,      XEND=260878.6393 m,    YEND=-18.4990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-503",       WALL="Wall-infield",
NSEGMENT=1,      XEND=261399.3552 m,    YEND=-20.9070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-504",       WALL="Wall-infield",
NSEGMENT=1,      XEND=261920.0710 m,    YEND=-22.1170 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-505",       WALL="Wall-infield",
NSEGMENT=1,      XEND=262440.7869 m,    YEND=-23.6160 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-506",       WALL="Wall-infield",
NSEGMENT=1,      XEND=262961.5027 m,    YEND=-24.1470 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-507",       WALL="Wall-infield",
NSEGMENT=1,      XEND=263482.2186 m,    YEND=-24.9730 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-508",       WALL="Wall-infield",
NSEGMENT=1,      XEND=264002.9344 m,    YEND=-25.2610 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-509",       WALL="Wall-infield",
NSEGMENT=1,      XEND=264523.6503 m,    YEND=-25.7640 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-510",       WALL="Wall-infield",
NSEGMENT=1,      XEND=265044.3661 m,    YEND=-26.6070 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-511",       WALL="Wall-infield",
NSEGMENT=1,      XEND=265565.0820 m,    YEND=-26.7710 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-512",       WALL="Wall-infield",
NSEGMENT=1,      XEND=266085.7978 m,    YEND=-26.5020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-513",       WALL="Wall-infield",
NSEGMENT=1,      XEND=266606.5137 m,    YEND=-27.3600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-514",       WALL="Wall-infield",
NSEGMENT=1,      XEND=267127.2295 m,    YEND=-28.2330 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-515",       WALL="Wall-infield",
NSEGMENT=1,      XEND=267647.9454 m,    YEND=-28.7060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-516",       WALL="Wall-infield",
NSEGMENT=1,      XEND=268168.6612 m,    YEND=-29.1270 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-517",       WALL="Wall-infield",
NSEGMENT=1,      XEND=268689.3770 m,    YEND=-28.4750 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-518",       WALL="Wall-infield",
NSEGMENT=1,      XEND=269210.0929 m,    YEND=-28.8990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-519",       WALL="Wall-infield",
NSEGMENT=1,      XEND=269730.8087 m,    YEND=-29.3310 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-520",       WALL="Wall-infield",
NSEGMENT=1,      XEND=270251.5246 m,    YEND=-28.6380 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-521",       WALL="Wall-infield",
NSEGMENT=1,      XEND=270772.2404 m,    YEND=-26.6510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-522",       WALL="Wall-infield",
NSEGMENT=1,      XEND=271292.9563 m,    YEND=-25.0470 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-523",       WALL="Wall-infield",
NSEGMENT=1,      XEND=271813.6721 m,    YEND=-25.2930 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-524",       WALL="Wall-infield",
NSEGMENT=1,      XEND=272334.3880 m,    YEND=-25.6620 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-525",       WALL="Wall-infield",
NSEGMENT=1,      XEND=272855.1038 m,    YEND=-25.8810 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-526",       WALL="Wall-infield",
NSEGMENT=1,      XEND=273375.8197 m,    YEND=-26.9510 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-527",       WALL="Wall-infield",
NSEGMENT=1,      XEND=273896.5355 m,    YEND=-27.0660 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-528",       WALL="Wall-infield",
NSEGMENT=1,      XEND=274417.2514 m,    YEND=-26.7060 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-529",       WALL="Wall-infield",
NSEGMENT=1,      XEND=274937.9672 m,    YEND=-26.4360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-530",       WALL="Wall-infield",
NSEGMENT=1,      XEND=275458.6831 m,    YEND=-26.2550 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-531",       WALL="Wall-infield",
NSEGMENT=1,      XEND=275979.3989 m,    YEND=-27.0040 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-532",       WALL="Wall-infield",
NSEGMENT=1,      XEND=276500.1148 m,    YEND=-27.7770 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-533",       WALL="Wall-infield",
NSEGMENT=1,      XEND=277020.8306 m,    YEND=-27.0280 m,        DIAMETER=0.711 m
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 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-534",       WALL="Wall-infield",
NSEGMENT=1,      XEND=277541.5464 m,    YEND=-27.7420 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-535",       WALL="Wall-infield",
NSEGMENT=1,      XEND=278062.2623 m,    YEND=-27.4650 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-536",       WALL="Wall-infield",
NSEGMENT=1,      XEND=278582.9781 m,    YEND=-27.1700 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-537",       WALL="Wall-infield",
NSEGMENT=1,      XEND=279103.6940 m,    YEND=-27.3480 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-538",       WALL="Wall-infield",
NSEGMENT=1,      XEND=279624.4098 m,    YEND=-28.0600 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-539",       WALL="Wall-infield",
NSEGMENT=1,      XEND=280145.1257 m,    YEND=-31.1020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-540",       WALL="Wall-infield",
NSEGMENT=1,      XEND=280665.8415 m,    YEND=-30.0880 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-541",       WALL="Wall-infield",
NSEGMENT=1,      XEND=281186.5574 m,    YEND=-28.2370 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-542",       WALL="Wall-infield",
NSEGMENT=1,      XEND=281707.2732 m,    YEND=-29.4360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-543",       WALL="Wall-infield",
NSEGMENT=1,      XEND=282227.9891 m,    YEND=-31.8320 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-544",       WALL="Wall-infield",
NSEGMENT=1,      XEND=282748.7049 m,    YEND=-31.9360 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-545",       WALL="Wall-infield",
NSEGMENT=1,      XEND=283269.4208 m,    YEND=-33.3630 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-546",       WALL="Wall-infield",
NSEGMENT=1,      XEND=283790.1366 m,    YEND=-35.1800 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-547",       WALL="Wall-infield",
NSEGMENT=1,      XEND=284310.8525 m,    YEND=-33.6020 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-548",       WALL="Wall-infield",
NSEGMENT=1,      XEND=284831.5683 m,    YEND=-34.4300 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-549",       WALL="Wall-infield",
NSEGMENT=1,      XEND=285352.2842 m,    YEND=-31.9990 m,        DIAMETER=0.711 m
 PIPE ROUGHNESS=0.0001 m,       LABEL="Pipe-550",       WALL="Wall-infield",
NSEGMENT=1,      XEND=285873.0000 m,    YEND=17.4900 m, DIAMETER=0.711 m
ENDNETWORKCOMPONENT


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! Network Component
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NETWORKCOMPONENT TYPE=FLOWPATH, TAG="HEWETT_WELLS_LB"
  PARAMETERS LABEL=HEWETT_WELLS_LB
  BRANCH FLUID=Fluid1
  GEOMETRY LABEL=WELL2, XSTART=-40 ft, YSTART=17.49 m
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-AIR", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=100.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-000", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=000.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-001", WALL="SEC_30-wt",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-40.0000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-002", WALL="SEC_30-in",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-80.0000 ft, DIAMETER=219.0 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-003", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-120.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-004", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-160.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-005", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-200.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-006", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-240.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-007", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-280.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-008", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-320.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-009", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-360.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-010", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-400.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-011", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-440.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-012", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-480.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-013", WALL="SEC_13-3/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-520.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-014", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-560.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-015", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-600.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-016", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.00000 ft,  YEND=-640.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-017", WALL="SEC_9-5/8",
NSEGMENT=1, XEND=0.102672 ft,  YEND=-680.000 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-018", WALL="SEC_7-in",
NSEGMENT=1, XEND=0.646604 ft,  YEND=-719.996 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-019", WALL="SEC_7-in",
NSEGMENT=1, XEND=1.26007 ft,  YEND=-759.991 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-020", WALL="SEC_7-in",
NSEGMENT=1, XEND=2.14582 ft,  YEND=-799.982 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-021", WALL="SEC_7-in",
NSEGMENT=1, XEND=3.43897 ft,  YEND=-839.961 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-022", WALL="SEC_7-in",
NSEGMENT=1, XEND=4.73212 ft,  YEND=-879.94 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-023", WALL="SEC_7-in",
NSEGMENT=1, XEND=6.63223 ft,  YEND=-919.895 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-024", WALL="SEC_7-in",
NSEGMENT=1, XEND=8.61737 ft,  YEND=-959.845 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-025", WALL="SEC_7-in",
NSEGMENT=1, XEND=10.9013 ft,  YEND=-999.78 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-026", WALL="SEC_7-in",
NSEGMENT=1, XEND=13.5807 ft,  YEND=-1039.69 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-027", WALL="SEC_7-in",
NSEGMENT=1, XEND=16.2601 ft,  YEND=-1079.6 ft, DIAMETER=219.0 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-028", WALL="SEC_7-in",
NSEGMENT=1, XEND=19.5921 ft,  YEND=-1119.46 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-029", WALL="SEC_7-in",
NSEGMENT=1, XEND=22.9661 ft,  YEND=-1159.32 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-030", WALL="SEC_7-in",
NSEGMENT=1, XEND=26.6843 ft,  YEND=-1199.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-031", WALL="SEC_7-in",
NSEGMENT=1, XEND=30.7523 ft,  YEND=-1238.94 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-032", WALL="SEC_7-in",
NSEGMENT=1, XEND=34.8292 ft,  YEND=-1278.73 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-033", WALL="SEC_7-in",
NSEGMENT=1, XEND=39.5904 ft,  YEND=-1318.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-034", WALL="SEC_7-in",
NSEGMENT=1, XEND=44.3515 ft,  YEND=-1358.16 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-035", WALL="SEC_7-in",
NSEGMENT=1, XEND=49.5057 ft,  YEND=-1397.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-036", WALL="SEC_7-in",
NSEGMENT=1, XEND=54.9588 ft,  YEND=-1437.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-037", WALL="SEC_7-in",
NSEGMENT=1, XEND=60.4779 ft,  YEND=-1477.07 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-038", WALL="SEC_7-in",
NSEGMENT=1, XEND=66.6213 ft,  YEND=-1516.6 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-039", WALL="SEC_7-in",
NSEGMENT=1, XEND=72.7647 ft,  YEND=-1556.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-040", WALL="SEC_7-in",
NSEGMENT=1, XEND=79.3504 ft,  YEND=-1595.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-041", WALL="SEC_7-in",
NSEGMENT=1, XEND=86.1823 ft,  YEND=-1634.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-042", WALL="SEC_7-in",
NSEGMENT=1, XEND=93.1082 ft,  YEND=-1674.38 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-043", WALL="SEC_7-in",
NSEGMENT=1, XEND=100.477 ft,  YEND=-1713.7 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-044", WALL="SEC_7-in",
NSEGMENT=1, XEND=107.998 ft,  YEND=-1752.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-045", WALL="SEC_7-in",
NSEGMENT=1, XEND=115.562 ft,  YEND=-1792.27 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-046", WALL="SEC_7-in",
NSEGMENT=1, XEND=123.429 ft,  YEND=-1831.48 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-047", WALL="SEC_7-in",
NSEGMENT=1, XEND=131.694 ft,  YEND=-1870.62 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-048", WALL="SEC_7-in",
NSEGMENT=1, XEND=140.768 ft,  YEND=-1909.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-049", WALL="SEC_7-in",
NSEGMENT=1, XEND=149.843 ft,  YEND=-1948.53 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-050", WALL="SEC_7-in",
NSEGMENT=1, XEND=159.999 ft,  YEND=-1987.22 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-051", WALL="SEC_7-in",
NSEGMENT=1, XEND=170.426 ft,  YEND=-2025.84 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-052", WALL="SEC_7-in",
NSEGMENT=1, XEND=181.311 ft,  YEND=-2064.33 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-053", WALL="SEC_7-in",
NSEGMENT=1, XEND=193.079 ft,  YEND=-2102.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-054", WALL="SEC_7-in",
NSEGMENT=1, XEND=204.847 ft,  YEND=-2140.79 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-055", WALL="SEC_7-in",
NSEGMENT=1, XEND=217.773 ft,  YEND=-2178.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-056", WALL="SEC_7-in",
NSEGMENT=1, XEND=230.867 ft,  YEND=-2216.44 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-057", WALL="SEC_7-in",
NSEGMENT=1, XEND=244.510 ft,  YEND=-2254.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-058", WALL="SEC_7-in",
NSEGMENT=1, XEND=258.915 ft,  YEND=-2291.36 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-059", WALL="SEC_7-in",
NSEGMENT=1, XEND=273.319 ft,  YEND=-2328.68 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-060", WALL="SEC_7-in",
NSEGMENT=1, XEND=288.949 ft,  YEND=-2365.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-061", WALL="SEC_7-in",
NSEGMENT=1, XEND=304.647 ft,  YEND=-2402.29 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-062", WALL="SEC_7-in",
NSEGMENT=1, XEND=320.977 ft,  YEND=-2438.8 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-063", WALL="SEC_7-in",
NSEGMENT=1, XEND=337.949 ft,  YEND=-2475.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-064", WALL="SEC_7-in",
NSEGMENT=1, XEND=354.952 ft,  YEND=-2511.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-065", WALL="SEC_7-in",
NSEGMENT=1, XEND=373.177 ft,  YEND=-2546.84 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-066", WALL="SEC_7-in",
NSEGMENT=1, XEND=391.402 ft,  YEND=-2582.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-067", WALL="SEC_7-in",
NSEGMENT=1, XEND=410.333 ft,  YEND=-2617.68 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-068", WALL="SEC_7-in",
NSEGMENT=1, XEND=429.790 ft,  YEND=-2652.63 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-069", WALL="SEC_7-in",
NSEGMENT=1, XEND=449.375 ft,  YEND=-2687.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-070", WALL="SEC_7-in",
NSEGMENT=1, XEND=470.039 ft,  YEND=-2721.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-071", WALL="SEC_7-in",
NSEGMENT=1, XEND=490.703 ft,  YEND=-2756.00 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-072", WALL="SEC_7-in",
NSEGMENT=1, XEND=512.137 ft,  YEND=-2789.78 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-073", WALL="SEC_7-in",
NSEGMENT=1, XEND=533.983 ft,  YEND=-2823.28 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-074", WALL="SEC_7-in",
NSEGMENT=1, XEND=556.046 ft,  YEND=-2856.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-075", WALL="SEC_7-in",
NSEGMENT=1, XEND=579.049 ft,  YEND=-2889.37 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-076", WALL="SEC_7-in",
NSEGMENT=1, XEND=602.051 ft,  YEND=-2922.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-077", WALL="SEC_7-in",
NSEGMENT=1, XEND=625.582 ft,  YEND=-2954.44 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-078", WALL="SEC_7-in",
NSEGMENT=1, XEND=649.453 ft,  YEND=-2986.54 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-079", WALL="SEC_7-in",
NSEGMENT=1, XEND=673.325 ft,  YEND=-3018.64 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-080", WALL="SEC_7-in",
NSEGMENT=1, XEND=697.196 ft,  YEND=-3050.73 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-081", WALL="SEC_7-in",
NSEGMENT=1, XEND=721.068 ft,  YEND=-3082.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-082", WALL="SEC_7-in",
NSEGMENT=1, XEND=744.939 ft,  YEND=-3114.92 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-083", WALL="SEC_7-in",
NSEGMENT=1, XEND=768.810 ft,  YEND=-3147.02 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-084", WALL="SEC_7-in",
NSEGMENT=1, XEND=792.682 ft,  YEND=-3179.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-085", WALL="SEC_7-in",
NSEGMENT=1, XEND=816.553 ft,  YEND=-3211.21 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-086", WALL="SEC_7-in",
NSEGMENT=1, XEND=840.425 ft,  YEND=-3243.31 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-087", WALL="SEC_7-in",
NSEGMENT=1, XEND=864.296 ft,  YEND=-3275.4 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-088", WALL="SEC_7-in",
NSEGMENT=1, XEND=888.167 ft,  YEND=-3307.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-089", WALL="SEC_7-in",
NSEGMENT=1, XEND=912.039 ft,  YEND=-3339.6 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-090", WALL="SEC_7-in",
NSEGMENT=1, XEND=936.566 ft,  YEND=-3371.19 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-091", WALL="SEC_7-in",
NSEGMENT=1, XEND=961.269 ft,  YEND=-3402.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-092", WALL="SEC_7-in",
NSEGMENT=1, XEND=987.767 ft,  YEND=-3432.62 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-093", WALL="SEC_7-in",
NSEGMENT=1, XEND=1014.34 ft,  YEND=-3462.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-094", WALL="SEC_7-in",
NSEGMENT=1, XEND=1041.95 ft,  YEND=-3491.46 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-095", WALL="SEC_7-in",
NSEGMENT=1, XEND=1070.55 ft,  YEND=-3519.43 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-096", WALL="SEC_7-in",
NSEGMENT=1, XEND=1099.21 ft,  YEND=-3547.32 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-097", WALL="SEC_7-in",
NSEGMENT=1, XEND=1129.69 ft,  YEND=-3573.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-098", WALL="SEC_7-in",
NSEGMENT=1, XEND=1160.16 ft,  YEND=-3599.14 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-099", WALL="SEC_7-in",
NSEGMENT=1, XEND=1191.66 ft,  YEND=-3623.79 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-100", WALL="SEC_7-in",
NSEGMENT=1, XEND=1223.87 ft,  YEND=-3647.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-101", WALL="SEC_7-in",
NSEGMENT=1, XEND=1256.27 ft,  YEND=-3670.97 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-102", WALL="SEC_7-in",
NSEGMENT=1, XEND=1290.05 ft,  YEND=-3692.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-103", WALL="SEC_7-in",
NSEGMENT=1, XEND=1323.84 ft,  YEND=-3713.81 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-104", WALL="SEC_7-in",
NSEGMENT=1, XEND=1358.57 ft,  YEND=-3733.65 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-105", WALL="SEC_7-in",
NSEGMENT=1, XEND=1393.76 ft,  YEND=-3752.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-106", WALL="SEC_7-in",
NSEGMENT=1, XEND=1429.21 ft,  YEND=-3771.18 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-107", WALL="SEC_7-in",
NSEGMENT=1, XEND=1465.65 ft,  YEND=-3787.69 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-108", WALL="SEC_7-in",
NSEGMENT=1, XEND=1502.08 ft,  YEND=-3804.2 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-109", WALL="SEC_7-in",
NSEGMENT=1, XEND=1539.32 ft,  YEND=-3818.82 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-110", WALL="SEC_7-in",
NSEGMENT=1, XEND=1576.81 ft,  YEND=-3832.75 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-111", WALL="SEC_7-in",
NSEGMENT=1, XEND=1614.57 ft,  YEND=-3845.95 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-112", WALL="SEC_7-in",
NSEGMENT=1, XEND=1652.95 ft,  YEND=-3857.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-113", WALL="SEC_7-in",
NSEGMENT=1, XEND=1691.33 ft,  YEND=-3868.51 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-114", WALL="SEC_7-in",
NSEGMENT=1, XEND=1730.30 ft,  YEND=-3877.49 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-115", WALL="SEC_7-in",
NSEGMENT=1, XEND=1769.40 ft,  YEND=-3885.93 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-116", WALL="SEC_7-in",
NSEGMENT=1, XEND=1808.54 ft,  YEND=-3894.21 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-117", WALL="SEC_7-in",
NSEGMENT=1, XEND=1847.93 ft,  YEND=-3901.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-118", WALL="SEC_7-in",
NSEGMENT=1, XEND=1887.32 ft,  YEND=-3908.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-119", WALL="SEC_7-in",
NSEGMENT=1, XEND=1926.71 ft,  YEND=-3915.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-120", WALL="SEC_7-in",
NSEGMENT=1, XEND=1966.11 ft,  YEND=-3921.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-121", WALL="SEC_7-in",
NSEGMENT=1, XEND=2005.50 ft,  YEND=-3928.94 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-122", WALL="SEC_7-in",
NSEGMENT=1, XEND=2044.89 ft,  YEND=-3935.88 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-123", WALL="SEC_7-in",
NSEGMENT=1, XEND=2084.28 ft,  YEND=-3942.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-124", WALL="SEC_7-in",
NSEGMENT=1, XEND=2123.68 ft,  YEND=-3949.77 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-125", WALL="SEC_7-in",
NSEGMENT=1, XEND=2163.07 ft,  YEND=-3956.72 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-126", WALL="SEC_7-in",
NSEGMENT=1, XEND=2202.46 ft,  YEND=-3963.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-127", WALL="SEC_7-in",
NSEGMENT=1, XEND=2241.85 ft,  YEND=-3970.61 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-128", WALL="SEC_7-in",
NSEGMENT=1, XEND=2281.25 ft,  YEND=-3977.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-129", WALL="SEC_7-in",
NSEGMENT=1, XEND=2320.64 ft,  YEND=-3984.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-130", WALL="SEC_7-in",
NSEGMENT=1, XEND=2360.03 ft,  YEND=-3991.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-131", WALL="SEC_7-in",
NSEGMENT=1, XEND=2399.42 ft,  YEND=-3998.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-132", WALL="SEC_7-in",
NSEGMENT=1, XEND=2438.81 ft,  YEND=-4005.34 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-133", WALL="SEC_7-in",
NSEGMENT=1, XEND=2478.21 ft,  YEND=-4012.29 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-134", WALL="SEC_7-in",
NSEGMENT=1, XEND=2517.60 ft,  YEND=-4019.23 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-135", WALL="SEC_7-in",
NSEGMENT=1, XEND=2556.99 ft,  YEND=-4026.18 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-136", WALL="SEC_7-in",
NSEGMENT=1, XEND=2596.38 ft,  YEND=-4033.12 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-137", WALL="SEC_7-in",
NSEGMENT=1, XEND=2635.78 ft,  YEND=-4040.07 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-138", WALL="SEC_7-in",
NSEGMENT=1, XEND=2675.17 ft,  YEND=-4047.02 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-139", WALL="SEC_7-in",
NSEGMENT=1, XEND=2714.56 ft,  YEND=-4053.96 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-140", WALL="SEC_7-in",
NSEGMENT=1, XEND=2753.95 ft,  YEND=-4060.91 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-141", WALL="SEC_7-in",
NSEGMENT=1, XEND=2793.35 ft,  YEND=-4067.85 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-142", WALL="SEC_7-in",
NSEGMENT=1, XEND=2832.74 ft,  YEND=-4074.8 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-143", WALL="SEC_7-in",
NSEGMENT=1, XEND=2872.13 ft,  YEND=-4081.75 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-144", WALL="SEC_7-in",
NSEGMENT=1, XEND=2911.52 ft,  YEND=-4088.69 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-145", WALL="SEC_7-in",
NSEGMENT=1, XEND=2950.91 ft,  YEND=-4095.64 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-146", WALL="SEC_7-in",
NSEGMENT=1, XEND=2990.31 ft,  YEND=-4102.58 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-147", WALL="SEC_7-in",
NSEGMENT=1, XEND=3029.70 ft,  YEND=-4109.53 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-148", WALL="SEC_7-in",
NSEGMENT=1, XEND=3069.09 ft,  YEND=-4116.48 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-149", WALL="SEC_7-in",
NSEGMENT=1, XEND=3108.48 ft,  YEND=-4123.42 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-150", WALL="SEC_7-in",
NSEGMENT=1, XEND=3147.88 ft,  YEND=-4130.37 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-151", WALL="SEC_7-in",
NSEGMENT=1, XEND=3187.27 ft,  YEND=-4137.31 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-152", WALL="SEC_7-in",
NSEGMENT=1, XEND=3226.66 ft,  YEND=-4144.26 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-153", WALL="SEC_7-in",
NSEGMENT=1, XEND=3266.05 ft,  YEND=-4151.2 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-154", WALL="SEC_7-in",
NSEGMENT=1, XEND=3305.45 ft,  YEND=-4158.15 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-155", WALL="SEC_7-in",
NSEGMENT=1, XEND=3344.84 ft,  YEND=-4165.1 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-156", WALL="SEC_7-in",
NSEGMENT=1, XEND=3384.23 ft,  YEND=-4172.04 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-157", WALL="SEC_7-in",
NSEGMENT=1, XEND=3423.62 ft,  YEND=-4178.99 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-158", WALL="SEC_7-in",
NSEGMENT=1, XEND=3463.01 ft,  YEND=-4185.93 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-159", WALL="SEC_7-in",
NSEGMENT=1, XEND=3502.41 ft,  YEND=-4192.88 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-160", WALL="SEC_7-in",
NSEGMENT=1, XEND=3541.80 ft,  YEND=-4199.83 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-161", WALL="SEC_7-in",
NSEGMENT=1, XEND=3581.19 ft,  YEND=-4206.77 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-162", WALL="SEC_7-in",
NSEGMENT=1, XEND=3620.58 ft,  YEND=-4213.72 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-163", WALL="SEC_7-in",
NSEGMENT=1, XEND=3659.98 ft,  YEND=-4220.66 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-164", WALL="SEC_7-in",
NSEGMENT=1, XEND=3699.37 ft,  YEND=-4227.61 ft, DIAMETER=157.1 mm
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  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-165", WALL="SEC_7-in",
NSEGMENT=1, XEND=3738.76 ft,  YEND=-4234.56 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-166", WALL="SEC_7-in",
NSEGMENT=1, XEND=3778.15 ft,  YEND=-4241.5 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-167", WALL="SEC_7-in",
NSEGMENT=1, XEND=3817.55 ft,  YEND=-4248.45 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-168", WALL="SEC_7-in",
NSEGMENT=1, XEND=3856.94 ft,  YEND=-4255.39 ft, DIAMETER=157.1 mm
  PIPE NEQUIPIPE=4, ROUGHNESS=0.015 mm, LABEL="PIPE-169", WALL="SEC_7-in",
NSEGMENT=1, XEND=3896.33 ft,  YEND=-4262.34 ft, DIAMETER=157.1 mm
  HEATTRANSFER LABEL=HT_well_2_00, PIPE="PIPE-AIR", HOUTEROPTION=AIR,
TAMBIENT=5.00 C,  VELOCITY=1.0 m/s
  HEATTRANSFER LABEL=HT_well_2_01, PIPE="PIPE-000", HOUTEROPTION=WATER,
TAMBIENT=7.00 C,  VELOCITY=1.0 m/s
  HEATTRANSFER LABEL=HT_well_2_02, PIPE="3-171", INTAMBIENT=7.00 C,
OUTTAMBIENT=52 C,  HAMBIENT=1000000 W/m2-C
  TRENDDATA VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h, HOL, PT bara, QG, QGST
MMscf/d,  QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3, ROL kg/m3),
PIPE="PIPE-000",  SECTION=1
  TRENDDATA VARIABLE=(EVR, GG kg/h, GLT kg/h, GT kg/h, HOL, PT bara, QG, QGST
MMscf/d,  QLST MMscf/d, QLT, QT, TM, UG, UL, ROG kg/m3, ROL kg/m3),
PIPE="PIPE-169",  SECTION=1
  INITIALCONDITIONS INTEMPERATURE=10 C, OUTTEMPERATURE=30 C, INPRESSURE=15.4
bara,  OUTPRESSURE=9 bara, VOIDFRACTION=1 -
  VALVE LABEL=WELL_MASTER_2, TIME=0 s, PIPE="PIPE-001", SECTIONBOUNDARY=1,
EQUILIBRIUMMODEL=EQUILIBRIUM,  OPENING=1, DIAMETER=4 IN
  POSITION LABEL="WELL_RES-POS_2", PIPE="Pipe-169", SECTION=1
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ENDNETWORKCOMPONENT


NETWORKCOMPONENT TYPE=NODE, TAG=OFFSHORE_MAN
  PARAMETERS LABEL=OFFSHORE_MAN, TYPE=INTERNAL
ENDNETWORKCOMPONENT

NETWORKCOMPONENT TYPE=NODE, TAG=NODE_BH_LB
 PARAMETERS LABEL=NODE_BH_LB, TYPE=PRESSURE, TEMPERATURE=(1644:4) C,\
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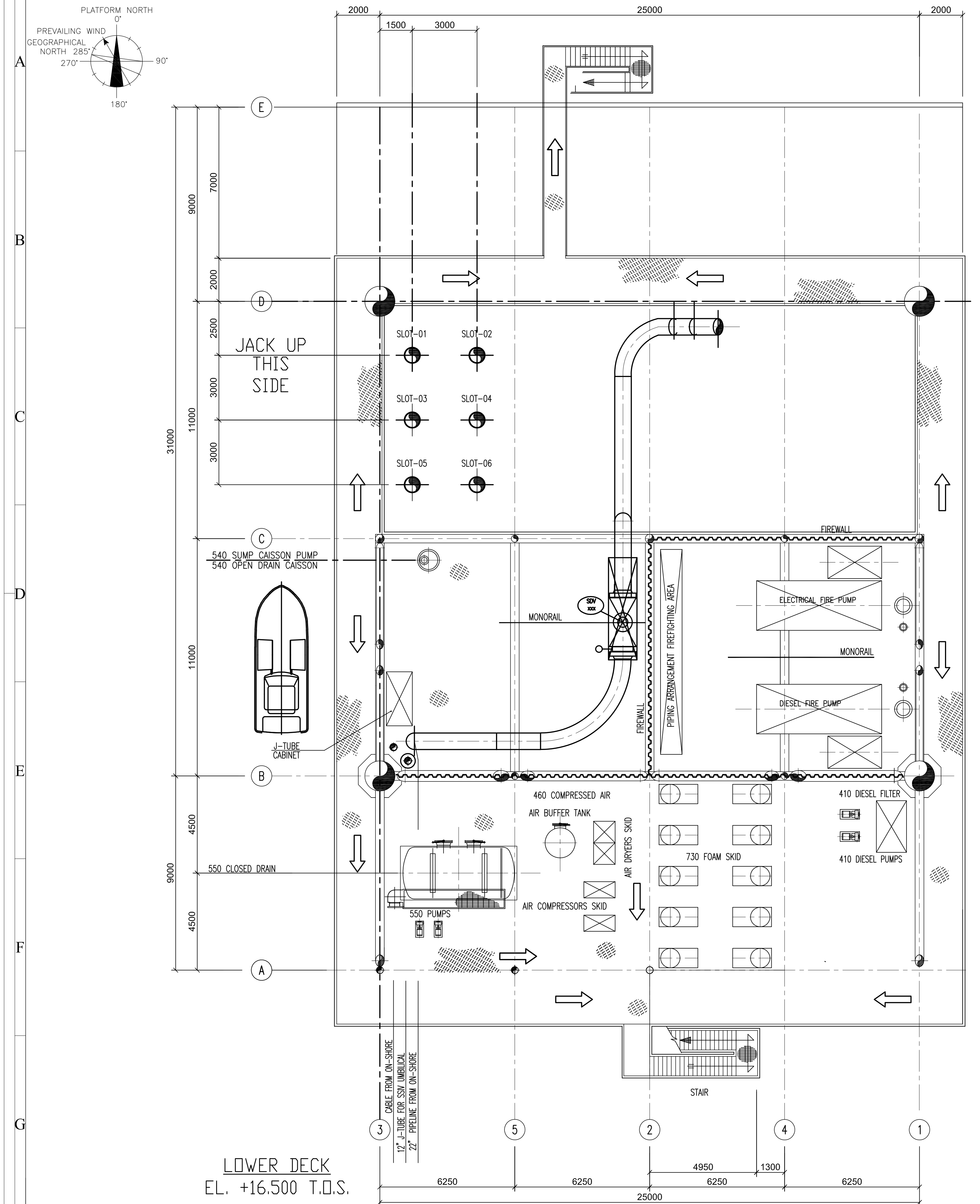

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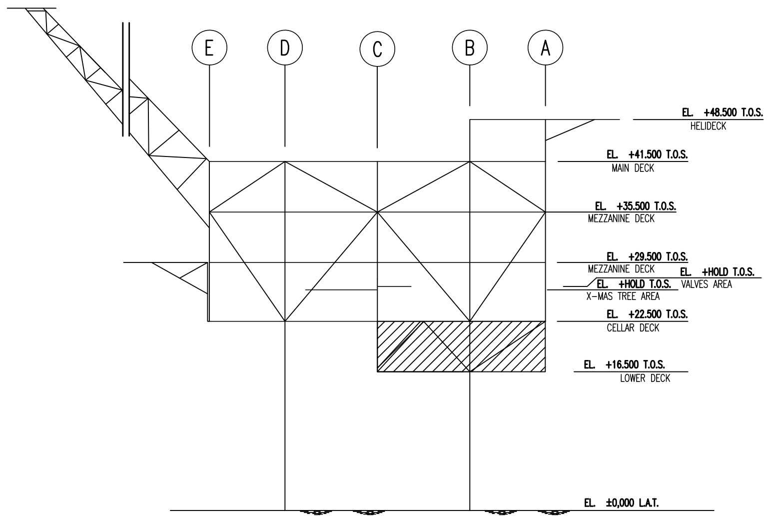

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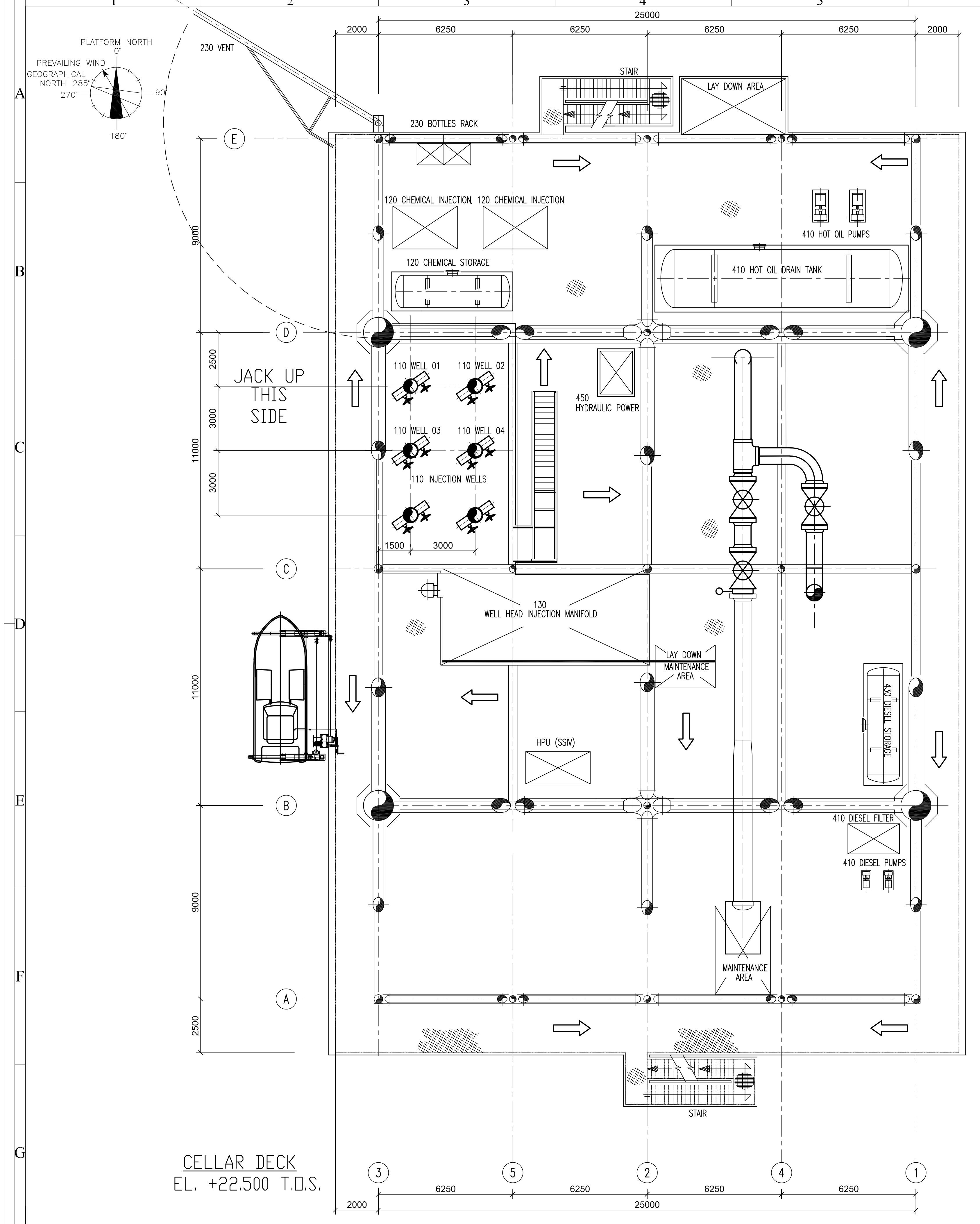
SOFTWARE Autocad 2018 FILE N.



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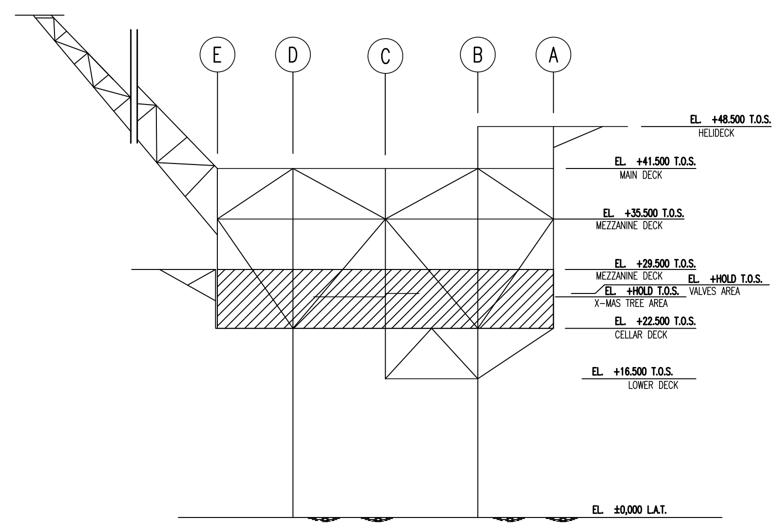

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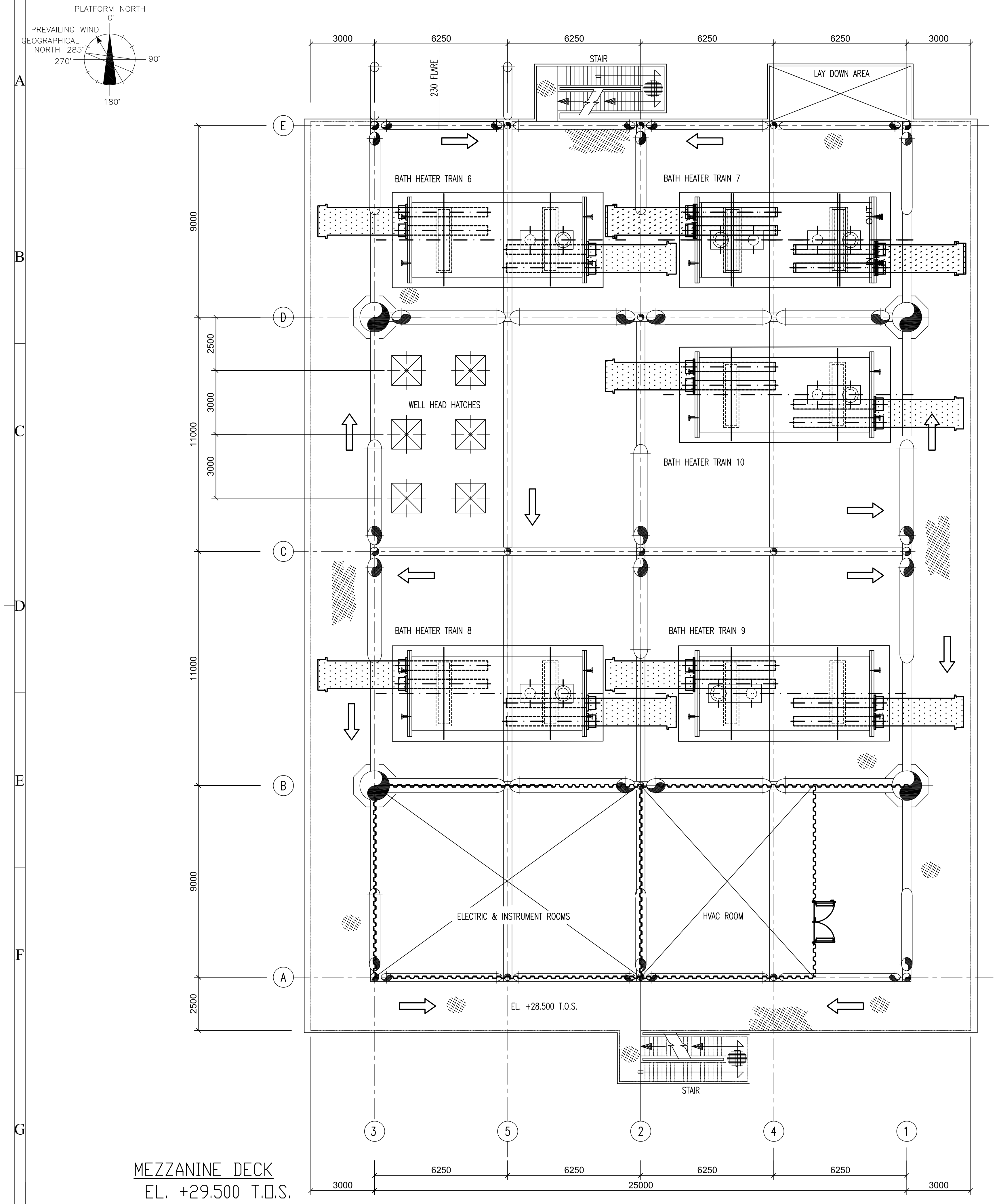

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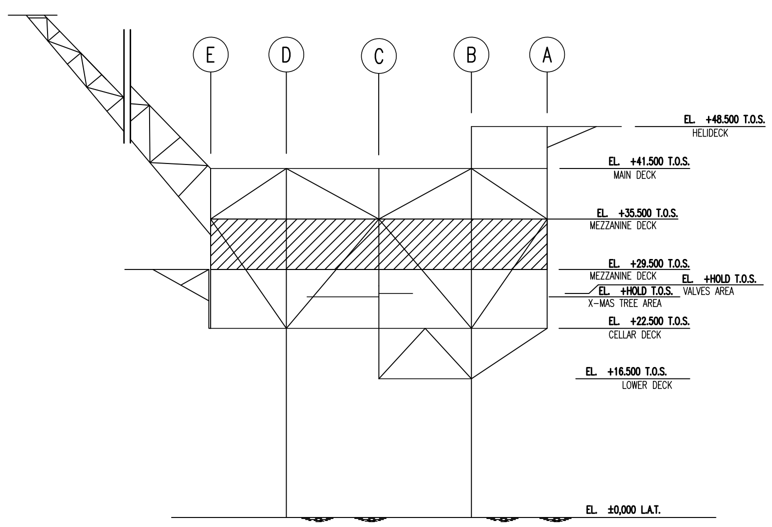

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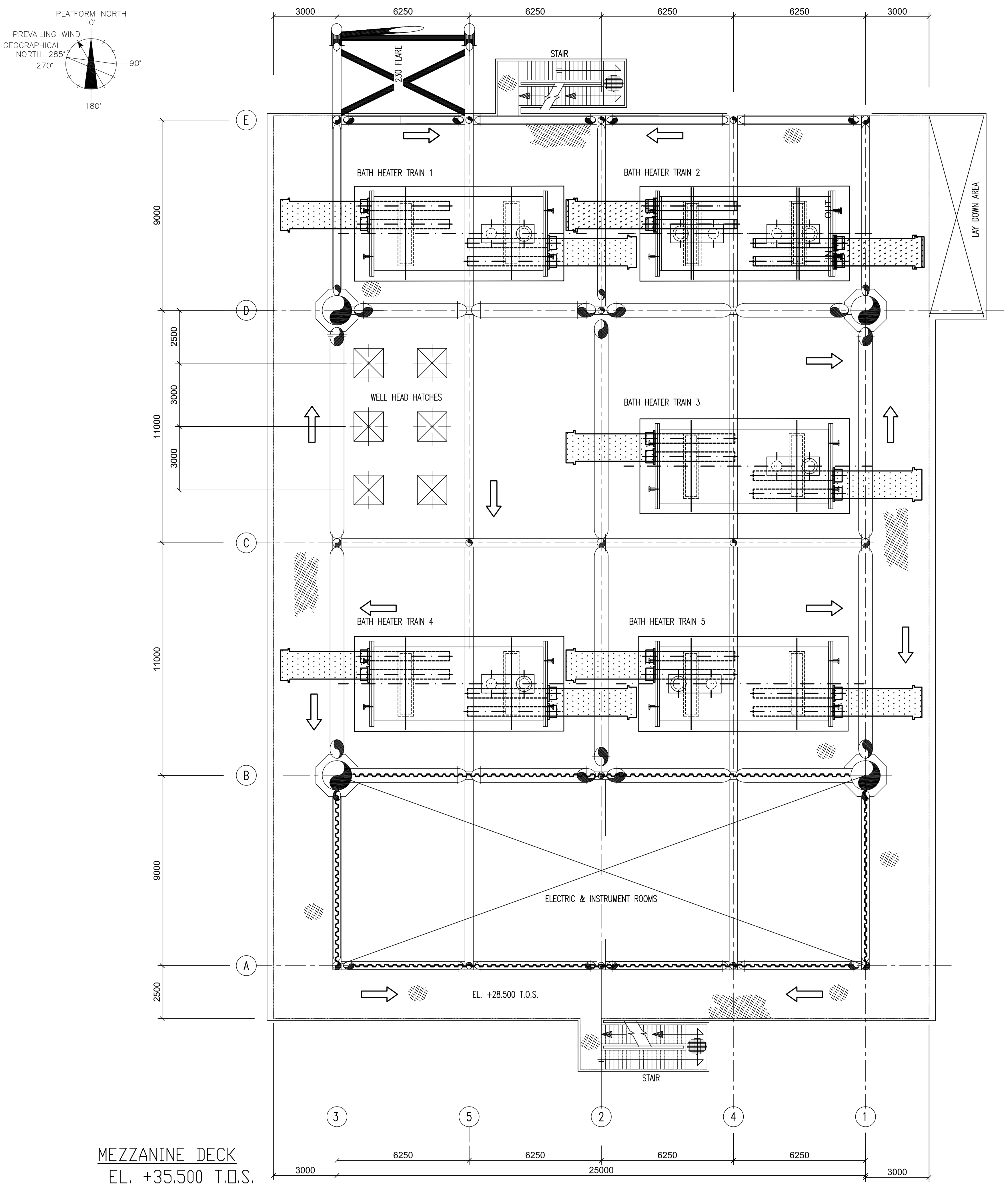

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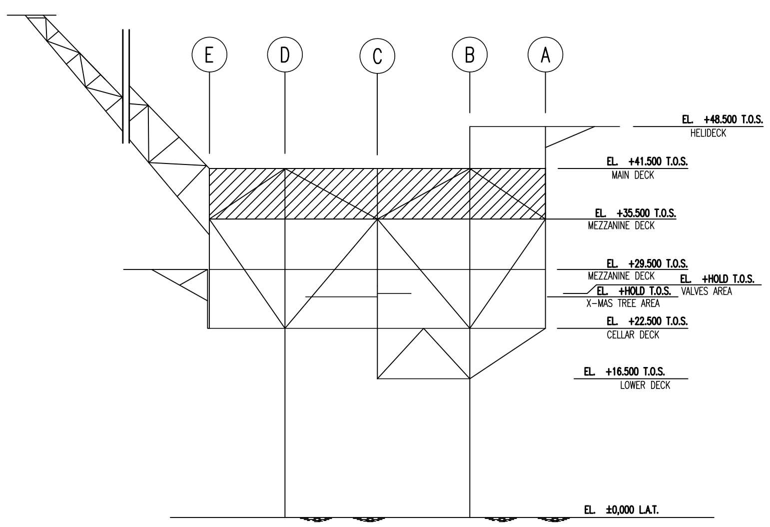

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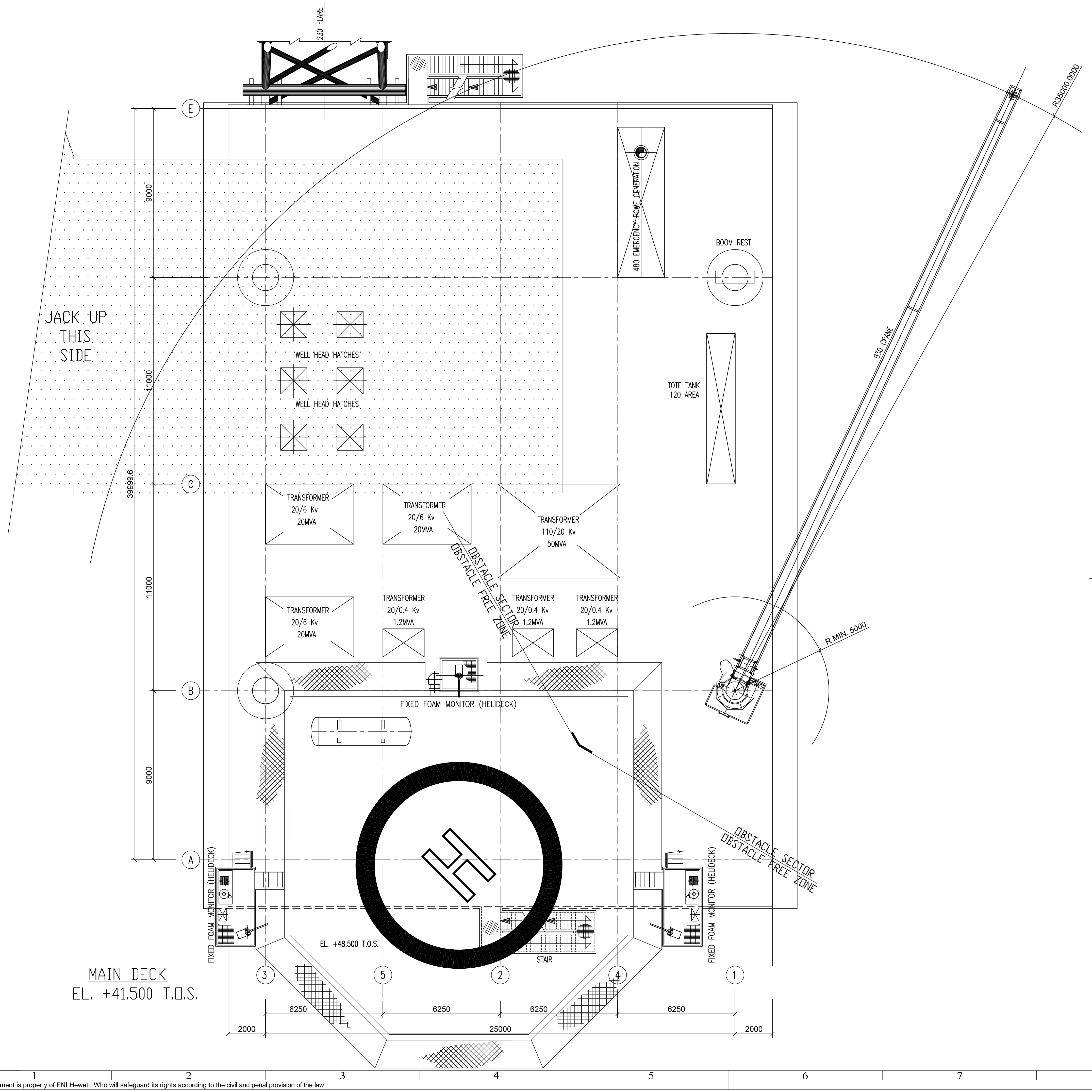

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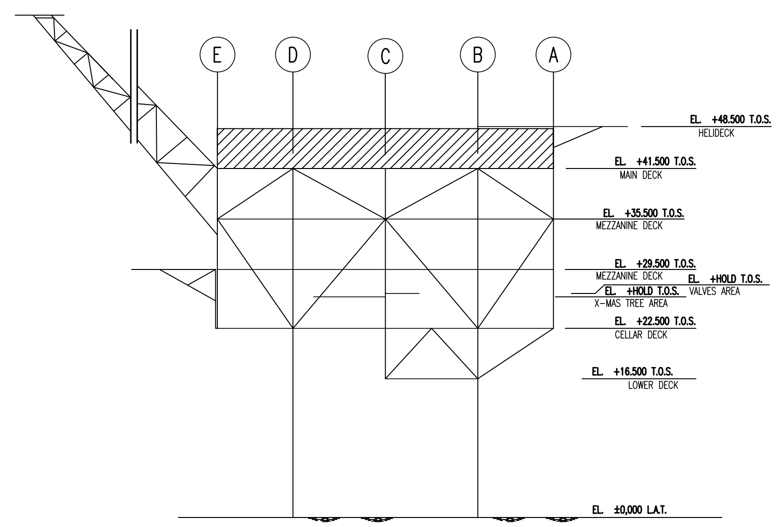

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DESCRIPTION	DWG Number

HEWETT – CO2 INJECTION PLATFORM
PLOT PLAN
MAIN DECK ELEVATION FROM +41.500 TO 48.500

SOFTWARE Autocad 2018 FILE N.

COSHER PROJECT

(Carbon Dioxide Safety, Health, Environment and Risks)

Large Scale Experiments to Study the Rupture of a High Pressure CO_2 Pipeline: Detailed Results of Test 1

Prepared by

Barbara Lowesmith

13 August 2013

COSHER PROJECT

Large Scale Experiments to Study the Rupture of a High Pressure CO_2 Pipeline: Detailed Results of Test 1

Executive Summary

The use of high pressure transmission pipelines to convey carbon dioxide, in the gaseous phase and, more particularly, in the dense phase, is regarded as an essential element of the development of Carbon Capture and Storage (CCS) projects. Pipeline operators will need to be able to demonstrate to regulatory authorities that such CO_2 pipelines can be operated safely and that the risks presented to the public are well understood, in order to obtain licences to operate. However, the processes that determine the hazards posed by intentional (such as venting) or accidental releases of CO_2 from pipelines are complex due to the complexity of the thermodynamics of the CO_2 outflow, with changes of phase, followed by the dispersion of the cold heavy gas. It is also important to understand the effects on the pipeline material caused by low temperatures during depressurisation. To improve the understanding of these hazards and to aid the development of well-validated mathematical models of CO_2 release and dispersion, a joint industry project has been formulated, coordinated by DNV KEMA. The partners of this joint industry project are StatoilHydro, Total, Petrobras, ENI, GASSCO and National Grid.

The focus of the COSHER project is on releases from underground CO_2 transmission pipelines simulating loss of containment. Phase 2 of this project involves the conduct of two large scale experiments to provide data under well-defined conditions studying the full bore rupture of a CO_2 dense phase high pressure underground pipeline at large scale. The experiments were conducted at the GL Noble Denton test site in Cumbria, UK. In order to simulate a very long pipeline, an 8” diameter pipeline loop was fed from both ends by a large reservoir of CO_2. The rig was designed to promote outflow in the liquid phase for as long as possible.

This report describes the detailed results of Test 1. For this test, the initial gauge pressure in the test rig was about 151 bar and the fluid temperature was 7.5°C, giving an initial inventory of about 151 tonnes. The wind speed was about 5 m s^{-1}. Upon rupture of a section of the 8” pipeline, a ground crater was formed and the CO_2 was allowed to flow freely from both ends of a ruptured section of the pipeline. The pressure dropped rapidly to about 34 bar and then remained fairly steady, although declining slowly, for nearly 4 minutes until the liquid was depleted, then two-phase and gaseous outflow occurred.

During the experiments, measurements of the fluid pressure, fluid temperature and wall temperature of the test facility were made together with measurements of concentration and temperature within the dispersing gas cloud.

Contents

COSHER PROJECT

Large Scale Experiments to Study the Rupture of a High Pressure CO_2 Pipeline: Detailed Results of Test 1

1. Background

The use of high pressure transmission pipelines to convey carbon dioxide, in the gaseous phase and, more particularly, in the dense phase, is regarded as an essential element of the development of Carbon Capture and Storage (CCS) projects. Pipeline operators will need to be able to demonstrate to regulatory authorities that such CO_2 pipelines can be operated safely and that the risks presented to the public are well understood, in order to obtain licences to operate.

However, the processes that determine the hazards posed by intentional (such as venting) or accidental releases of CO_2 from pipelines are complex due to the complexity of the thermodynamics of the CO_2 outflow, with changes of phase, followed by the dispersion of the cold heavy gas. It is also important to understand the effects on the pipeline material caused by low temperatures during depressurisation.

To improve the understanding of these hazards and to aid the development of well-validated mathematical models of CO_2 release and dispersion, a joint industry project has been formulated, coordinated by DNV KEMA. The partners of this joint industry project are StatoilHydro, Total, Petrobras, ENI, GASSCO and National Grid.

2. Introduction and Scope of Report

The focus of the COSHER project is on releases from underground CO_2 transmission pipelines simulating loss of containment. Phase 2 of this project involves the conduct of two large scale experiments to provide data under well-defined conditions studying the full bore rupture of a CO_2 dense phase high pressure underground pipeline at large scale. The experiments were conducted at the GL Noble Denton test site in Cumbria, UK. In order to simulate a very long pipeline, an 8” diameter pipeline loop was fed from both ends by a large reservoir of CO_2. During the experiments, the CO_2 was allowed to flow freely from both ends of a ruptured section of the pipeline. Measurements of the fluid pressure, fluid temperature and wall temperature of the test facility were made together with measurements of the dispersing gas cloud.

This report describes the detailed results of Test 1.

3. Experimental Arrangement

3.1 Location and Terrain

The test was conducted on the GL Noble Denton Test Site at Spadeadam in Cumbria, UK. The site is approximately 1500 m long the West-East direction and up to 320 m wide. The central area is reasonably level. However, the site is bounded to the north and south by small streams and the land falls away in height to these streams. Figure 1 shows a contour map of the area together with the site boundaries and key structures (such as 3 large concrete pads, roads and control buildings) and an aerial photograph. The test facility was located in the central area of the site between Pad A (at the west end) and Pad B (in the centre of the site). The terrain to the west and east was nominally level for at least 300 m. To the north and south earth banks were present running west-east, and then the land sloped away towards the site boundaries. The immediate terrain around the test facility (up to 100 m to the west and 300 m to the east) was surveyed at a number of locations using a GPS and the UK Ordnance Survey Grid System [1], which provided unique coordinates (in terms of an easting and northing) and elevation above sea level. Using the easting, northing and elevation of the release point of the test facility, an X,Y,Z coordinate of each surveyed location was derived such that X was the distance in the Grid East direction, Y was the distance in the Grid North direction and Z was the elevation relative to the release point. Figure 2 shows a series of profiles of the land (from south to north) at distances nominally 111 m west of the release point to 296 m east of the release point.

3.2 The Test Facility

The experimental test facility comprised a large reservoir formed from a 117.1 m long, 1321 mm (52") diameter steel pipeline connected to a 226.6 m long pipeline loop formed from 200 mm (8") diameter steel pipe. A schematic of the arrangement is shown on Figure 3.

The reservoir pipe was below ground level and orientated in the West-East direction. The reservoir was inclined by about 0.494°, such that the east end was lowest. Close to the east end of the reservoir, both ends of the pipeline loop were connected to the reservoir on the underside via sweepolet connections (Figure 4). The reservoir had a total volume of 148.75 m^3.

Both arms of the pipeline loop came up from under the reservoir to about 0.5 m below ground level. A loop was then formed, with a rupture spool forming the halfway point of the loop. The pipework each side of the rupture spool, which connected to the reservoir were equal in length. Each side incorporated a 5 elbows and a ball valve. The total volume of the loop was 6.68 m^3. The pipework loop is shown on Figures 5, 6 and 7. Table 1 summarises some dimensional and constructional information concerning the test rig.

The rupture spool was 4 m long with flange connections at each end, enabling its replacement before each test. The spool was reinforced on the underside with a steel bar welded to the spool to prevent the pipe section ringing off following the rupture. This avoids a projectile being produced and also helps to maintain the alignment of the two ends of the rupture, producing directly opposed outflow from each side. The pipeline loop was backfilled with the local clay soil to a depth of about 0.5 m, except immediately over the rupture spool, where a wooden structure permitted access to the pipe in order to lay an explosive charge. Figure 8 shows a photograph of the rupture location before the test.

The design of the test facility was aimed at ensuring CO_2 was released in the dense phase for as long as possible.

3.3 Test Procedure

The gas reservoir and pipeline loop was pressurised with CO_2 to nominally 150 bar. When full the test rig contained about 151 tonnes. A shaped explosive charge was laid on the top dead centre of the spool in the centre of the pipeline loop for a length of about 3.3 m. At each end of this length, the shaped charge was installed around the pipe circumference for about ¾ of its length. The objective was to achieve a clean cut and produce a release from each side of the rupture from the full bore of the pipe.

When suitable weather conditions were prevailing (a westerly wind), activation of the explosive charge initiated the release of CO_2 which flowed freely from the test rig. In order to protect the reservoir from excessively low temperatures, and to provide the option to terminate in an emergency, the ball valves either side of the rupture were to be closed when the wall temperatures measured near the sweepolet connections between the reservoir and the loop reached -25°C, indicating that the reservoir was nearly empty of liquid CO_2. However, during Test 1, the valve on the east side failed to close and the reservoir and loop were completed emptied.

4. Scientific Measurements and Data Recording

During the test a large number of measurements were made. On the test facility, the pressure, fluid temperature and wall temperatures were recorded. In addition, a measurement of differential pressure was aimed at determining the liquid level in the reservoir (and hence mass outflow). In the field, measurements of concentration and temperature in the dispersing cloud were made as well as records of the atmospheric conditions. Extensive video footage included close up views of the rupture location with high speed video and a thermal imaging (IR) camera. Aerial footage was taken from cameras attached to a helium balloon.

The field instrumentation was located at one of 64 locations (labelled L01 to L64), with the rupture location at L00 (see Figure 9). The concentration and dispersion measurements were principally located on radial lines 15° apart, being +45,+30, +15, 0, -15, -30 and -45° from the X (Grid East) direction), at distances up to 700 m from the release point. As the test was to be conducted with a westerly wind, the vast majority of the instruments were located downwind (east) of the release point.

The precise position of these locations was determined using a GPS and the UK Grid system as described in Section 3.1 in order to determine X, Y and Z coordinates relative to the release location. Table 2 presents these coordinates.

4.1 Pressure, Fluid Temperature and Wall Temperature in the Reservoir

4.1.1 Reservoir pressure

The reservoir pressure was measured at two locations, one at the west end on a blanked 12” NB outlet and the other at the east end at a 1 ¼” tapping, as shown on Figure 4. The instruments were Druck UNIK 5000 series transducers with a range of 0-160 bar and a stated accuracy of ±0.08% of full scale. The instruments were calibrated on site using a Druck pressure calibrator before the test and again after the test.

The pressure measurements were logged at 500Hz on a SPARTAN data acquisition system and the results provided in engineering units of gauge pressure in bar. The signals were also recorded on a high speed data acquisition system at 100 kHz (Hi-Techniques SYNERGY system).

4.1.2 Reservoir fluid temperature

The fluid temperature was measured at two locations on the reservoir, one close to the west end of the reservoir, inserted about 100 mm from the top of the pipe and other at the east end, inserted about 100 mm from the bottom of the pipe, as shown on Figure 4. The instruments were 1.5 mm diameter mineral insulated stainless steel sheathed Type T thermocouples, manufactured to a British Standard and supplied with a certificate of conformity. These temperatures were logged at 10 Hz on a SPARTAN data acquisition system. The results were provided in engineering units of degrees Celsius.

4.1.3 Reservoir wall temperature

The wall temperature of the reservoir was measured using welded tip, PTFE insulate, Type T thermocouples, spot welded to the outer pipe wall. The main purpose of these thermocouples was to monitor the reservoir temperature in order to protect the reservoir from excessively low temperatures. On detecting -25°C in the vicinity of the sweepolet connections, the valves in the pipeline loop were to be closed to terminate the test. Six thermocouples were located around the west end of the reservoir and eight were at the east end of the reservoir, including four on sweepolet connections to the pipeline loop, as shown on Figure 10. These instruments were logged at 10 Hz on a SPARTAN data acquisition system. The results were provided in engineering units of degrees Celsius.

4.2 Pressure, Fluid Temperature and Wall Temperature in the Pipeline Loop

4.2.1 Pipeline loop pressure

The pressure in the pipeline loop was measured at a total of 12 locations, 6 either side of the rupture. Two were located at the beginning of the loop on the sweepolet connections to the reservoir, as shown on Figure 5. The remaining 10 were located on the final straight length of pipe, 5 either side of the rupture as shown on Figure 7.

At positions A and D, high frequency pressure transducers with a range of 0-200 bar were used. These were manufactured by Kulite (Type CTL-3-375M-200BARSG), with a natural frequency of at least 1.4 MHz and an accuracy of ±0.5% of full scale.

At positions B, C and F, Druck UNIK 5000 series transducers with a range of 0-160 bar and a stated accuracy of ±0.08% of full scale were used. The instruments were calibrated on site using a Druck pressure calibrator before the test and again after the test.

The pressure measurements were logged at 500Hz on a SPARTAN data acquisition system and the results provided in engineering units of gauge pressure in bar. The signals were also recorded on a high speed data acquisition system at 100 kHz (Hi-Techniques SYNERGY system).

4.2.2 Pipeline loop fluid temperature

The fluid temperature was measured at 12 locations on the pipeline loop, 6 either side of the rupture. Two of these instruments were positioned on the sweepolet connections as shown on Figure 5, inserted about 3 mm through the side wall of the pipe. The other 10 were located at positions A, B, C, D and F either side of the rupture as shown on Figure 7. At these positions, the instruments were inserted about 3 mm through the bottom of the pipe. In all cases, 1.5 mm diameter mineral insulated stainless steel sheathed, Type T thermocouples were used, supplied with a certificate of conformity. The temperatures were logged on a SPARTAN data acquisition system at 10 Hz. The results were provided in engineering units of degrees Celsius.

4.2.3 Pipeline loop wall temperature

The pipeline loop wall temperature was measured using PTFE insulated Type thermocouples spot welded to the outer surface at the pipe at 16 locations, 8 either side of the rupture. Two were positioned on the bottom of the pipe on the sweepolet connections as shown on Figure 5. The remaining thermocouples were positioned on the side wall of the pipe at locations A, B, C, D, E (both sides) and F, as shown on Figure 7. The temperatures were recorded at 10 Hz on a SPARTAN data acquisition system. The results were provided in engineering units of degrees Celsius.

4.3 Mass Flow Rate by Differential Pressure Measurement

A differential pressure transducer was located below the east end of the reservoir. It was connected by small bore pipework on one side to the underside of the reservoir between the sweepolet outlets as shown on Figure 4, and on the other side to the top of the reservoir at the west end. A schematic of the arrangement is shown on Figure 11. The instrument was a Druck STX2100 series with a range of 0-300 mbar with a quoted accuracy of 0.1% of the calibrated span. The pressure was recorded at 500 Hz on a SPARTAN data acquisition system and backed up on a high speed data acquisition system at 100 kHz (Hi-Techniques SYNERGY system). The results were provided in engineering units of pressure in mbar.

An actuated valve on the small bore pipework (close to the west end of the reservoir) was closed during rig filling after the saturation pressure (about 40bar) was reached, in order to maintain gas on this side of the differential transducer and prevent liquid CO_2 entering this tube. About 3 seconds after the rupture this valve was opened allowing the transducer to measure the liquid head within the reservoir. If the liquid head (that is, the height of the liquid CO_2 in the reservoir above the location of the instrument), can be measured with time, then it is possible to calculate the amount of liquid remaining in the reservoir with time. From this, it is possible to determine the mass outflow from the reservoir with time.

4.4 Crater Formation and Solid CO_2 Production

After the test, a survey of the crater was performed to determine the dimensions and shape of the ground crater. An assessment of solid CO_2 formation was also undertaken.

4.5 Atmospheric Conditions

4.5.1 Atmospheric pressure, temperature, relative humidity and solar radiation

The atmospheric pressure, temperature, relative humidity and solar radiation were measured prior to and throughout the test at location L02, nominally 200 m west of the rupture location. A UNIK 5000 series 0-1.6 bar (abs) transmitter was used for the atmospheric pressure, a Type T thermocouple for the temperature and a Hygroclip2 proprietary pre-calibrated instrument manufactured by Omni Instruments was used for the humidity. A Kipp & Zonen CMP3 pyranometer was used to measure the background solar radiation. All these instruments were recorded at 10 Hz on a SPARTAN data acquisition system and results provided in appropriate engineering units (mbar, °C, % and W m^{-2}K respectively).

4.5.2 Wind speed and direction

The wind speed and direction was measured at 4 locations: L02 nominally 200 m west of the rupture; L26 nominally 100 m east of the rupture; L29 nominally

200 m south-east of the rupture; and L51 nominally 300 m east of the rupture (see Figure 9 and Table 2). The measurement to the west at L02 was at 5 m above local ground level and the other measurements were at 3 m above local ground level. In all cases, a Gill Windsonic, 2-direction sonic anemometer was used. The data was recorded at 10 Hz on a SPARTAN data acquisition system and provided in engineering units of m s^{-1} for the wind speed and degrees from Grid North for the direction.

4.6 Conditions in the Dispersing Cloud

Conditions within the dispersing cloud of CO_2 were monitored using 70 oxygen cells, 48 thermocouples and 2 infra-red CO_2 sensors as detailed below.

4.6.1 Concentration using oxygen cells

An array of 70 Citicell A02 oxygen cells (numbered OC01 to OC70) were used to determine oxygen depletion and hence CO_2 concentration. Fifty six were located 1 m above local ground level and fourteen at 1.8 m above local ground level. The arrangement of the oxygen cells are shown on Figures 12 and 13 respectively and the locations summarised in Table 3. These were principally located on radial lines 15° apart, being +45,+30, +15, 0, -15, -30 and -45° from the X (Grid East) direction), at distances up to 700 m from the rupture location. As the test was to be conducted with a westerly wind, the vast majority of the instruments were located downwind of the rupture location, although a limited number were also located crosswind and upwind near the rupture location. The instruments were recorded one of several SPARTAN data acquisition systems at 10 Hz and the data supplied in engineering units of volume percentage CO_2 in air.

The oxygen cells output a nominal voltage of 10 mV when in air, which reduces linearly with oxygen depletion, which can then be translated into CO_2 concentration. The data was post-processed such that the average of each oxygen cell output during the 30 s prior to rupture was taken to correspond to 0% CO_2 for that oxygen cell.

The oxygen cells are temperature compensated, but their output varies slightly with temperature. The manufacturer states that the variation is less than 2% over range 0 – 40 °C. Taking this variation to be ±1% of the reading in air (nominally 10 mV), corresponds to ±0.1 mV. This corresponds to ±1 CO_2. So the accuracy of the dispersion measurements can be considered to be accurate to an absolute value of ±1%.

4.6.2 Concentration by IR sensors

The gas concentration was also measured using two Draeger PIR 7200 detectors positioned at L26 and L40, nominally 100 and 200 m to the east of the rupture location, at a height of 1 m above local ground level. These instruments are designed for long term continuous monitoring and alarming on detection of a dangerous level of CO_2. The ranges for the 2 instruments used were 0-50% and 0-20%. A single point calibration was provided by the supplier. This single point calibration needs to be at a value close to the expected maximum concentration to be measured, since above the calibration point, the response is highly non-linear and can lead to large errors. The data recorded at 10 Hz on a SPARTAN data acquisition system and supplied in engineering units of volume percentage CO_2 in air.

4.6.3 Temperature

The temperature in the dispersing gas cloud was determined using an array of 48 thermocouples (numbered FT01 to FT48) formed from PTFE insulated Type T thermocouple wire, twisted at the ends to make a joint. These thermocouples were deployed close to the majority of the oxygen cells at 1 m and 1.8 m above ground level within 200 m of the rupture location. The arrangement of these thermocouples is shown on Figures 14 and 15 and summarised on Table 4.

These instruments were logged at 10 Hz on one of several SPARTAN data acquisition systems and the results provided in engineering units of degrees Celsius.

4.7 Noise

Noise was measured 1m above local ground level at 2 locations: L12, nominally 17.5m to the south of the rupture location and; L26 nominally 100 m to the east of the rupture location. The instruments were Cirrus Research 800 series integrating sound level meters in the range 20-140 dB. The ranges set for Test 1 were 60-130 dBA for position L12 and 20-90 dBA for position L26. The data was recorded on an internal logging system supplied with the instrument. The results were provided in engineering units of dBA.

4.8 Video Records

Video records were made using:

- Two high speed cine cameras (one B&W and one colour) located at L12 nominally 17.5 m south of the rupture location. These cameras captured the initial rupture event (up to 3s) at 2000 fps.
- One Infra-red camera (FLIR A325) located at L12, nominally 17.5 m south of the rupture location.
- A normal speed video with sound (Handycam) located at L12, nominally 17.5 m south of the rupture location.
- A normal speed video with sound (Handycam) located at L05, nominally 100 m south west of the rupture location.
- Four CCTV cameras (no sound) located at L01 (400 m west), L05 (100 m south-west), L54 (300 m east) and L60 (500 m east).
- Three wide angle normal speed video cameras (with sound) attached to a helium filled blimp, tethered to the west of the rupture location providing an aerial view.

5. Test Conditions and Description

5.1 Initial Conditions

The test was initiated at approximately 09:50 hrs on 4th May 2013. The morning was sunny and dry with a WSW wind of about 5 m s^{-1}. The prevailing atmospheric conditions for the 30 s period leading up to the rupture are summarised in Table 5.

The rig was pressurised to a gauge pressure of 151.7 bar (averaged over all measurement locations). The average fluid temperature and wall temperatures were both 7.5 °C (see Table 5). Based on the measurements of pressure and temperature at the east end of the reservoir, the estimated inventory was 151.4 tonnes.

5.2 Description of the Test

A shaped linear explosive charge was used to cut the rupture section along the top dead centre of the rupture spool for a length of 3.3 m. At end each, the explosives extended part-way around the circumference, aiding a clean opening of the pipe and providing unobstructed flow from each end. Upon rupture, CO_2 and soil were ejected into the air, significant debris throw was observed for about 25 s and then small amounts of soil continued to be ejected until about 60 s after the rupture. After that no further ejection of soil was apparent.

The initial rupture produced a visible plume projecting vertically into the air and reaching a maximum height after 9 s of about 50 m and a width of about 55 m. After that, this initial cloud appeared to drift downwind and closer to the ground. The height of the plume ejected from the crater remained relatively steady for a prolonged period between 50 and 250 s after the rupture, being in the region of 24 – 28 m high. During this steady period the visible plume extended close to ground level for a significant distance downwind to the east. Until about 90 s, the spread was evenly to the north and south crosswind, but thereafter, the cloud to the south side cleared and the plume was spreading more to the north side.

The release became more noisy at around 225 s, coinciding with the time at which the pressure began to drop more quickly, probably indicative of gas phase outflow at the exit. The valves either side of the rupture were activated to close soon after, although the valve on the east side failed to close. The valve on the West side had closed completely by about 285 s. At this time, a vertical jet was produced at the crater extending over 30 m into the air. At about 298 s, this tipped over to the west and formed an angled jet, close to the ground as the pressure decayed through the exit on the east side of the rupture.

The visible cloud downwind dispersed quickly. An area extending a few metres downwind of the crater and about 15 m to the south side and 35 m to the north side was covered in a thin white coating. By 10 minutes after the rupture, this had disappeared.

6. Detailed Results

This report presents the detailed time varying results of Test 1. Further analysis of the pseudo-steady period can be found in the overall report. The minimum of post-processing of data has taken place and where relevant is detailed in the sections below.

6.1 Pressure and Temperature in the Reservoir

6.1.1 Pressure in the reservoir

The pressure dropped rapidly over about 3 s to about 34 bar. A relatively stable period then persisted until 225 s, when the pressure started to drop more quickly. As one of the valves near the rupture failed to close, the reservoir depressurised completely. Figure 16 (a) shows the whole period and Figures 16 (b), (c) and (d) show the initial period, the pseudo-steady period and the end period in more detail.

6.1.2 Fluid temperature in the reservoir

The fluid temperature throughout the test is shown on Figure 17(a). Figures 17 (b), (c) and (d) show the temperatures in more detail for the initial period, the pseudo-steady period and the end period. A divergence in temperature at the west and east ends starts to occur around 285 s when continued gas outflow, after all liquid had been depleted, (due to failure of the loop valve on the west side) resulted very cold temperatures around the reservoir at the east end.

6.1.3 Wall Temperature in the reservoir

The wall temperatures experienced by the reservoir throughout the test are shown on Figure 18(a) for the west end and (b) for the east end of the reservoir. (See Figure 10 for detail about the locations).

6.2 Pressure and Temperature in the Pipeline Loop

6.2.1 Pressure in the pipeline loop

The pressure at position B on the east side of the rupture was lost within 1 s of the rupture and at position B on the west side was lost at about 4 s.(see Figure 7).

Figure 19(a) shows the pressure (relative to the initial pressure) measured immediately around the time of zero by the high speed transducers and logged at 100 kHz. This data has had a 0.1 ms rolling average applied. As can be seen, good agreement is apparent between the west and east sides, indicating equal flow to each side of the rupture. The time of initial rupture, as determined by the response of the transducers at Position A (East and West), is slightly before zero indicating the timing wire around the pipe did not break until slightly later. The spike in pressure on rupture is due to the pressure pulse generated by the explosive charge.

Figure 19(b) shows the pressure in the pipeline loop immediately around the time of the rupture using data logged at 500 Hz with a 0.006 s rolling average applied. Figure 19(c) presents the pressures in the pipeline loop in the first 4 s using the data logged at 500 Hz with a 0.006 s rolling average applied. Once again, good agreement is apparent between the west and east sides, indicating equal flow to each side of the rupture. The time of rupture differs very slightly from that shown on Figure 19(a), due to a slight inaccuracy in time zero logged on the SPARTAN system as a result of the logging speed of the timing wire.

Figures 19(d) and (e) show the pressures in more detail during the pseudo-steady period and the final period respectively using the 10 Hz data. At about 285 s, the valve on the west side of the rupture closed and hence the short length of pipe between the valve and the rupture quickly depressurised (positions A, C and D), but increased for a short time at position F (behind the valve). However, the valve on the east side did not close and hence the pressure continued to drop as the whole rig depressurised.

6.2.2 Fluid temperature in the pipeline loop

The fluid temperature in the pipeline loop is shown on Figure 20(a) throughout the test. Figures 20(b), (c) and (d) show the temperatures for the initial period, the pseudo-steady period and the final period, respectively, in more detail. As can be seen, good agreement is apparent between the west and east sides until about 285 s, when the valve on the west side of the rupture closed. After this time, very low temperatures were experienced in the east side of the loop and close to the sweepolet outlets, due to the continued depressurisation of the rig through the eastern side of the loop.

6.2.3 Wall temperature in the pipeline loop

Figure 21(a) presents the wall temperatures measured on the pipeline loop throughout the test. Figure 21(b) presents this information in more detail during the pseudo-steady period.

6.3 Mass Outflow

The intention was to determine the mass outflow from the reservoir by measuring the differential pressure across the reservoir generated by the liquid head. This would enable determination of the liquid level within the reservoir with time, from which the mass outflow can be determined. Unfortunately, no successful measurements were achieved during the test, perhaps due to blockage by liquid CO_2 in the small bore pipes connected to the gas side (west side) transducer.

However, the outflow can be estimated by taking the initial reservoir inventory (151.4 t) and subtracting the inventory at 230 s when liquid had run out, which was calculated to be 9.3 t. This is then divided by 230 s, giving an estimated pseudo-steady outflow of 618 kg s^{-1}.

6.4 Crater Formation and Solid CO_2

After the test, the area was inspected for solid CO_2 production.

6.4.1 Solid CO_2 production

As noted in Section 5.2, the video footage suggested a light covering of CO_2 was produced around the crater on the downwind side. However, no significant accumulation was identified when access to the area was possible. Some delay in access to the area occurred due to failure of the valve on the east of the rupture to close. No accumulation of CO_2 was found within the crater, although the pipework was encrusted with haw-frost.

6.4.2 Crater formation

As noted in Section 5.2, a ground crater was formed by the release. Most soil was ejected within the first 25 s and no soil ejection was identifiable after 60 s. A photograph of the crater is shown on Figure 23. The ground crater was surveyed to provide a profile of the crater edge (Figure 24). The depth of the crater was surveyed on several sections from west to east, as shown on Figure 25.

6.5 Noise

The data recorded by the noise instruments was recorded on the instruments dedicated logger and produced data values for each second, which represent a time-averaged value over that one second period. Several data points had an 'overload' warning, despite the measured levels being generally less than the maximum range set for the instrument. The 'overload' warning indicates that one or more instantaneous value contributing to the one-second average exceeded the maximum range. However, the one-second average values were mostly less than the maximum range and always less than the maximum range plus 10 dBA. (The manufacturer indicated that the instrument can read to 10dBA over the set range). Therefore, it is concluded that the proportion of instantaneous data which exceeded these thresholds was small and does not invalidate the one-second average values.

Figure 26 presents the noise measurements at the two locations. As can be seen, a significant increase in noise level occurred around 225 s, coinciding with a change in the rate of pressure drop, most likely associated with the onset of 2-phase flow. A drop in noise level occurred at 285 s when the valve on the west side of the rupture closed. Thereafter the noise level continued to reduce as the test facility depressurised.

6.6 Solar Radiation

The solar radiation recorded nominally 200 m upwind of the release is shown on Figure 27. The drop in solar radiation around 50 s is likely to be associated with obscuration of the sun by the initial vertical cloud produced following the rupture. The drop around 340 s is most likely associated with the angled jet produced around this time following closure of the valve on the west side of the rupture. A visible cloud, close to ground level and directed to the west was observed on the video footage.

6.7 Wind Speed and Direction during the Release

Figure 28 and 29 present the wind speed and direction measured throughout the test. The measurement at L02 was upwind of the release and not within the cloud at any time and hence is most representative of the prevailing atmospheric conditions. This measurement was at 5 m above local ground level and over the first 300 s of the release indicated an average wind speed of 4.7 m s^{-1} with a direction of 255° from Grid North. Measurements at the other locations were within the dispersing cloud for some of all of the duration of the experiment and hence the speeds and directions measured may a combination of the weather conditions and a velocity field generated by the release itself. Table 6 summarises a series of one minute averages over the first 300 s of the test at each location, together with an overall average. Comparison of the data in Table 6 with the averages for 30 s prior to the rupture, as shown in Table 5, does not suggest any obvious effect of the release on the velocity field.

6.8 Video Coverage

The video coverage was analysed where possible to determine the extent of the visible cloud produced. The height of the visible plume in the vicinity of the rupture location is shown on Figure 30, as determined from cameras at locations L05, L54 and L60. Figure 31 shows a series of images from the wide angle aerial camera at 0, 10, 20, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 and 360 s after the rupture.

As noted in Section 5.2, the initial rupture produced a visible plume projecting vertically into the air and reaching a maximum height after 9 s of about 50 m and a width of about 55 m (Figure 30 and Figure 31(b)). After that, this initial cloud appeared to drift downwind and closer to the ground (Figure 31(c)-(d)). The height of the plume ejected from the crater remained relatively steady for a prolonged period between 50 and 250 s after the rupture, being in the region of 24 – 28 m high (Figure 30).

During this steady period the visible plume extended close to ground level for a significant distance downwind to the east. Until about 90 s, the spread was evenly to the north and south crosswind (Figure 31(e)), but thereafter, the cloud to the south side cleared and the plume was spreading more to the north side (Figure 31(f)-(k)).

Figure 31(l) shows the transition to a vertical gas jet near the end of the release and Figures (m) and (n) show this gas jet angled to the west following closure of the west side valve. The rapid dispersion of the remaining gas cloud can also be seen.

6.9 Concentration in the Dispersing Cloud

The gas concentration data from the oxygen cells was post-processed by applying a 3 s rolling average to eliminate short duration fluctuations. Additionally, this period is typical of the intake of breath. As noted in Section

4.6.1, the oxygen cells are subject to some temperature related drift and their overall accuracy can be considered to be an absolute variation of ±1%. This means that very low concentrations may be unreliable, especially if they occur sometime after the zeroing of the signal. Table 7 notes issues concerning the validity/accuracy of the data from each oxygen cell.

Figure 32(a) to (k) shows the gas concentration with time measured 1 m above local ground level on radial lines downwind, crosswind and upwind from the rupture location. (See Figure 12 for a map of the locations). As can be seen, the concentration reduces with increasing distance as expected. The initial spread to both the south and north of the downwind direction is evident on Figures 32(a) to (g) and after 90 s, the gas concentrations decline on the south side of the downwind line (especially Figures 32(f) and (g)). A prolonged pseudo-steady period is evident on Figures 32(a) to (d). Virtually no CO_2 was measured crosswind, apart from a brief spike around 165 s, 50 m to the north (Figure 32(h)). As can be seen from Figures 32(i) to (k), no CO_2 was measured upwind of the rupture (except after 300 s when the angled gas jet was directed westwards).

Figures 33(a) to (j) present the gas concentrations with time measured 1 m above local ground level on arcs 100 and 50 m upwind, and 50, 100, 150, 200, 250, 300, 500 and 700 m downwind. Similar observations can be made as noted for Figure 32. The asymmetry to the south side after the initial period is particularly evident (Figures 33(c) to (h)) and the highest concentrations during the pseudo-steady period were typically along the radial line 15 degree north of the X axis, consistent with the wind direction data.

Figures 34(a) to (e) present the gas concentrations with time measured 1.8 m above local ground level on arcs 50 m upwind and 50, 100, 150 and 200 m downwind.

Figure 35 shows the gas concentration measured by the two PIR devices at 100 and 200 m downwind on the X axis. For comparison, the oxygen cells at the same locations are also shown. As can be seen, initially the response of the PIR is similar to the adjacent oxygen cell and both respond to the arrival of the gas cloud at the same time. However, the PIR devices deviate from the oxygen cells when 4% CO_2 is reached. The reason for this discrepancy is unclear, but as noted in Section 4.6.2, these instruments were designed for detection of dangerous levels rather than measuring concentration over a wide range. Additionally the sensitivity can be highly non-linear away from the single point calibration.

6.10 Temperature in the Dispersing Cloud

Thermocouples FT04, FT28, FT29 and FT33 to FT38 failed during the test. The data for FT18 is spurious between 40 and 50 s after the rupture.

Figures 36(a) to (f) present the temperatures measured at 1 m above local ground level on arcs 100 and 50 m crosswind/upwind, and 50, 100, 150 and 200 m downwind.

Figures 37(a) to (e) present the temperatures measured at 1.8 m above local ground level on arcs 50 m crosswind/upwind, and 50, 100, 150 and 200 m downwind.

7. References

[1] http://www.ordnancesurvey.co.uk/oswebsite/gi/nationalgrid/nationalgrid.pdf

Table1: Test Rig Construction and Dimensions

	Reservoir	**Loop**
Steel	API-5LX80	A333 Grade 6
Outside Diameter	1320.8mm	219.1mm
Wall thickness	25.8mm	12.7mm
Internal diameter	1269.2mm	193.7mm
Surface roughness	-	Range: 7.8-3.7 μm Ra. Average: 5.5 μm Ra
Length	117.1m (between dome ends)	226.6m
Dome end volume (each)	0.3m^3	-
Reservoir slope	0.494°	-
Volume	148.752m^3	6.677m^3
TOTAL VOLUME	**155.429m^3**	

Table 2: Coordinates of the Locations Used for Instrumentation

Location	X	Y	Z	Location	X	Y	Z
L00	0.00	0.00	0.00	L33	149.63	-3.54	4.31
L01	-408.66	79.88	9.72	L34	145.45	-36.35	3.82
L02	-192.88	-4.16	9.44	L35	129.06	-75.89	-1.21
L03	-68.29	71.34	0.11	L36	103.58	-104.97	-2.43
L04	-99.23	-0.83	1.11	L37	140.33	142.15	-1.15
L05	-121.90	-68.38	-3.61	L38	172.63	100.58	-0.41
L06	-69.85	-72.23	-4.36	L39	192.51	52.38	3.62
L07	-32.81	36.55	1.12	L40	200.80	0.70	3.76
L08	-48.09	1.22	0.94	L41	192.35	-49.90	3.94
L09	-33.86	-36.19	-1.57	L42	172.48	-104.72	-2.52
L10	-0.01	97.82	-5.03	L43	142.03	-142.27	-9.53
L11	1.84	49.26	-0.06	L44	214.76	124.35	0.19
L12	-2.80	-17.49	-0.53	L45	242.53	62.99	-5.27
L13	1.49	-50.65	-0.26	L46	249.30	-5.11	-3.00
L15	1.14	-100.93	-7.35	L47	240.46	-61.95	-6.75
L16	35.76	39.79	5.70	L48	217.62	-126.49	-9.74
L17	43.05	25.70	6.68	L49	258.59	149.77	0.33
L18	48.52	11.78	0.19	L50	288.13	77.37	-1.16
L19	50.56	-1.76	0.67	L51	298.25	1.38	1.49
L20	49.24	-13.39	0.24	L52	289.63	-78.34	-0.92
L21	44.44	-25.36	-0.37	L53	260.01	-150.75	-10.78
L22	36.58	-36.69	0.69	L54	334.12	39.52	2.20
L23	68.90	69.63	2.99	L55	431.49	181.93	11.51
L24	85.02	47.25	5.49	L56	482.25	130.08	6.00
L25	96.09	25.37	5.28	L57	499.22	0.77	2.49
L26	100.31	2.56	4.90	L58	480.80	-126.93	1.38
L27	96.84	-23.82	3.45	L59	433.05	-239.67	-7.14
L28	86.93	-47.89	6.38	L60	509.22	-89.54	6.93
L29	72.96	-71.18	-5.32	L61	674.57	180.39	10.79
L30	105.35	101.43	-0.10	L62	698.52	-5.81	2.48
L31	139.24	74.43	1.92	L63	675.41	-179.51	-0.76
L32	144.44	37.94	3.69	L64	803.58	-54.82	1.71

Note: Z is elevation relative to rupture location (L00).

Table 3: Locations of the Oxygen Cells

Oxygen cell	Location	Height above Local Ground Level (m)	Oxygen cell	Location	Height above Local Ground Level (m)
OC01	L03	1	OC36	L31	1.8
OC02	L04	1	OC37	L32	1
OC03	L06	1	OC38	L33	1
OC04	L07	1	OC39	L33	1.8
OC05	L08	1.8	OC40	L34	1
OC06	L08	1	OC41	L35	1
OC07	L09	1	OC42	L35	1.8
OC08	L10	1	OC43	L36	1
OC09	L11	1	OC44	L37	1
OC10	L11	1.8	OC45	L38	1
OC11	L13	1	OC46	L39	1
OC12	L13	1.8	OC47	L39	1.8
OC13	L15	1	OC48	L40	1
OC14	L16	1	OC49	L41	1.8
OC15	L17	1	OC50	L41	1
OC16	L17	1.8	OC51	L42	1
OC17	L18	1	OC52	L43	1
OC18	L19	1	OC53	L44	1
OC19	L19	1.8	OC54	L45	1
OC20	L20	1	OC55	L46	1
OC21	L21	1.8	OC56	L47	1
OC22	L21	1	OC57	L48	1
OC23	L22	1	OC58	L49	1
OC24	L23	1	OC59	L50	1
OC25	L24	1	OC60	L51	1
OC26	L24	1.8	OC61	L52	1
OC27	L25	1	OC62	L53	1
OC28	L26	1	OC63	L55	1
OC29	L26	1.8	OC64	L56	1
OC30	L27	1	OC65	L57	1
OC31	L28	1.8	OC66	L58	1
OC32	L28	1	OC67	L59	1
OC33	L29	1	OC68	L61	1
OC34	L30	1	OC69	L62	1
OC35	L31	1	OC70	L63	1

Table 4: Locations of the Thermocouples

Thermocouple	Location	Height above Local Ground Level (m)	Thermocouple	Location	Height above Local Ground Level (m)
FT01	L04	1	FT25	L26	1.8
FT02	L08	1	FT26	L27	1
FT03	L08	1.8	FT27	L28	1
FT04	L10	1	FT28	L28	1.8
FT05	L11	1	FT29	L29	1
FT06	L11	1.8	FT30	L31	1
FT07	L13	1	FT31	L31	1.8
FT08	L13	1.8	FT32	L32	1
FT09	L15	1	FT33	L33	1
FT10	L16	1	FT34	L33	1.8
FT11	L17	1	FT35	L34	1
FT12	L17	1.8	FT36	L35	1
FT13	L18	1	FT37	L35	1.8
FT14	L19	1	FT38	L36	1
FT15	L19	1.8	FT39	L37	1
FT16	L20	1	FT40	L38	1
FT17	L21	1	FT41	L39	1
FT18	L21	1.8	FT42	L39	1.8
FT19	L22	1	FT43	L40	1
FT20	L23	1	FT44	L41	1
FT21	L24	1	FT45	L41	1.8
FT22	L24	1.8	FT46	L42	1
FT23	L25	1	FT47	L43	1
FT24	L26	1	FT48	L30	1

Table 5: Conditions for COSHER Rupture Test 1 Prior to the Rupture

Date:	4 May 2013		Time:	09:48hrs
Atmospheric Conditions for 30s prior to Rupture				
Pressure (mbar)	980.1 ± 0.0			
Temperature (°C)	6.3 ± 0.1			
Relative Humidity (%)	79.6 ± 0.1			
Solar Radiation (W m^{-2} K)	649.4 ± 4.4			
Background Noise (dBA)	46 – 50 dBA			
Wind Speed and Direction for 30s prior to Rupture				
	Location and elevation above local ground level			
	L02 @ 5m	**L26 @ 3m**	**L29 @ 3m**	**L51 @ 3m**
Wind Speed (m s^{-1})	4.9 ± 0.6	4.9 ± 0.8	4.8 ± 1.1	3.1 ± 1.1
Wind Direction (degrees from Grid North)	258 ± 11	268 ± 8	250 ± 14	242 ± 23
Overall Conditions in the Test Rig prior to Rupture (averaged over all measurement locations)				
Gauge Pressure (bar)	151.7 ± 0.7			
Fluid Temperature (°C)	7.5 ± 0.9			
Wall Temperature (°C)	7.5 ± 1.3			

Table 6: Summary of Wind Conditions during the Test

Time frame		Locations of Measurement and Height			
		L02 @ 5m	**L26 @ 3m**	**L29 @ 3m**	**L51 @ 3m**
0-60s	Speed (m s^{-1})	5.2 ± 1.1	6.4 ± 1.1	3.1 ± 0.9	3.3 ± 1.1
	Direction (° from Grid N)	263 ± 13	277 ± 19	271 ± 20	245 ± 24
60-120s	Speed (m s^{-1})	5.3 ± 1.2	6.6 ± 1.2	6.5 ± 1.6	4.0 ± 1.0
	Direction (° from Grid N)	248 ± 15	282 ± 14	278 ± 9	265 ± 9
120-180s	Speed (m s^{-1})	4.0 ±0.7	6.4 ± 0.9	5.6 ± 1.7	4.3 ± 1.0
	Direction (° from Grid N)	253 ± 12	271 ± 18	267 ± 13	261 ± 10
180-240s	Speed (m s^{-1})	5.2 ± 1.4	5.7 ± 0.6	4.8 ± 1.6	3.7 ± 1.2
	Direction (° from Grid N)	252 ± 12	284 ± 7	268 ± 15	245 ± 22
240-300s	Speed (m s^{-1})	4.0 ± 1.1	5.5 ± 1.0	4.4 ± 1.7	4.0 ± 1.5
	Direction (° from Grid N)	259 ± 13	266 ± 11	263 ± 14	253 ± 18
Overall (0-300s)	Speed (m s^{-1})	4.7 ± 1.3	6.1 ± 1.1	4.9 ± 1.9	3.9 ± 1.3
	Direction (° from Grid N)	255 ± 14	276 ± 16	269 ± 15	254 ± 20

Table 7: Oxygen Cell Data Validity

Oxygen cell	Validity (blank indicates no problem identified)	Oxygen cell	Validity (blank indicates no problem identified)
OC01	No CO2	OC36	
OC02	No CO2	OC37	
OC03	No CO2	OC38	
OC04	No CO2 except after 300s	OC39	
OC05	No CO2 except after 300s	OC40	
OC06	No CO2 except after 300s	OC41	
OC07	No CO2	OC42	
OC08	No CO2	OC43	
OC09		OC44	Spurious data 140-180s
OC10		OC45	
OC11	No CO2	OC46	
OC12	No CO2	OC47	
OC13	No CO2	OC48	
OC14		OC49	
OC15		OC50	Spurious data after 180s
OC16		OC51	
OC17		OC52	
OC18		OC53	
OC19		OC54	
OC20		OC55	
OC21		OC56	
OC22		OC57	
OC23		OC58	
OC24		OC59	
OC25		OC60	
OC26		OC61	
OC27		OC62	
OC28		OC63	
OC29		OC64	
OC30		OC65	
OC31		OC66	
OC32		OC67	No CO2
OC33		OC68	Some CO2 around 200s but also drift
OC34		OC69	Some CO2 around 200s but also drift
OC35		OC70	No CO2

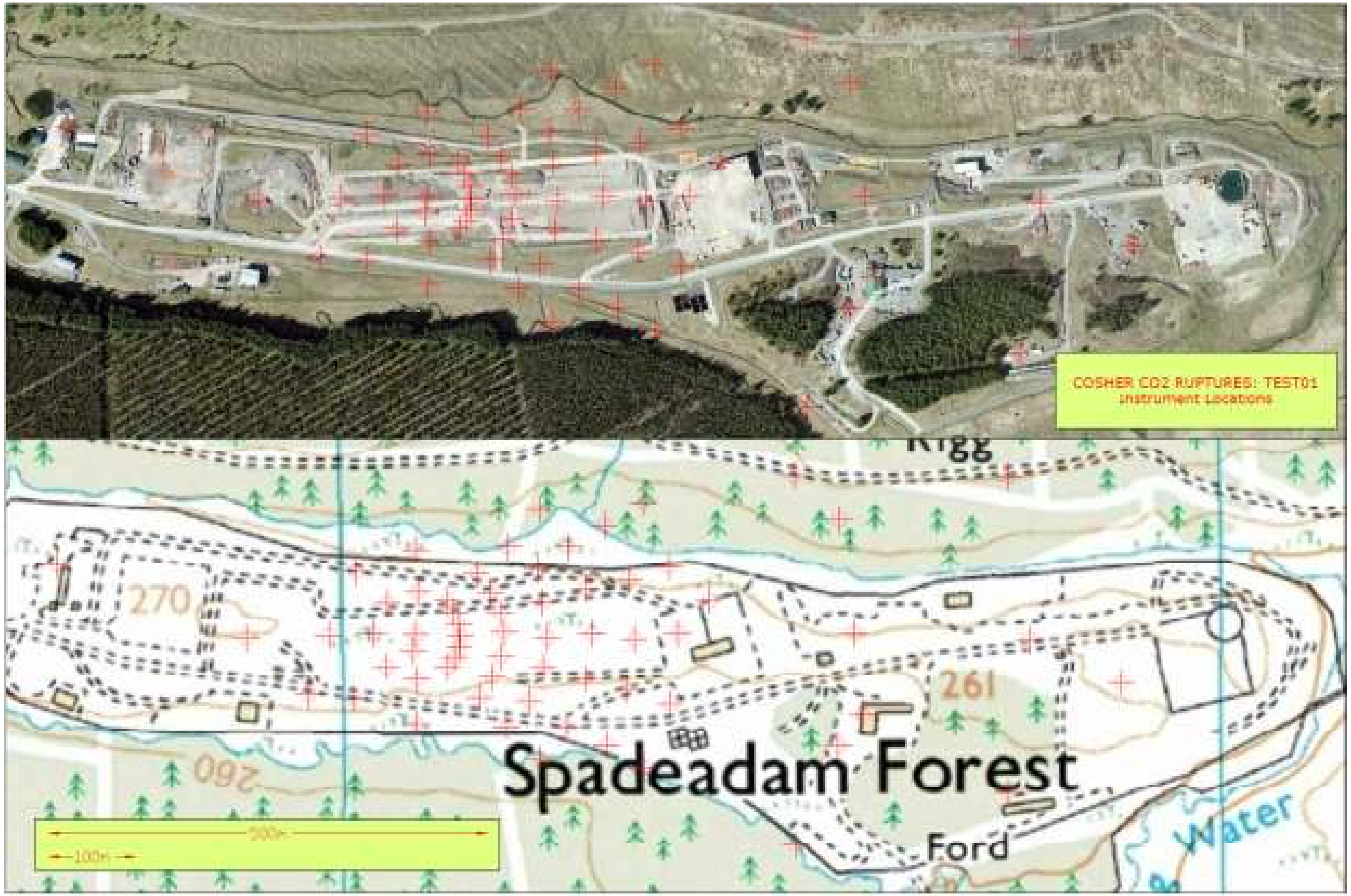


Figure 1: The Spadeadam Test Site Topography and Outline

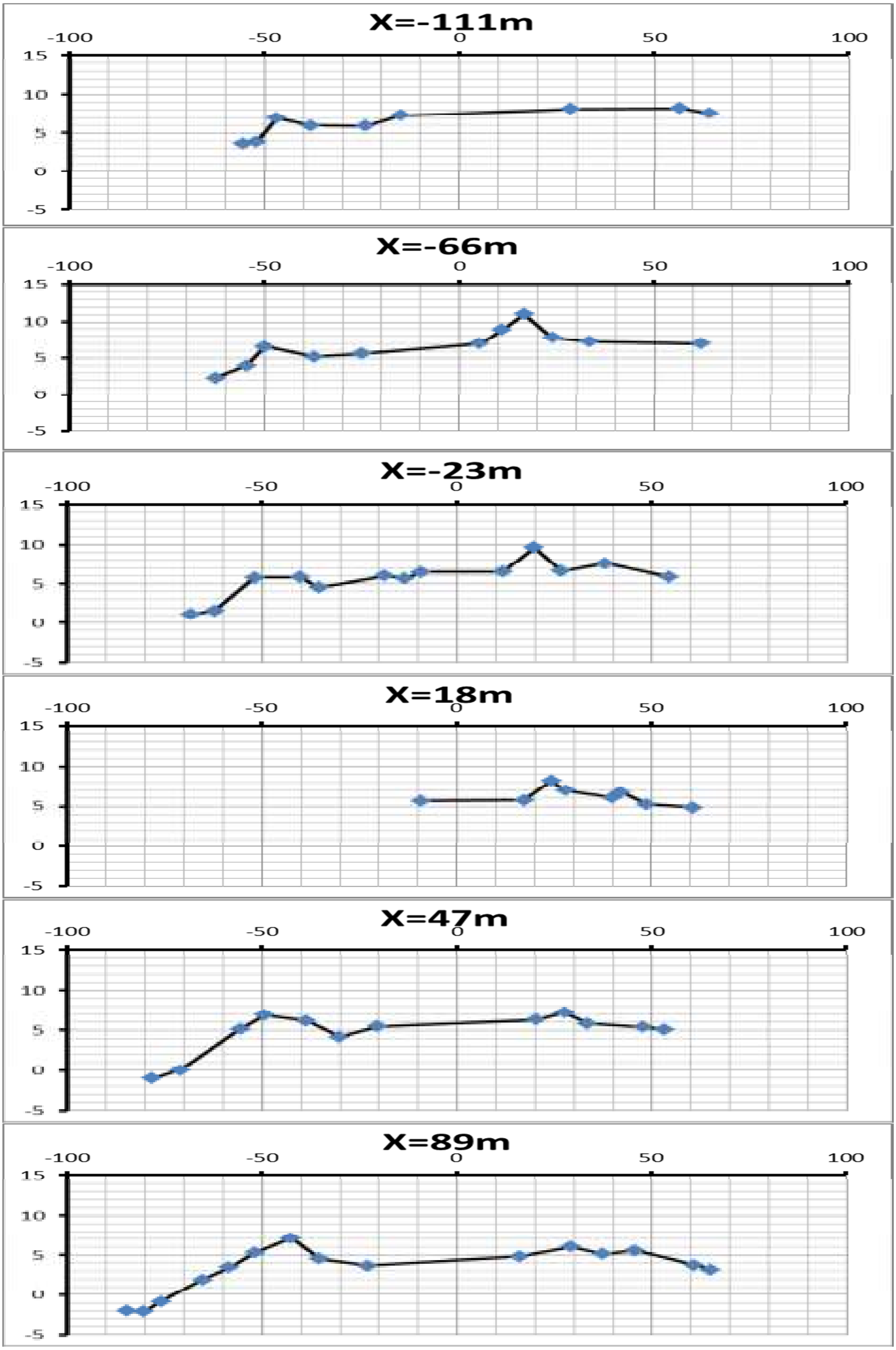


Figure 2: Ground Survey in the Vicinity of the Release

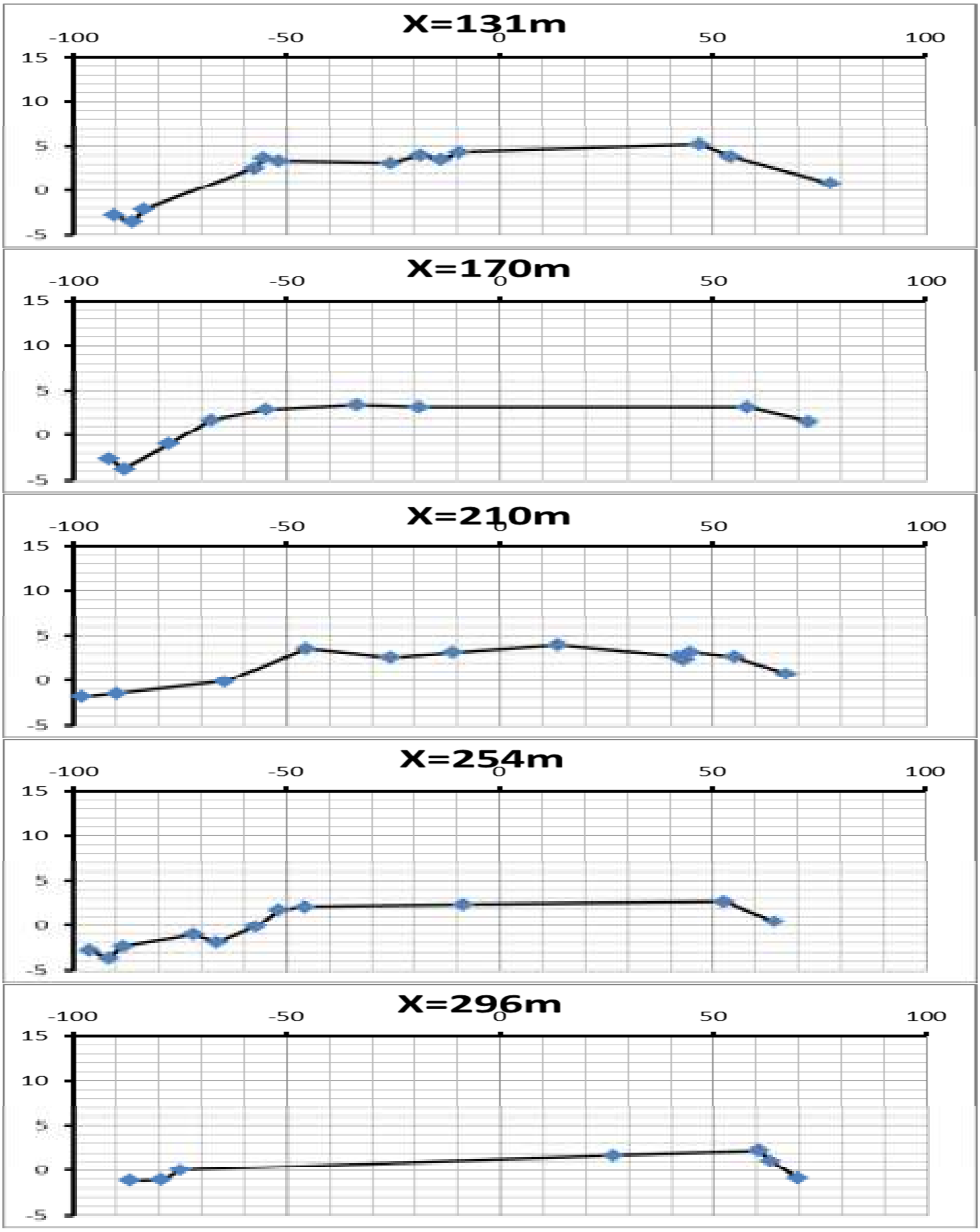


Figure 2 (continued): Ground Survey in the Vicinity of the Release

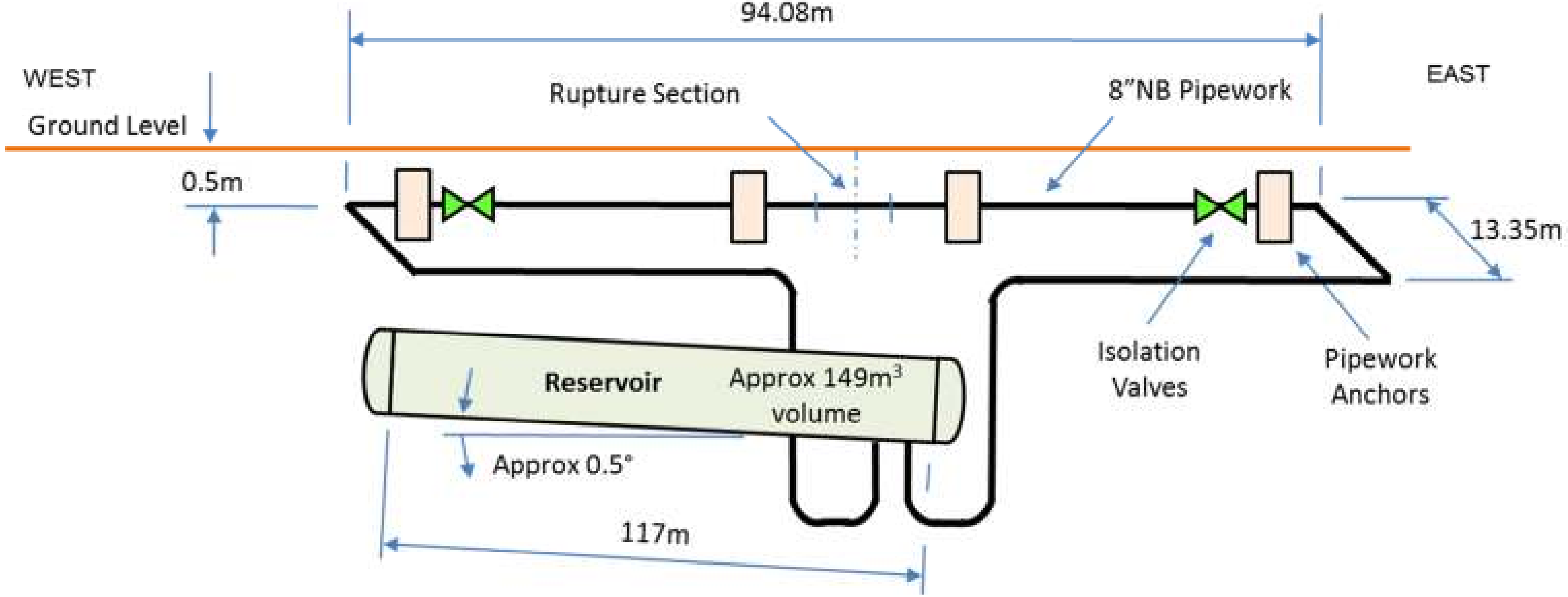


Figure 3: Schematic of the Test Facility

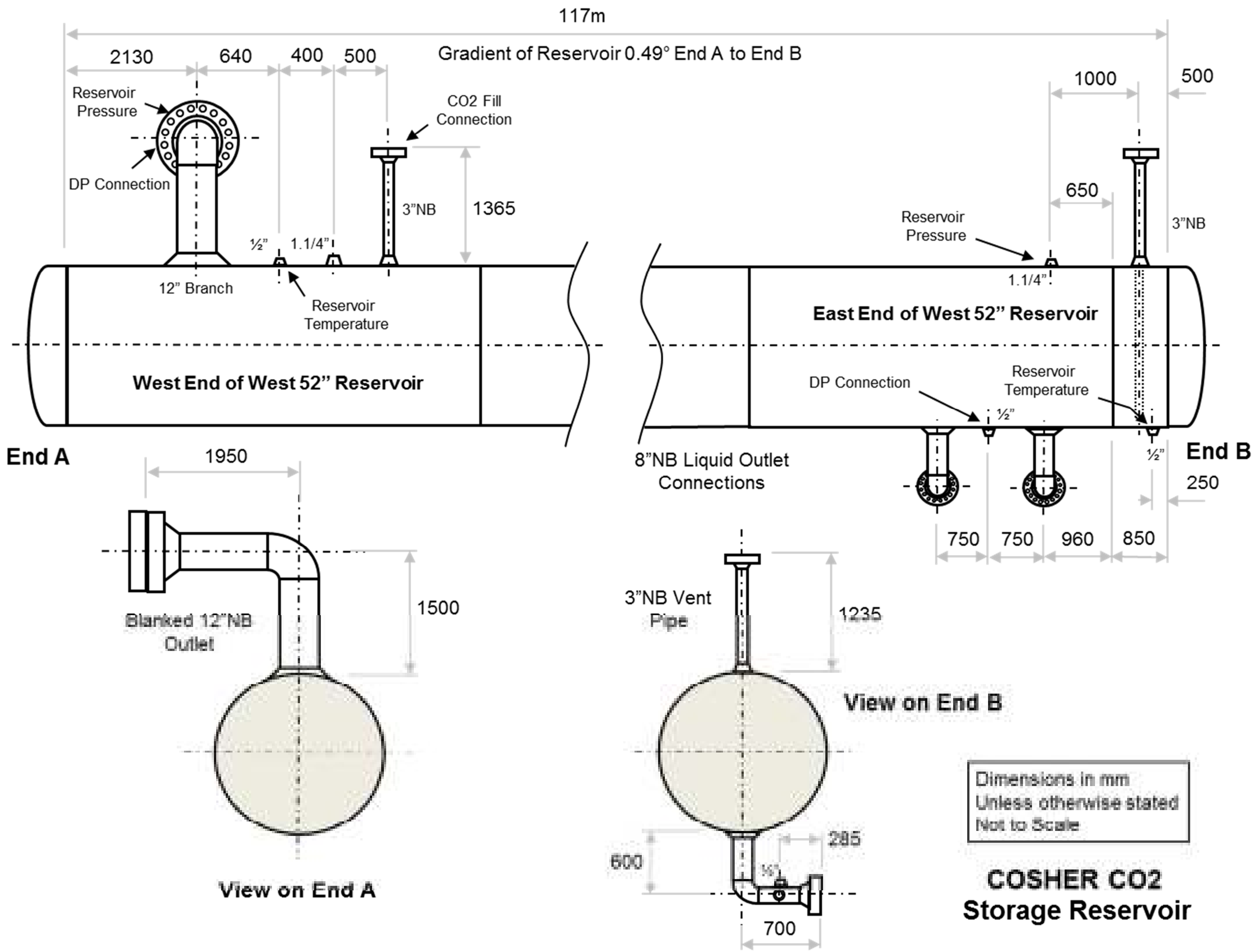


Figure 4: The Storage Reservoir

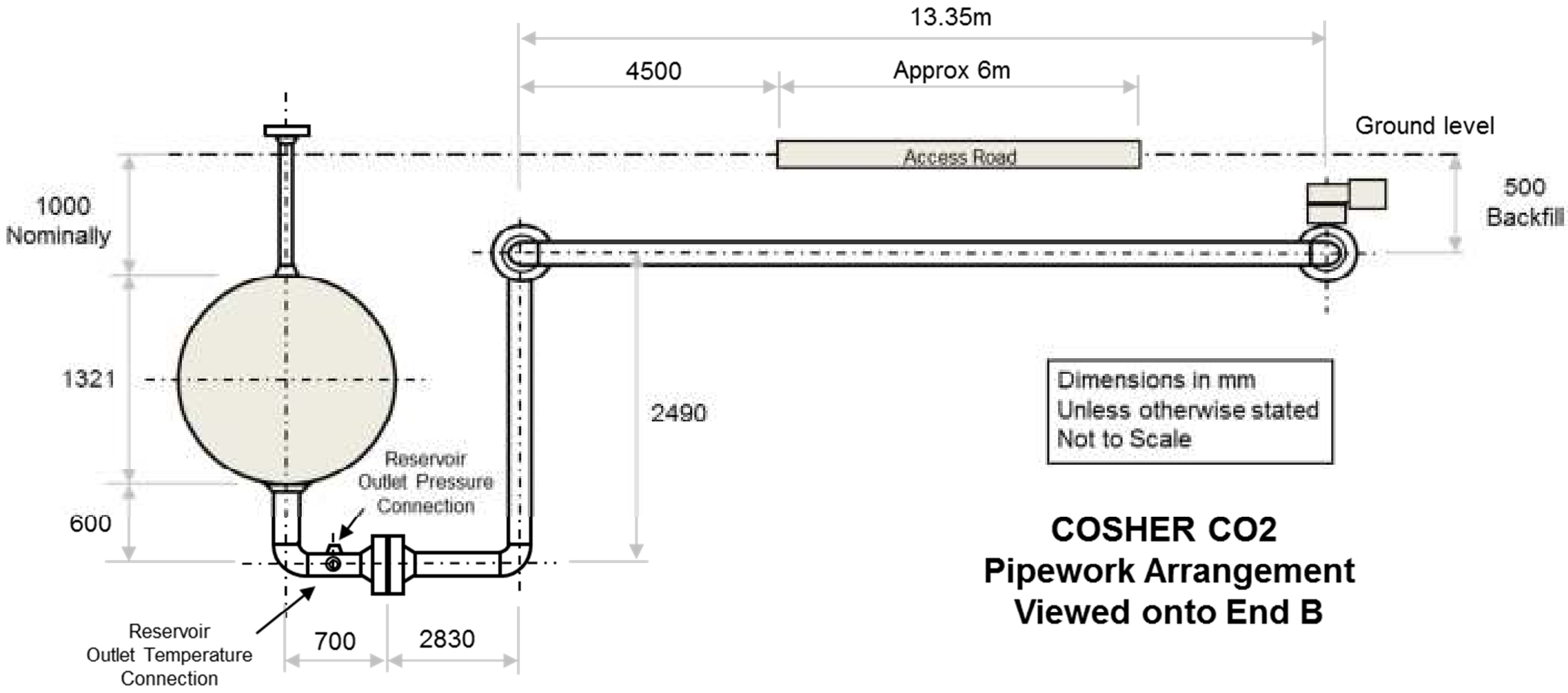


Figure 5: The Pipeline Loop (Viewed from the East)

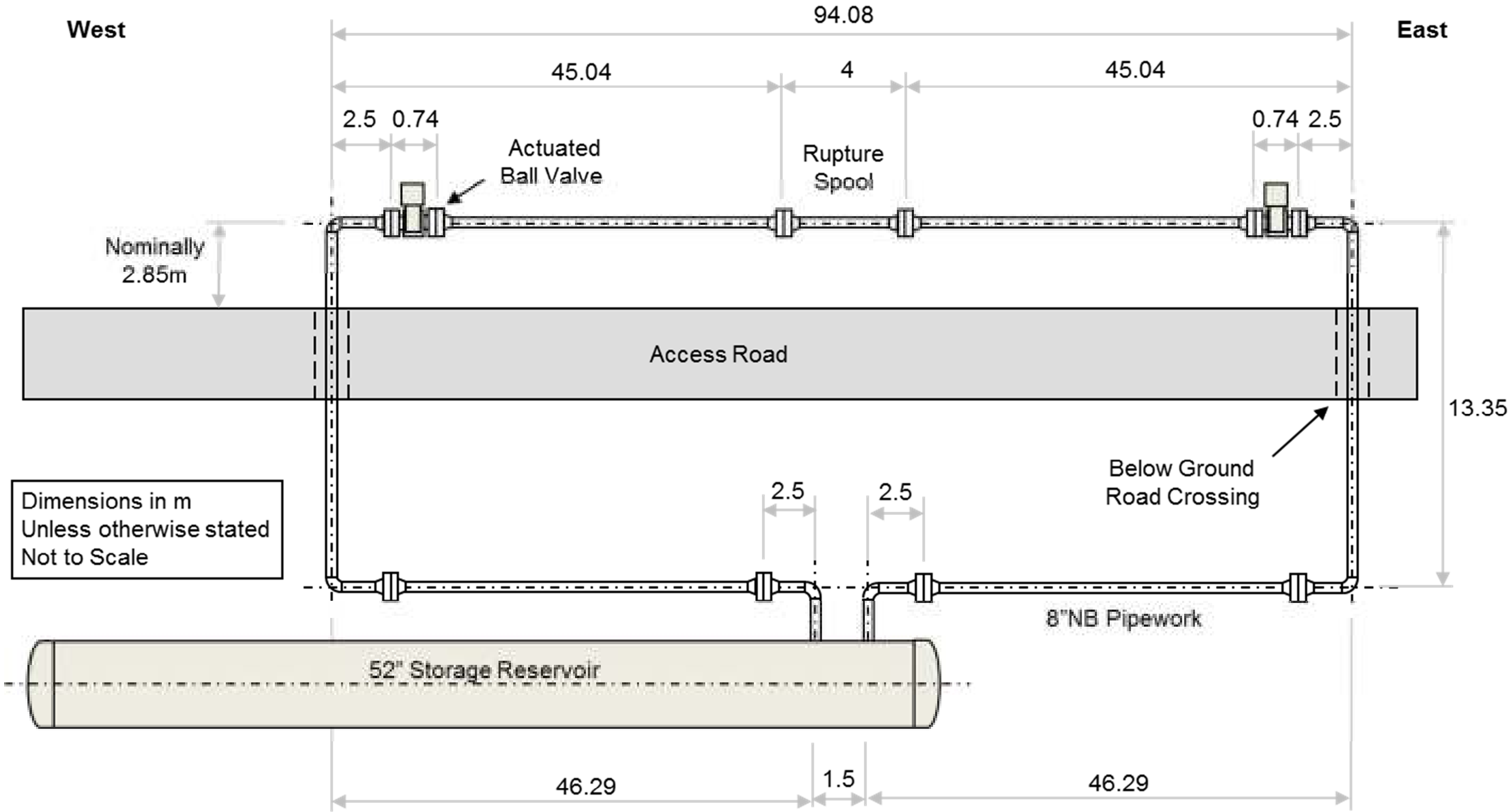
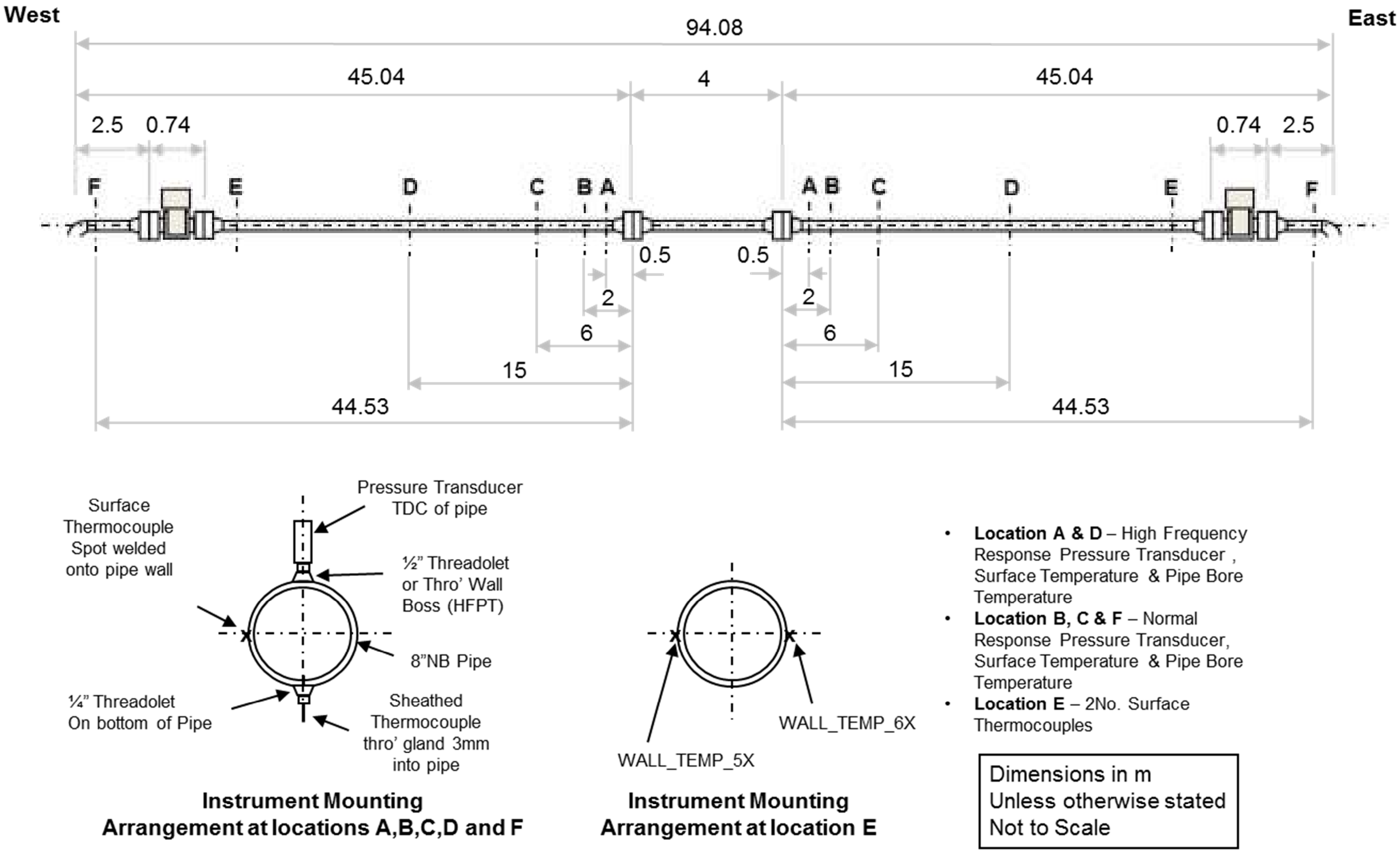


Figure 6: The Pipeline Loop (Plan View)



- **Location A & D** – High Frequency Response Pressure Transducer , Surface Temperature & Pipe Bore Temperature
- **Location B, C & F** – Normal Response Pressure Transducer, Surface Temperature & Pipe Bore Temperature
- **Location E** – 2No. Surface Thermocouples

Dimensions in m
Unless otherwise stated
Not to Scale

Figure 7: Instrument Locations Either Side of the Rupture

Figure 8: The Rupture Location Before the Test

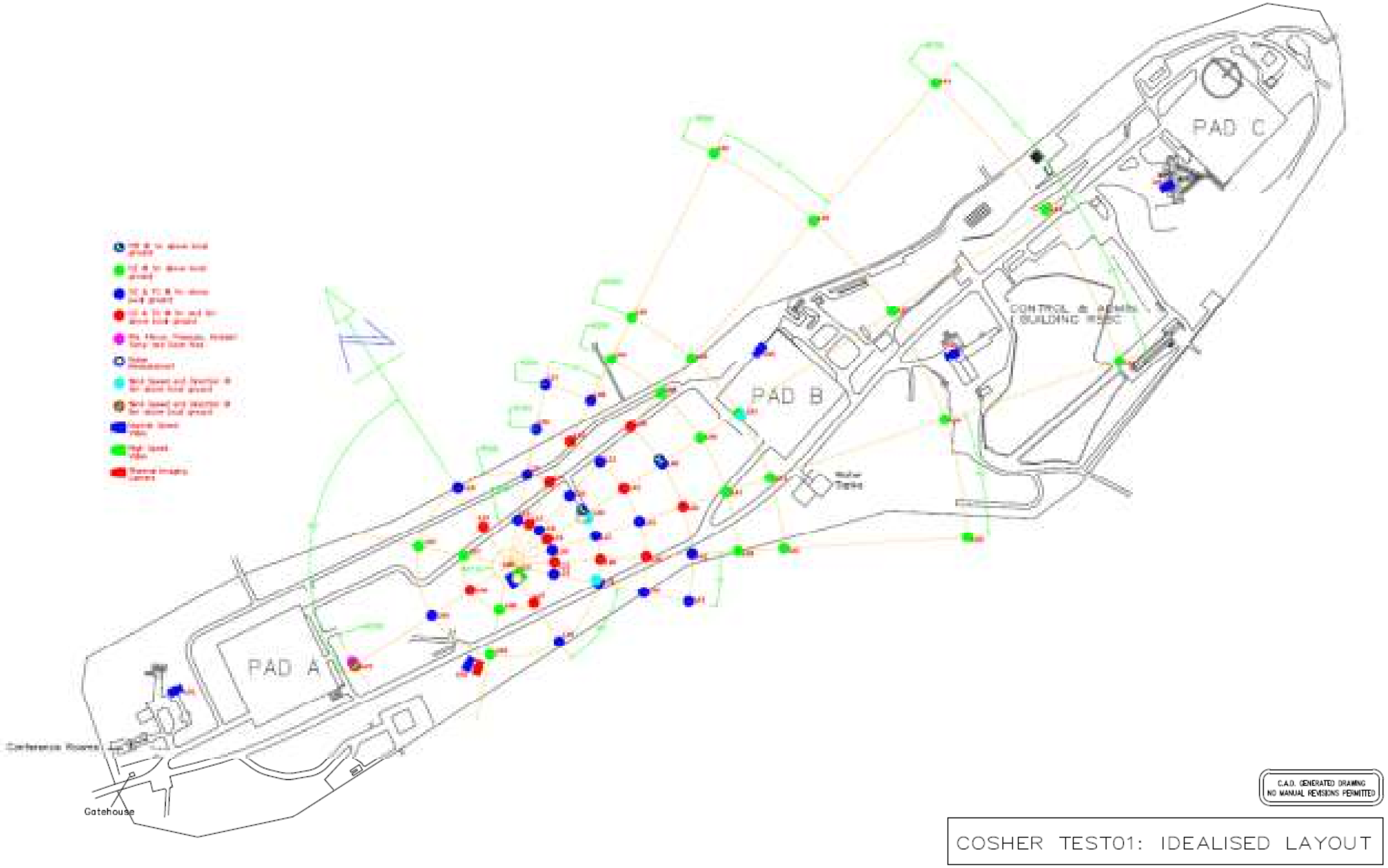


Figure 9: Layout of Nominal Locations for Field Instrumentation

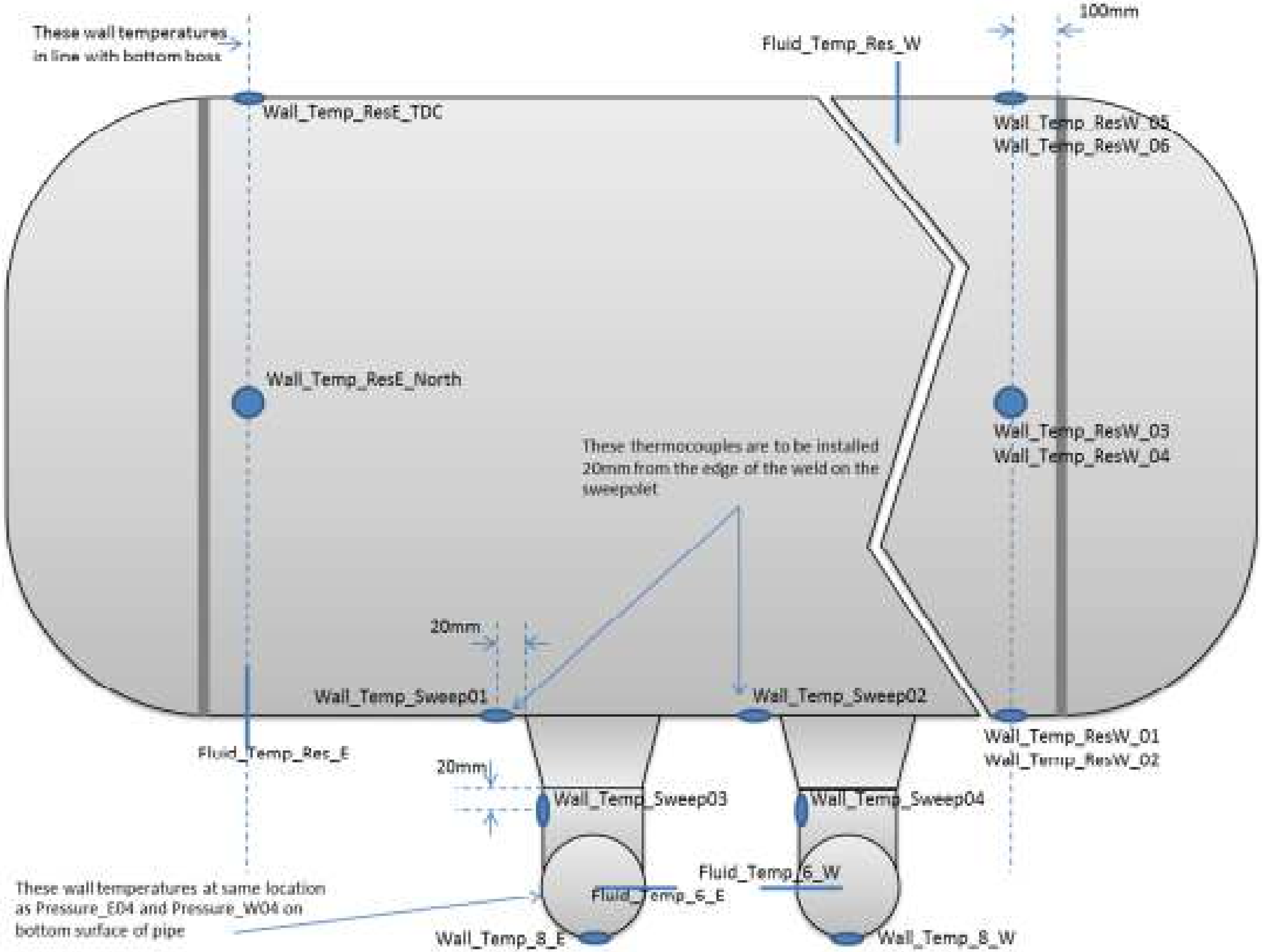


Figure 10: Schematic of the Wall Temperature Measurements on the Reservoir

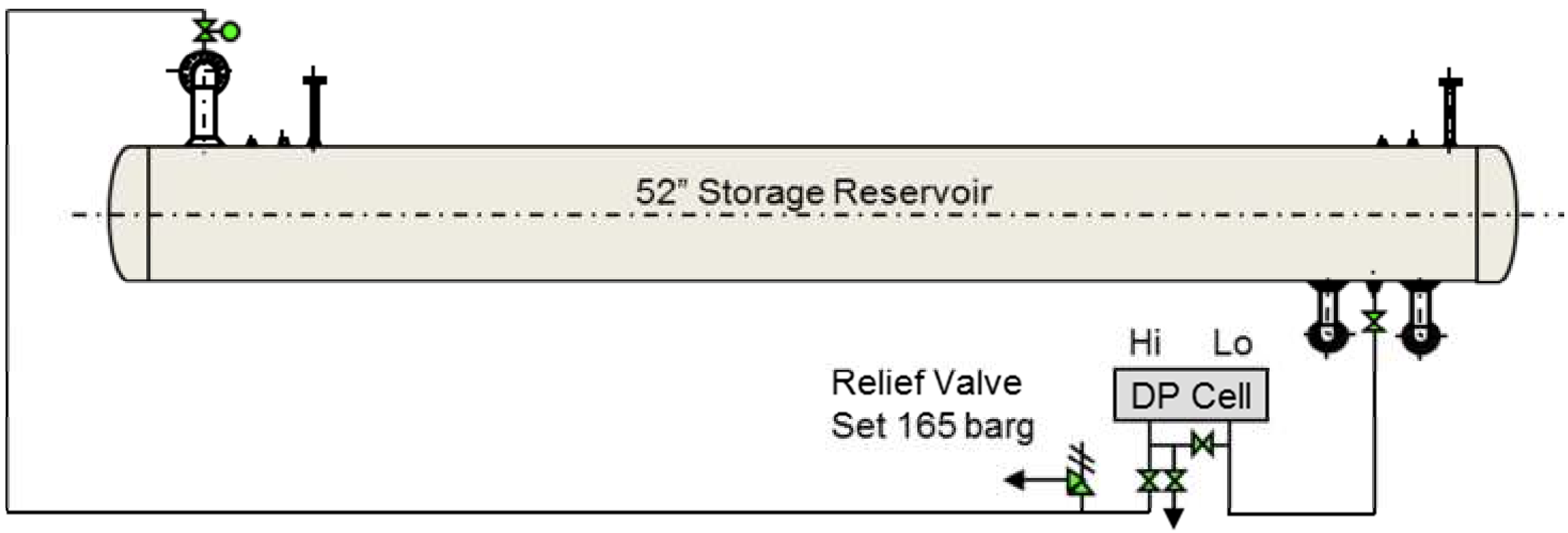


Figure 11: Schematic of the Differential Pressure Measurement System

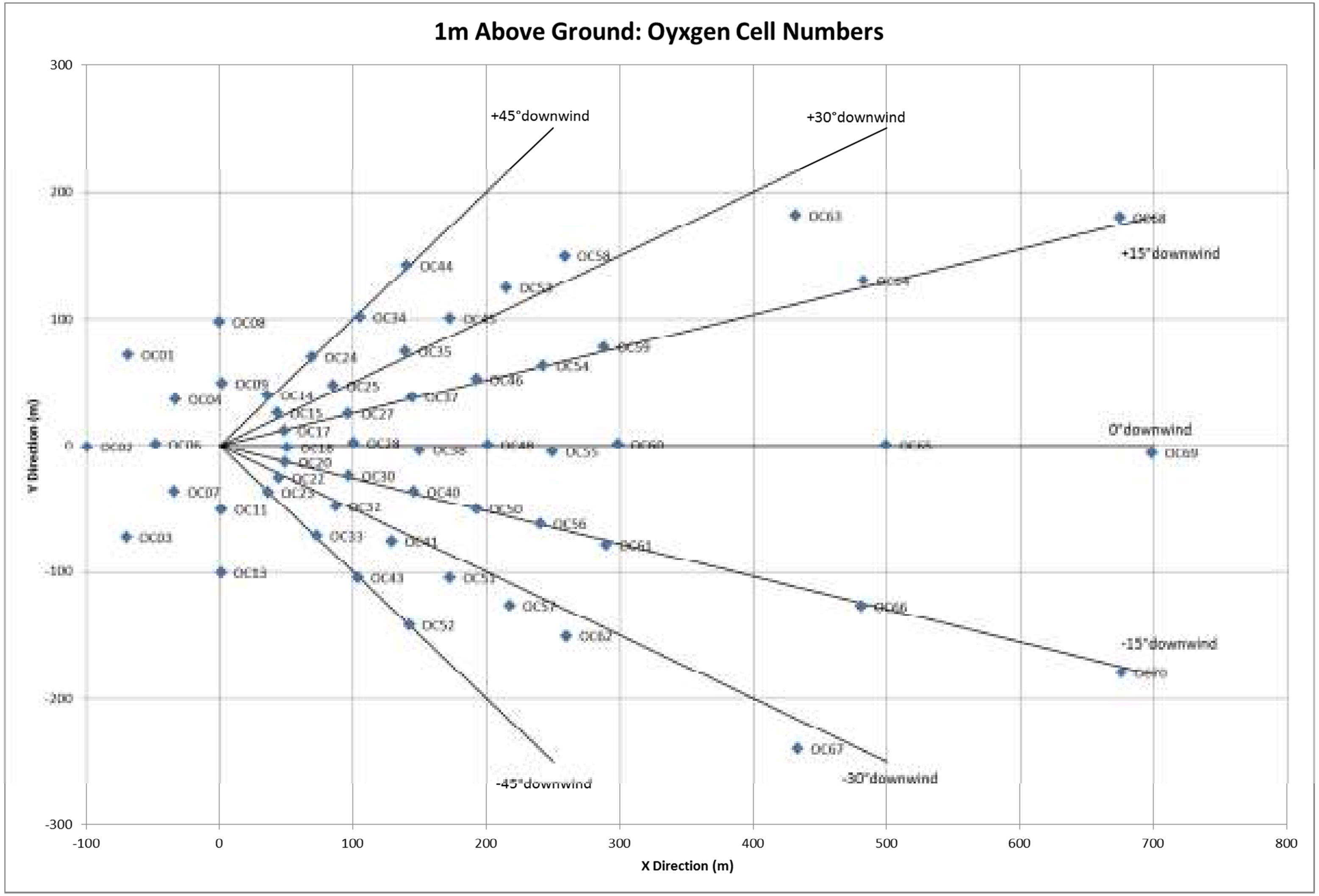


Figure 12: Arrangement of Oxygen Cells at 1m above Local Ground Level

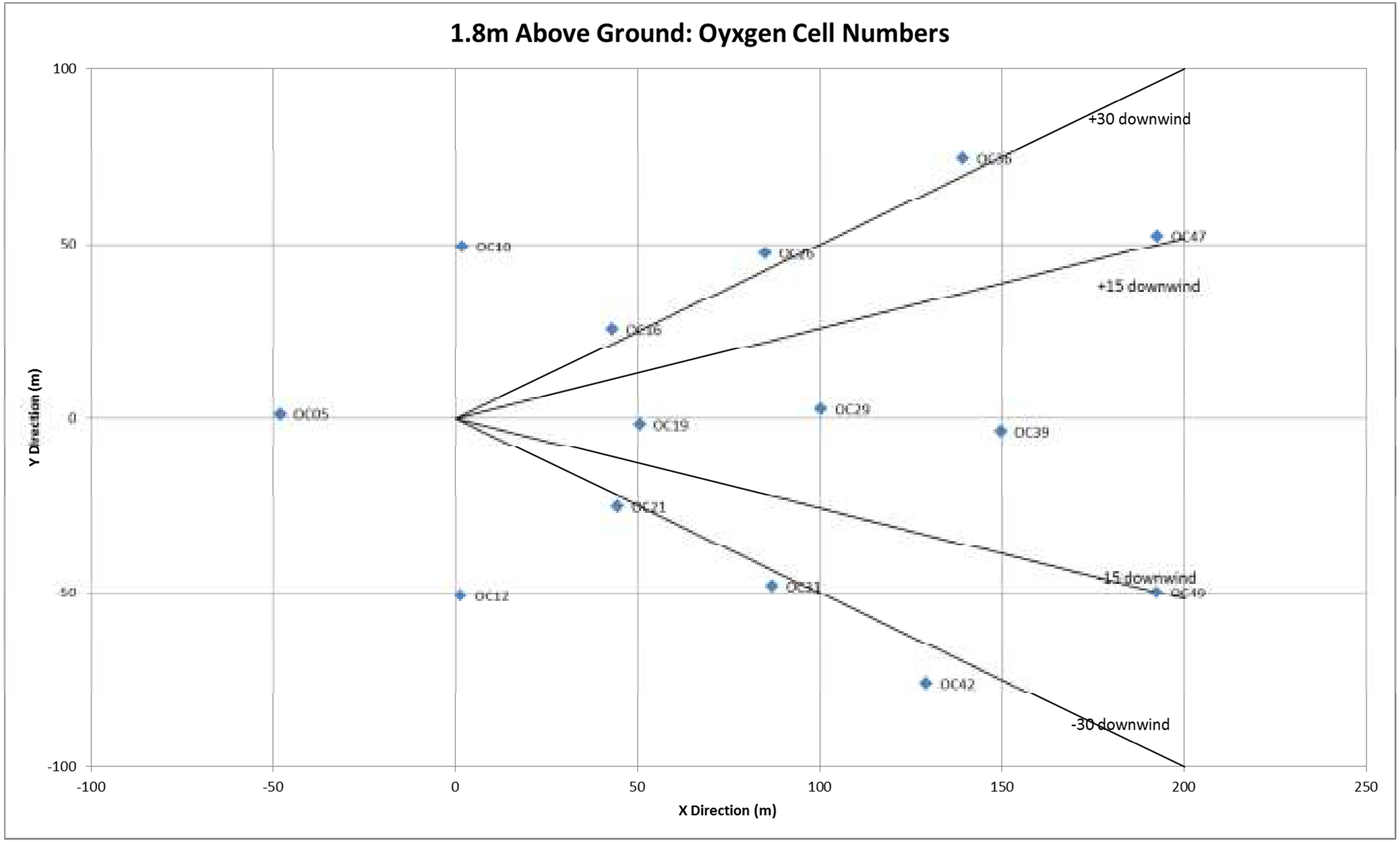


Figure 13: Arrangement of Oxygen Cells at 1.8m above Local Ground Level

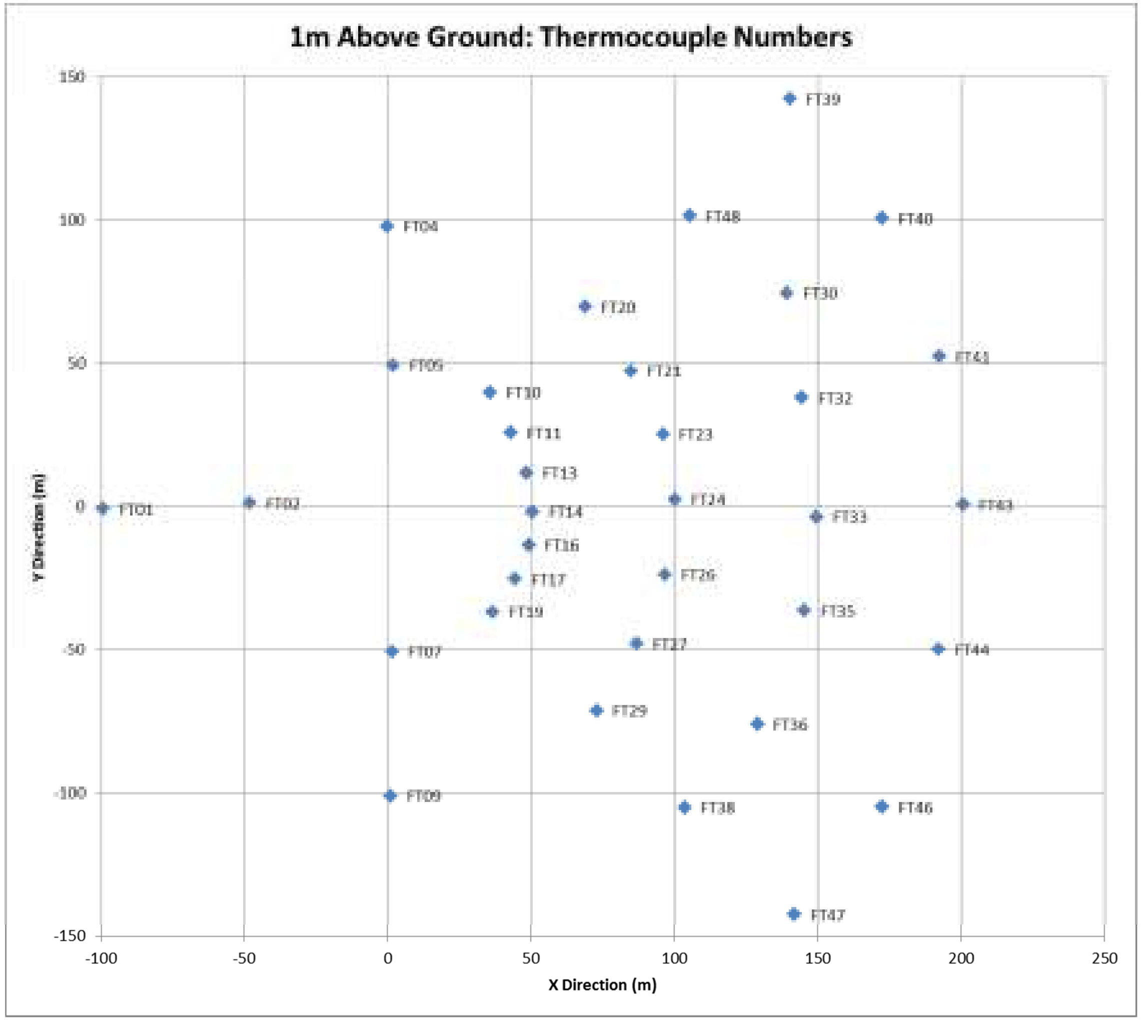


Figure 14: Arrangement of Thermocouples 1m above Local Ground Level

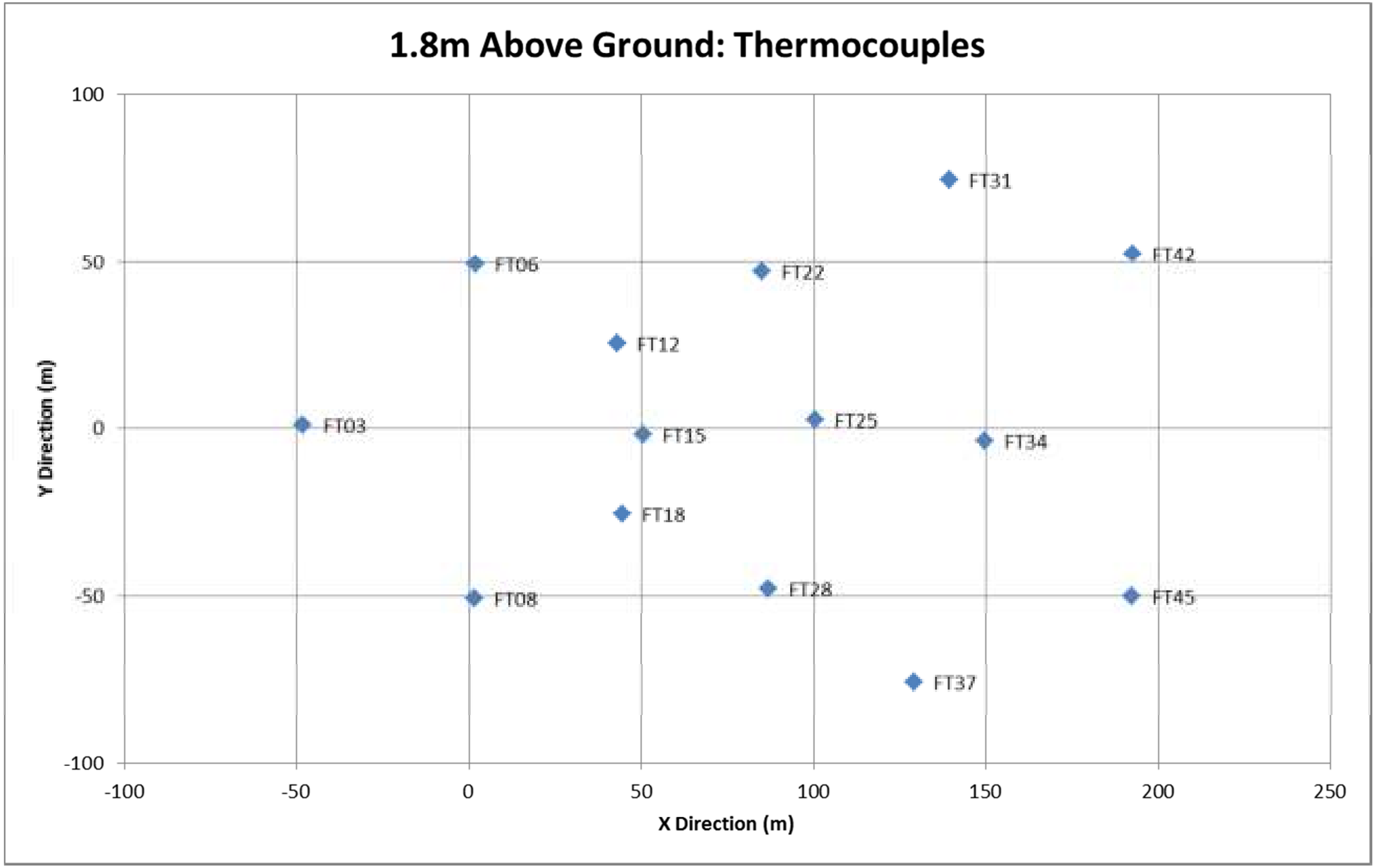


Figure 15: Arrangement of Thermocouples 1.8m above Local Ground Level

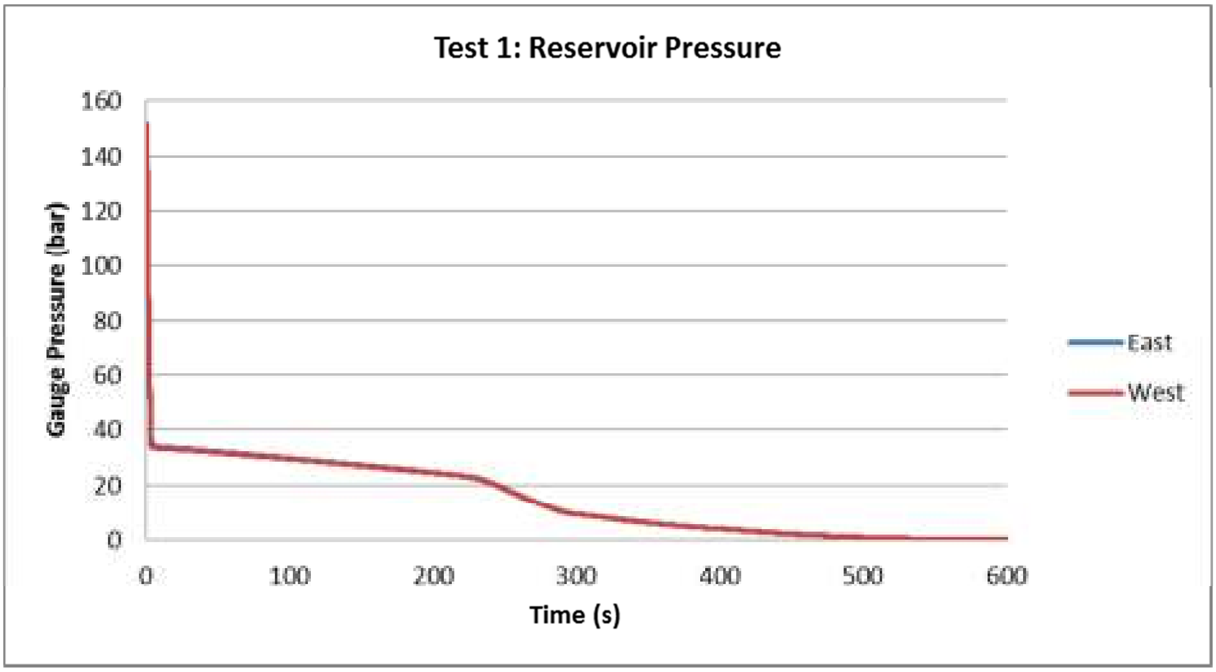


Figure 16(a): Reservoir Pressure throughout the Test

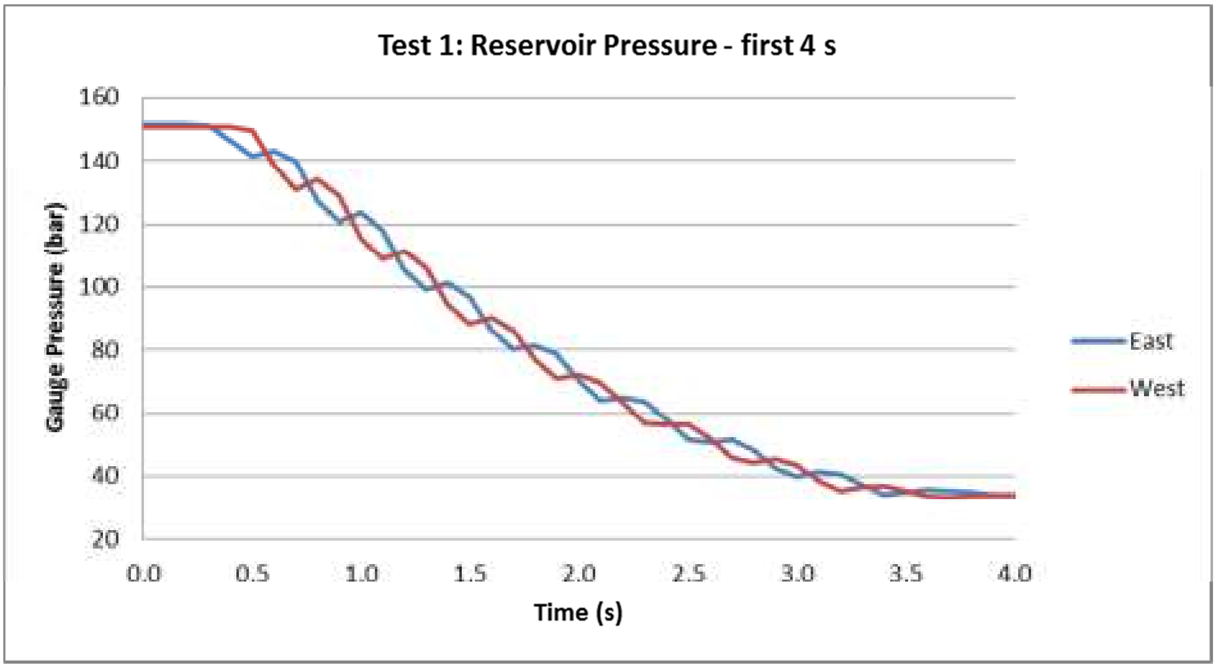


Figure 16(b): Reservoir Pressure in the first 4 Seconds

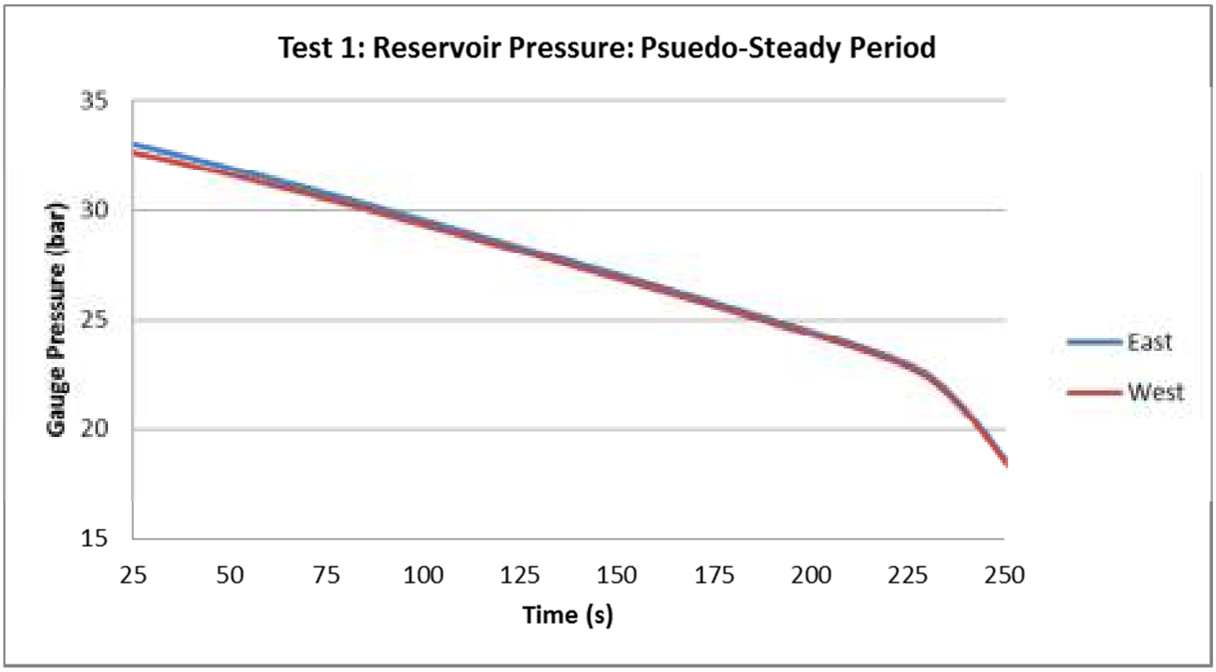


Figure 16(c): Reservoir Pressure during the Pseudo-Steady Period

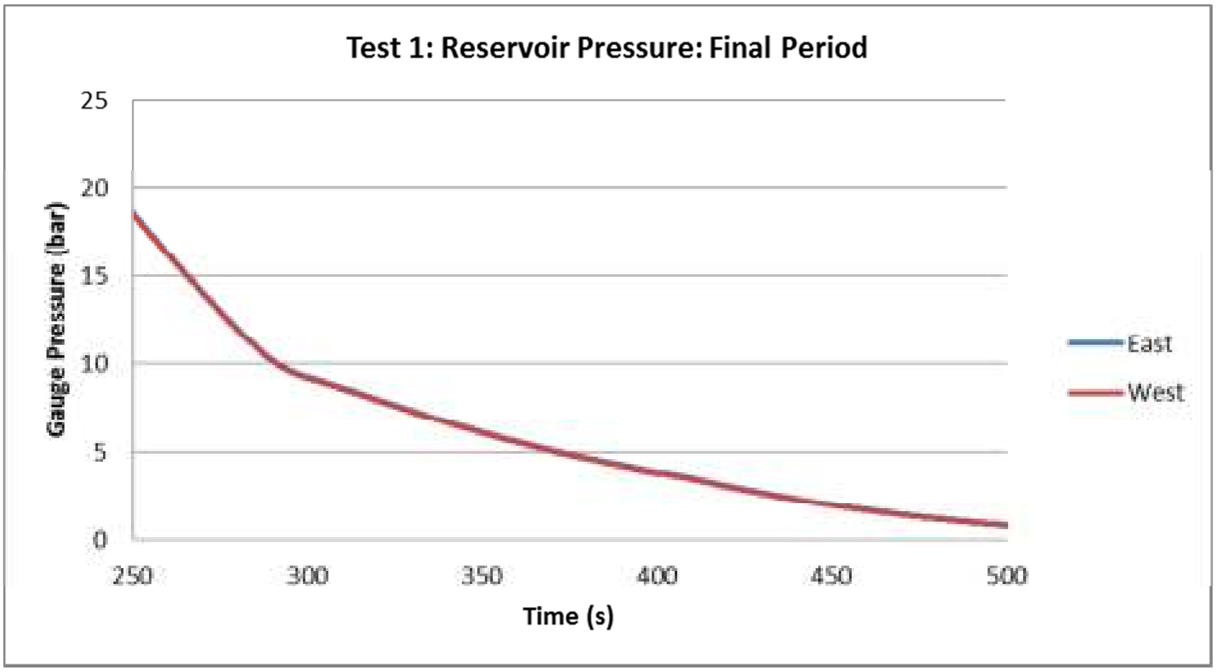


Figure 16(d): Reservoir Pressure for the Final Period of the Test

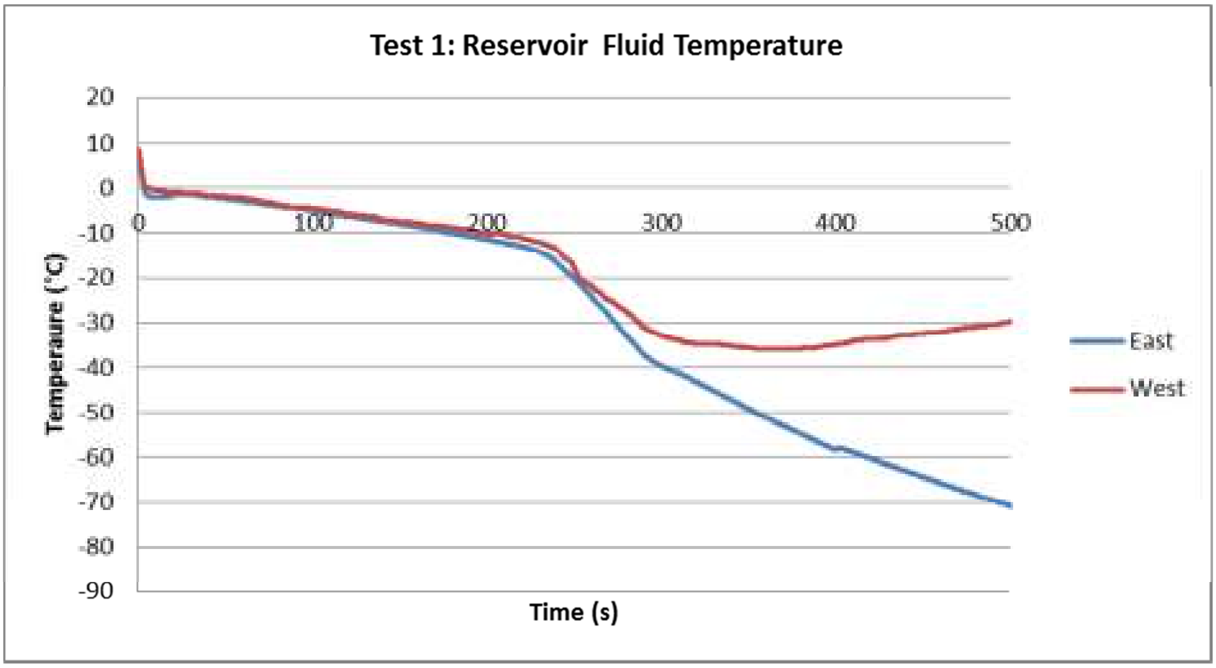


Figure 17(a): Reservoir Fluid Temperature throughout the Test

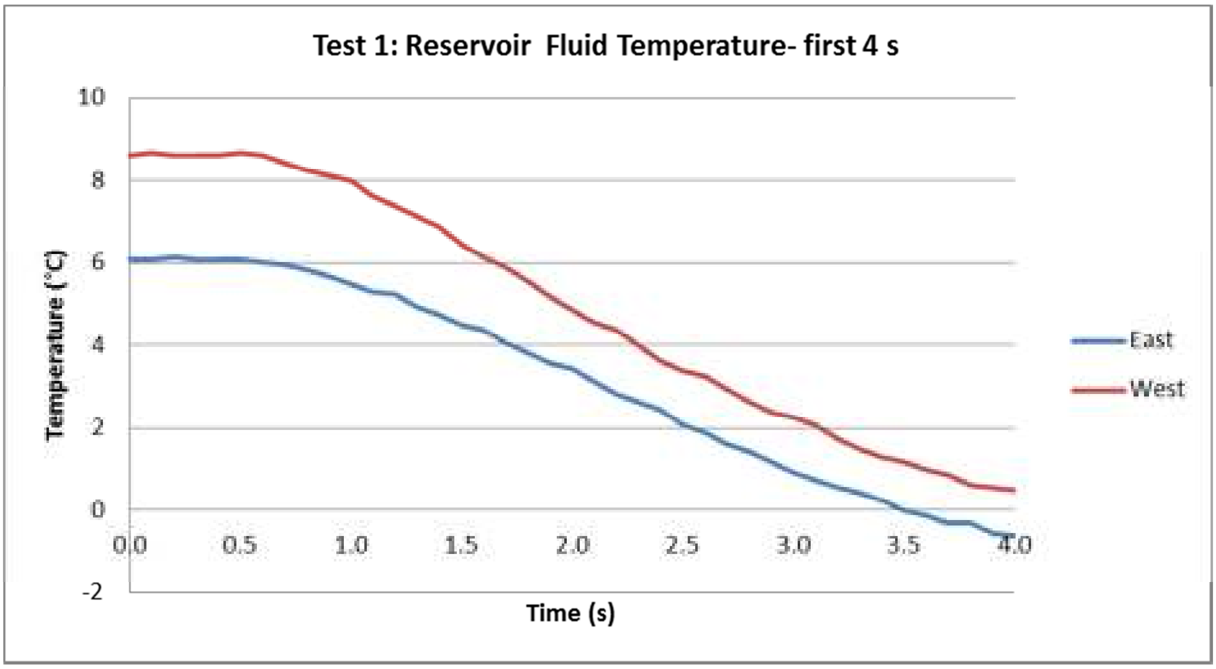


Figure 17(b): Reservoir Fluid Temperature in the first 4 Seconds

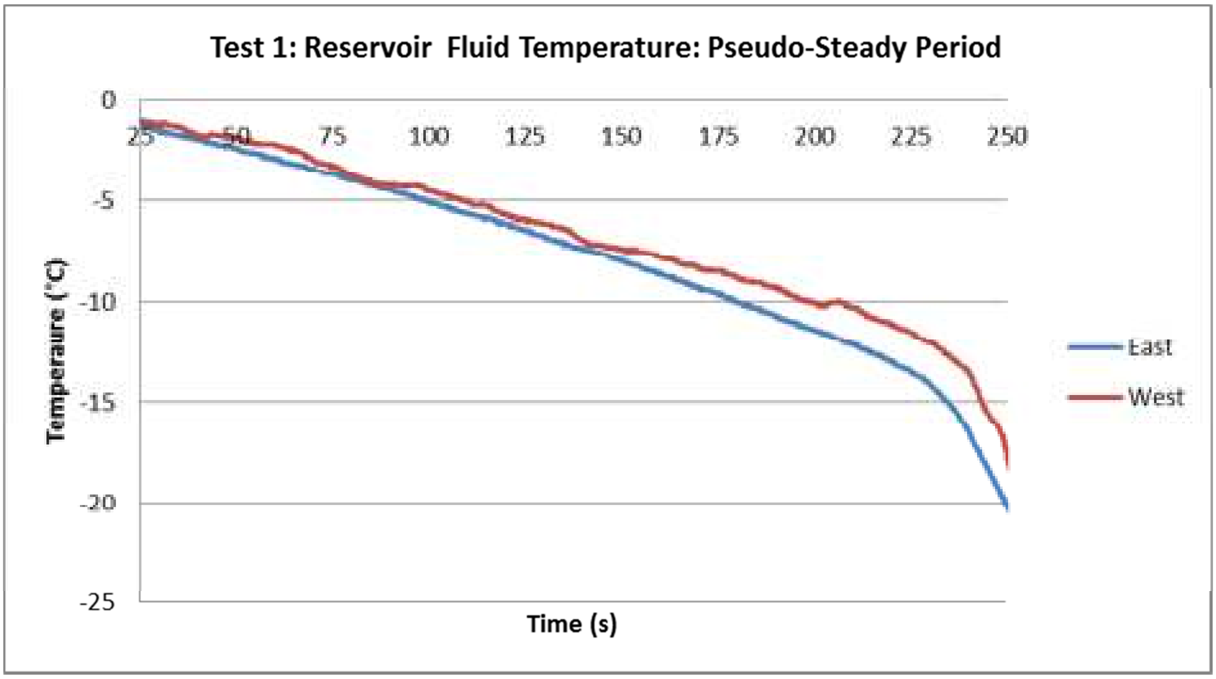


Figure 17(c): Reservoir Fluid Temperature during the Pseudo-Steady Period

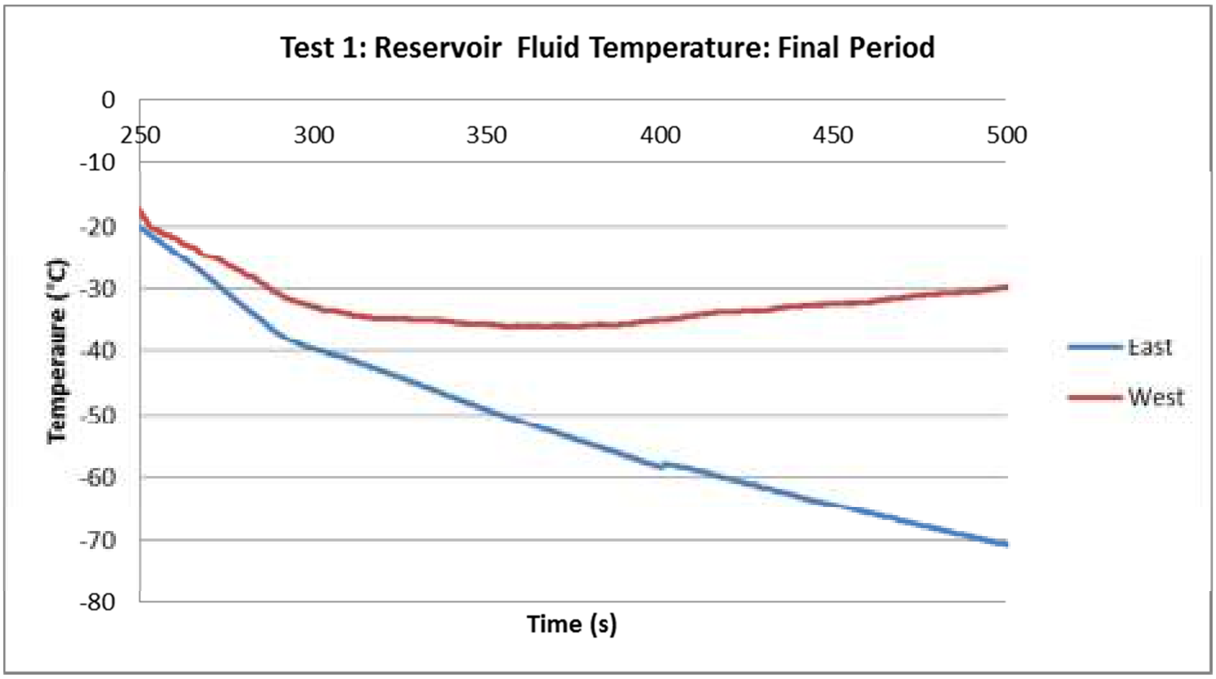


Figure 17(d): Reservoir Fluid Temperature for the Final Period of the Test

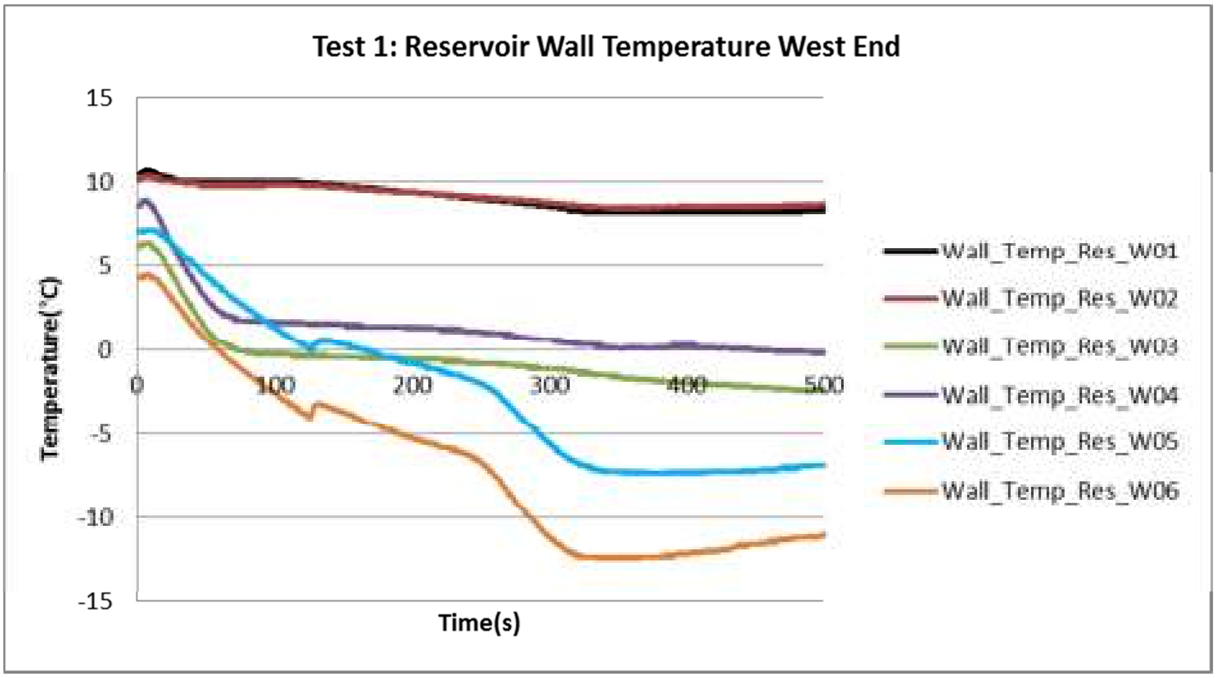


Figure 18(a): Reservoir Wall Temperature at the West End

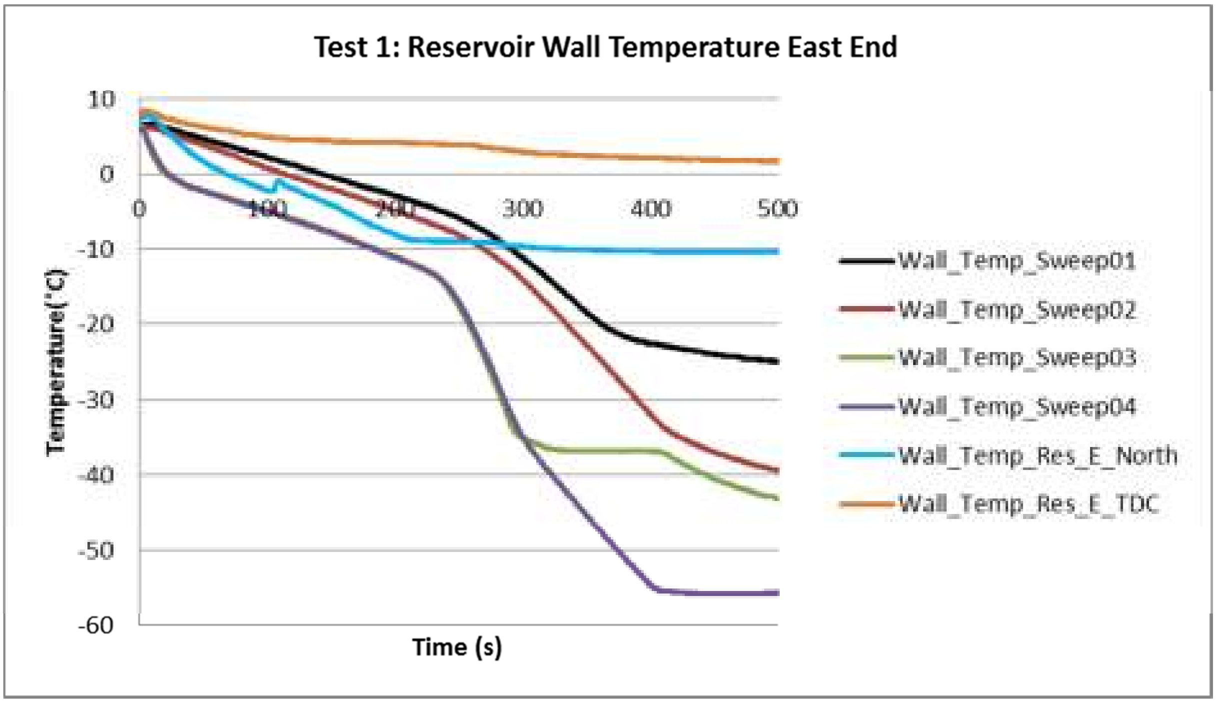


Figure 18(b): Reservoir Wall Temperature at the East End

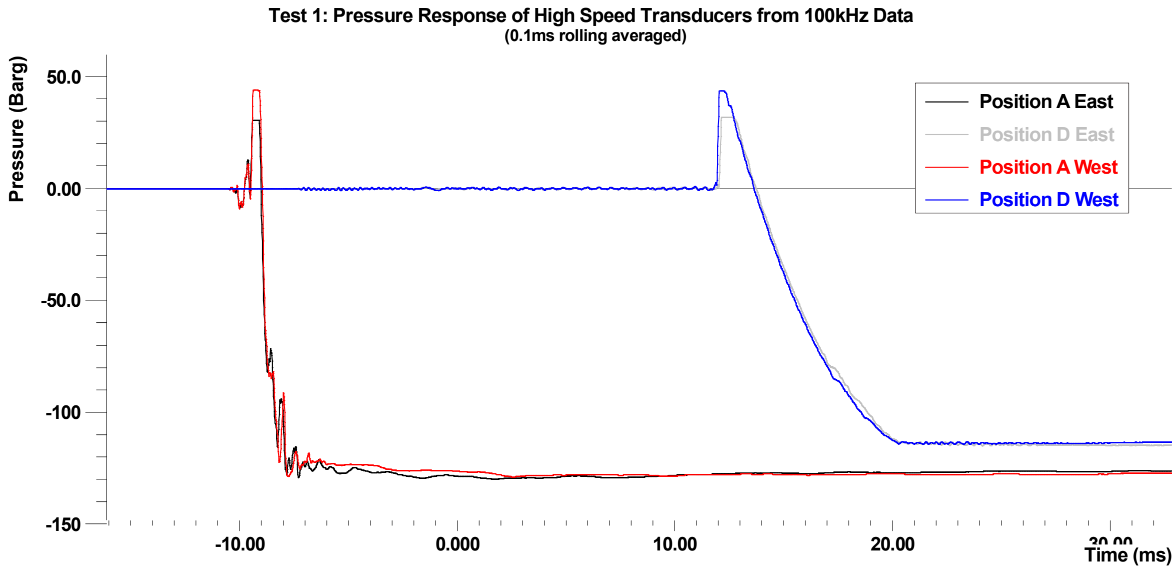


Figure 19(a): Pressures from the High Speed Pressure Transducers at the Time of Rupture from 100 kHz data

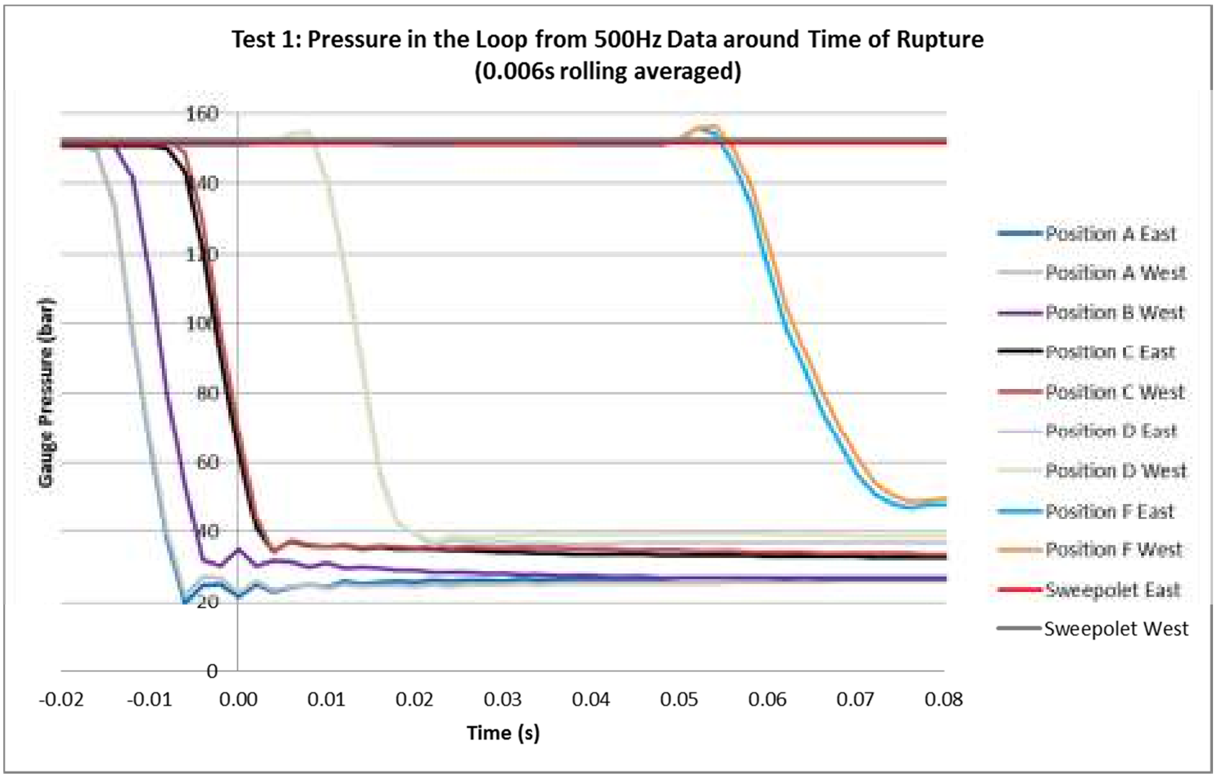


Figure 19(b): Pressures in the Pipeline Loop Around the Time of Rupture

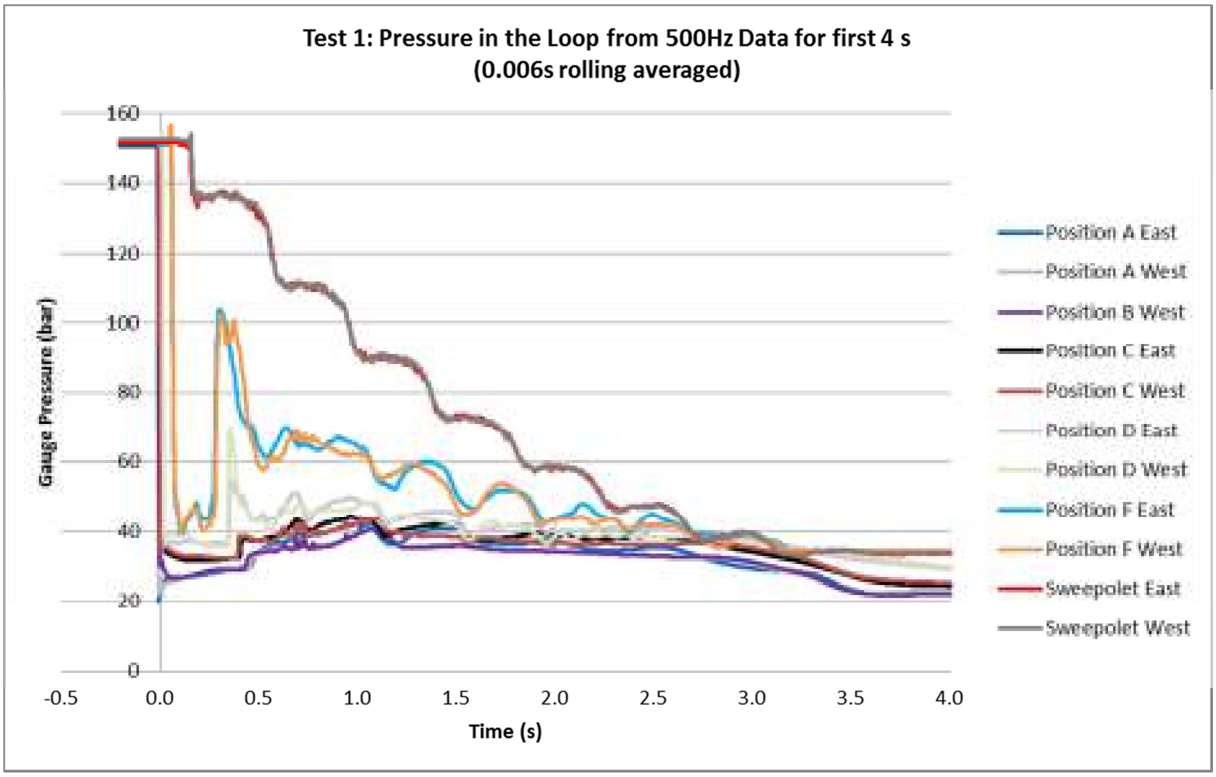


Figure 19(c): Pressures in the Pipeline Loop in the first 4 Seconds

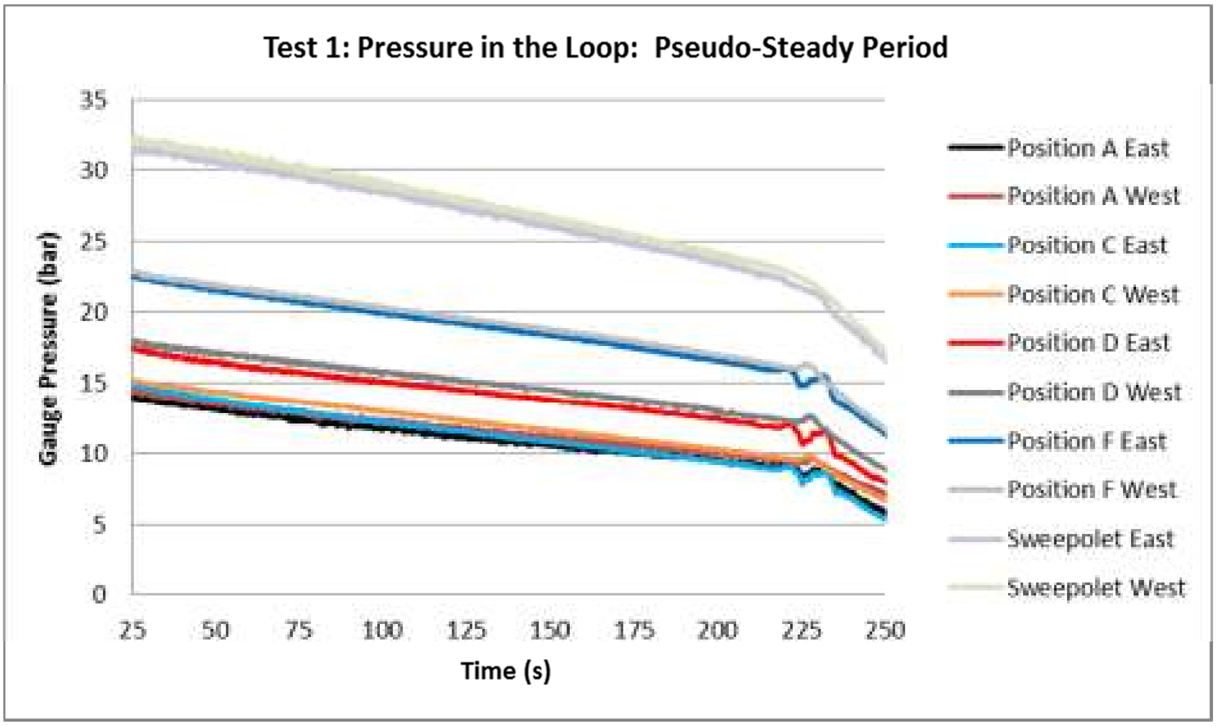


Figure 19(d): Pressures in the Pipeline Loop during the Pseudo-Steady Period

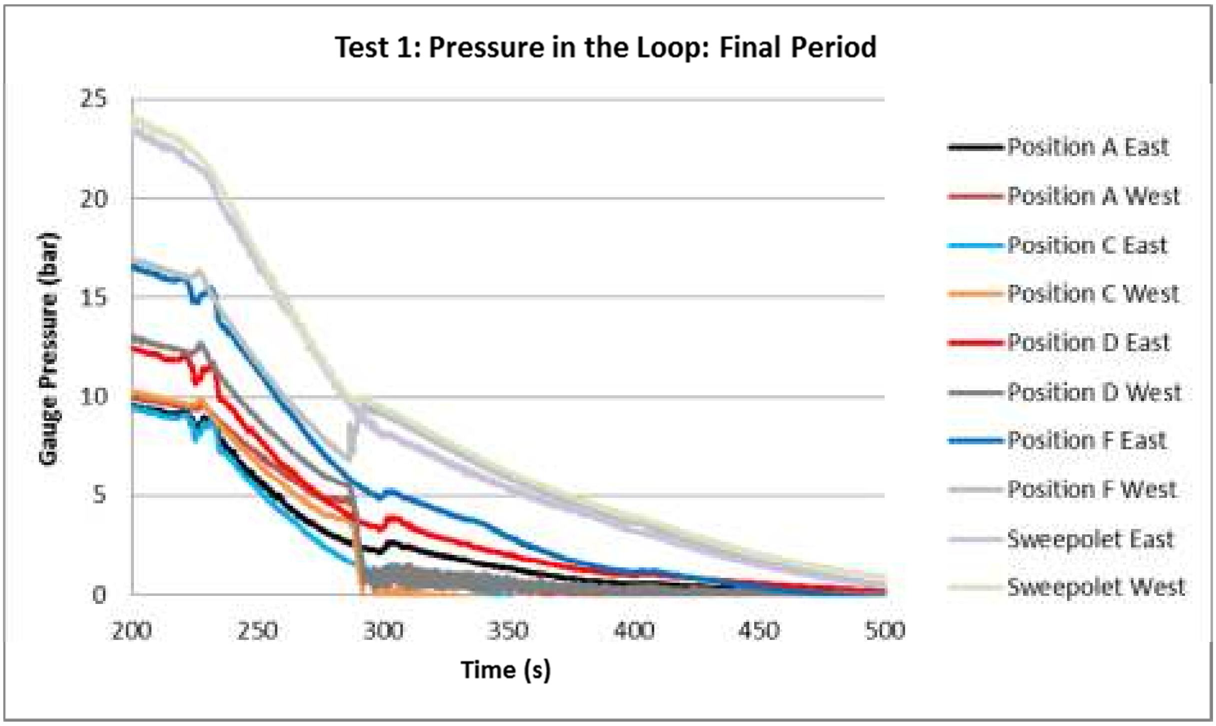


Figure 19(e): Pressures in the Pipeline Loop during the Final Period of the Test

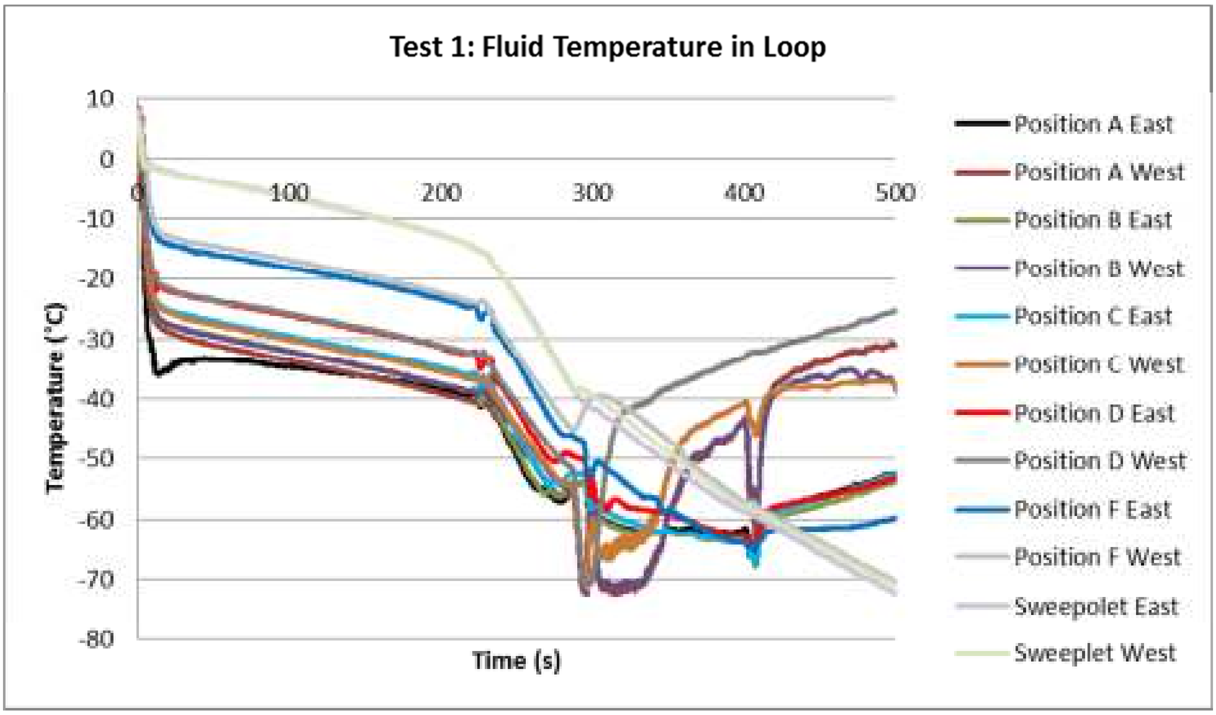


Figure 20(a): Fluid Temperatures in the Pipeline Loop throughout the Test

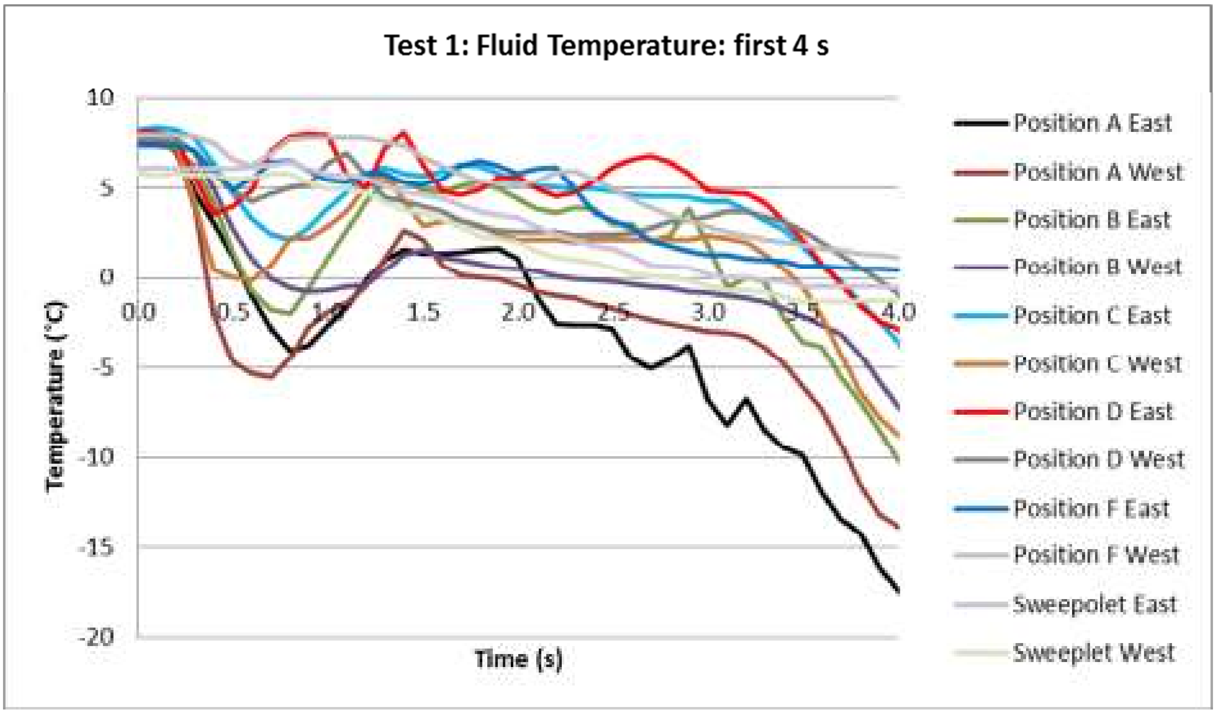


Figure 20(b): Fluid Temperatures in the Pipeline Loop in the first 4 Seconds

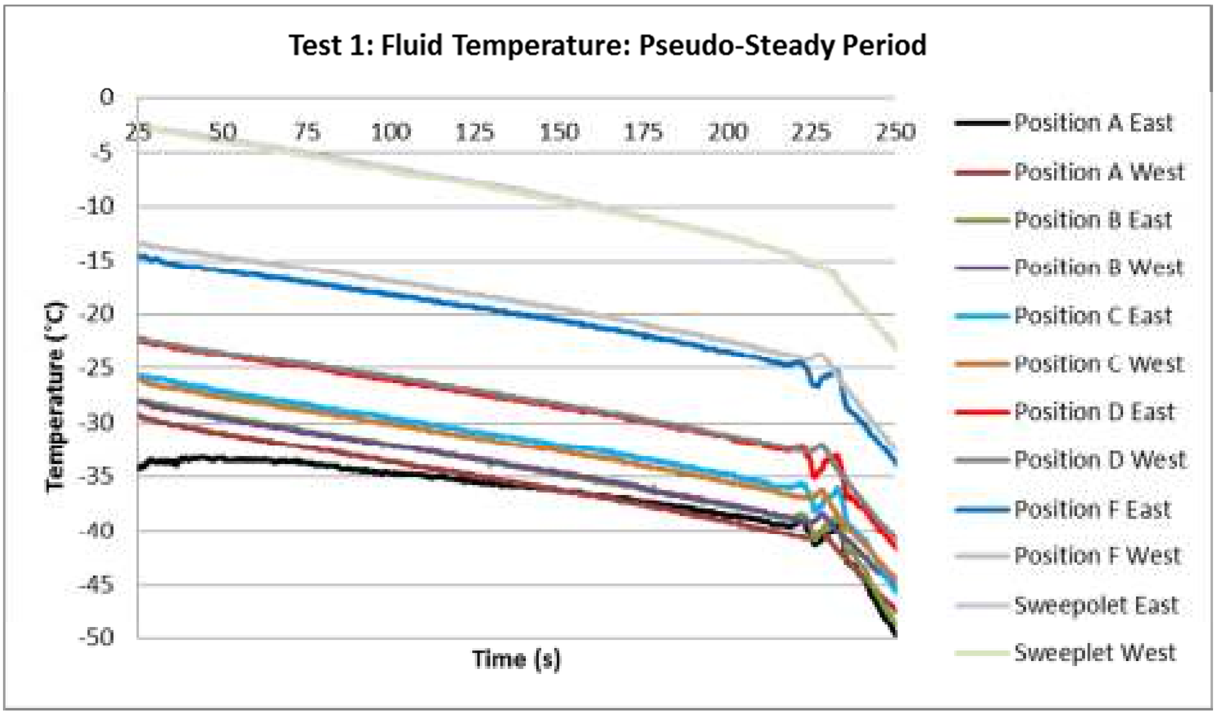


Figure 20(c): Fluid Temperatures in the Pipeline Loop during the Pseudo-Steady Period

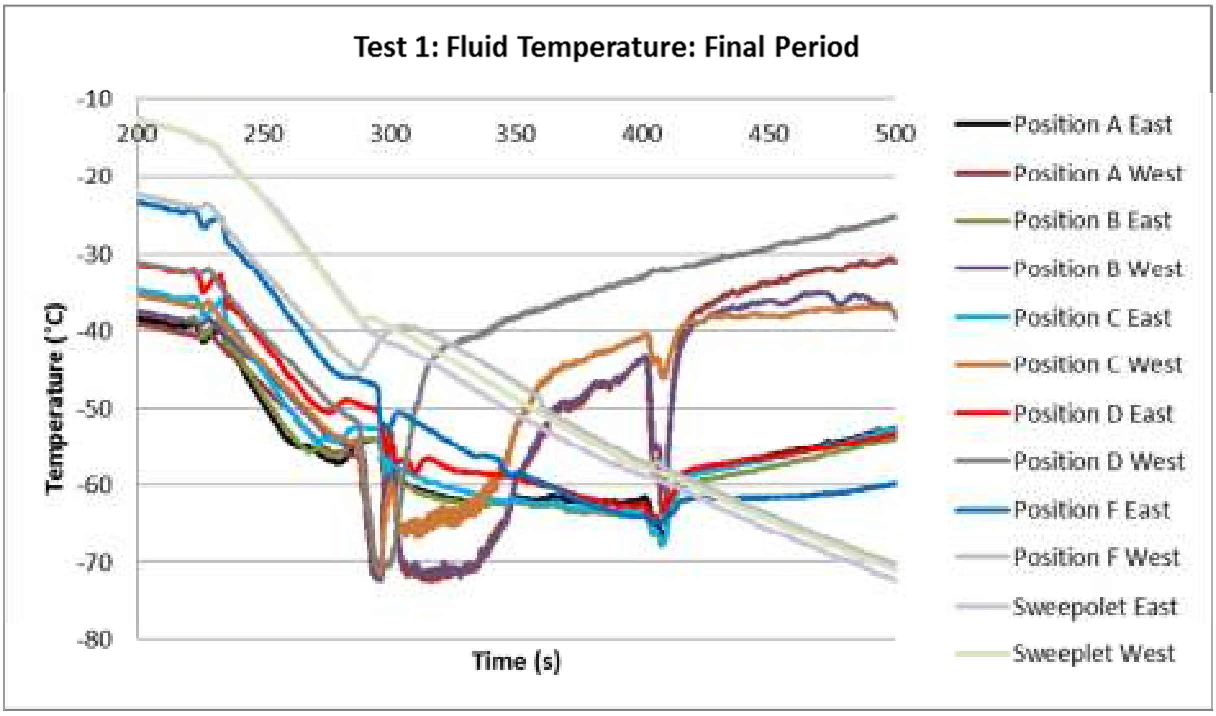


Figure 20(d): Fluid Temperatures in the Pipeline Loop during the Final Period of the Test

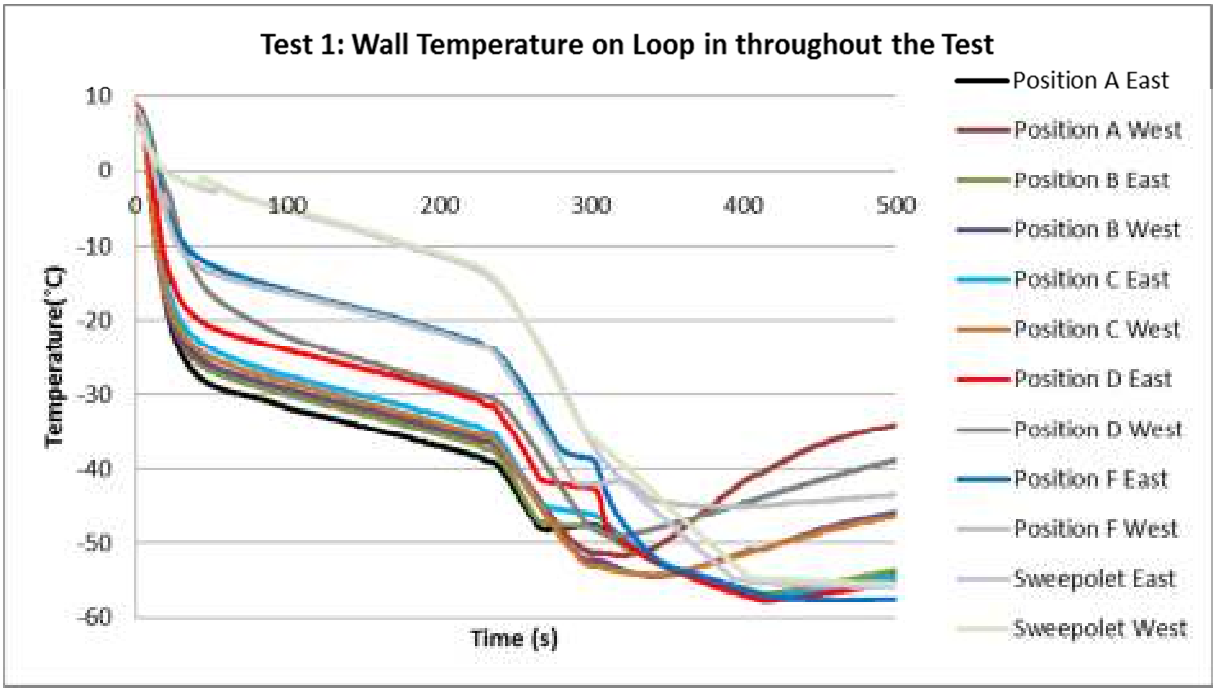


Figure 21(a): Wall Temperature in the Pipeline Loop throughout the Test

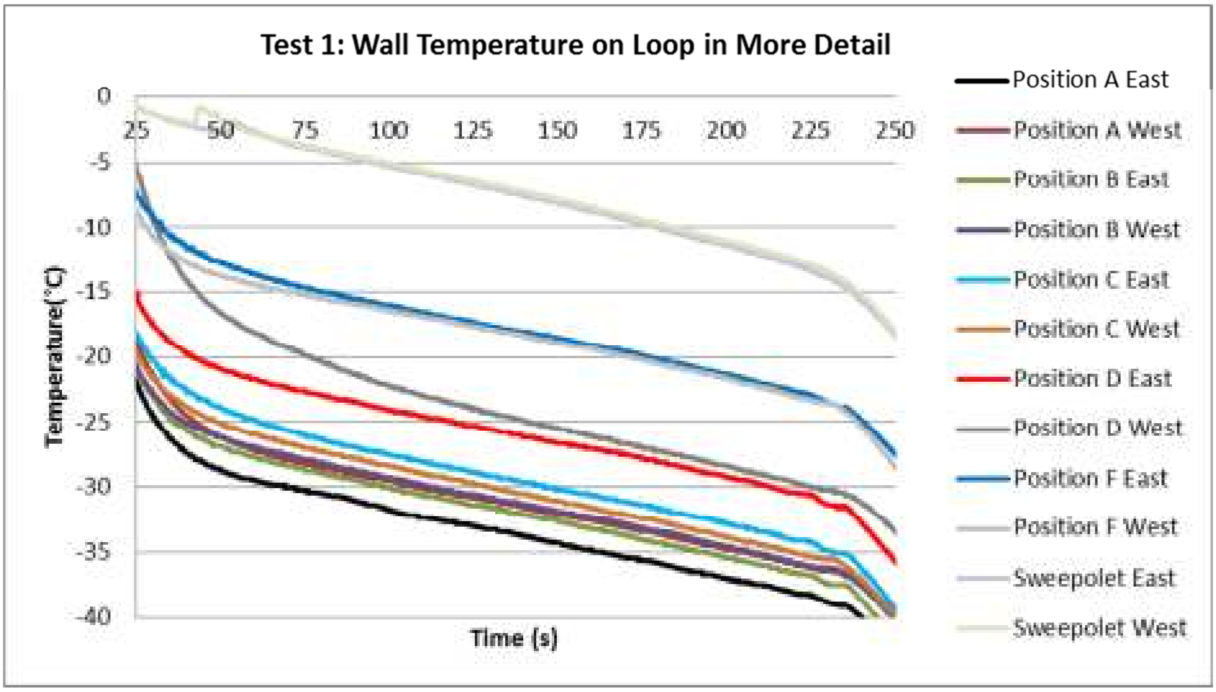


Figure 21(b): Wall Temperature in the Pipeline Loop during the Pseudo-Steady Period

THERE IS NO FIGURE 22

Figure 23: Photograph of the Crater and Ruptured Pipe

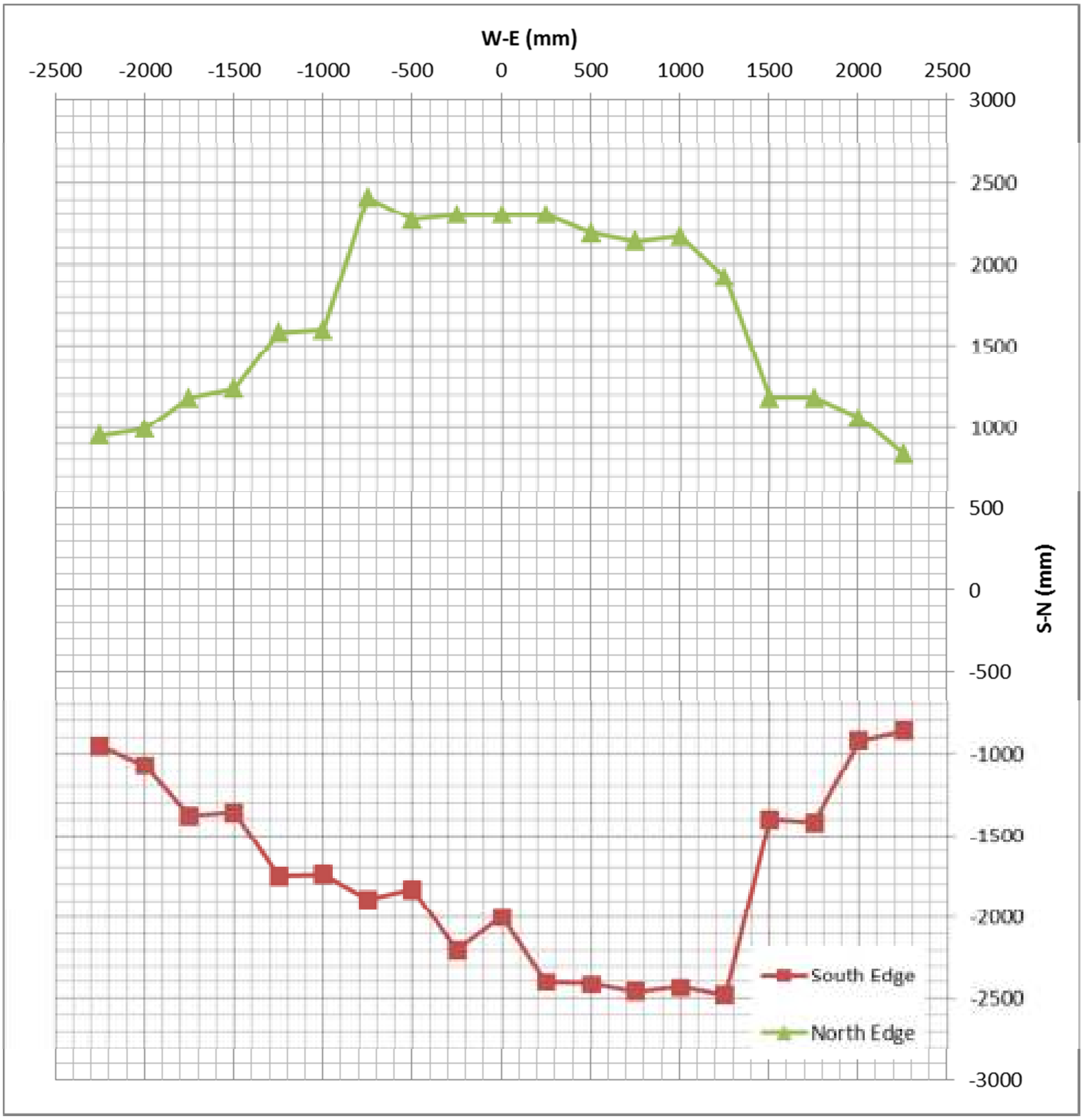


Figure 24: Shape of the Ground Crater in Plan View

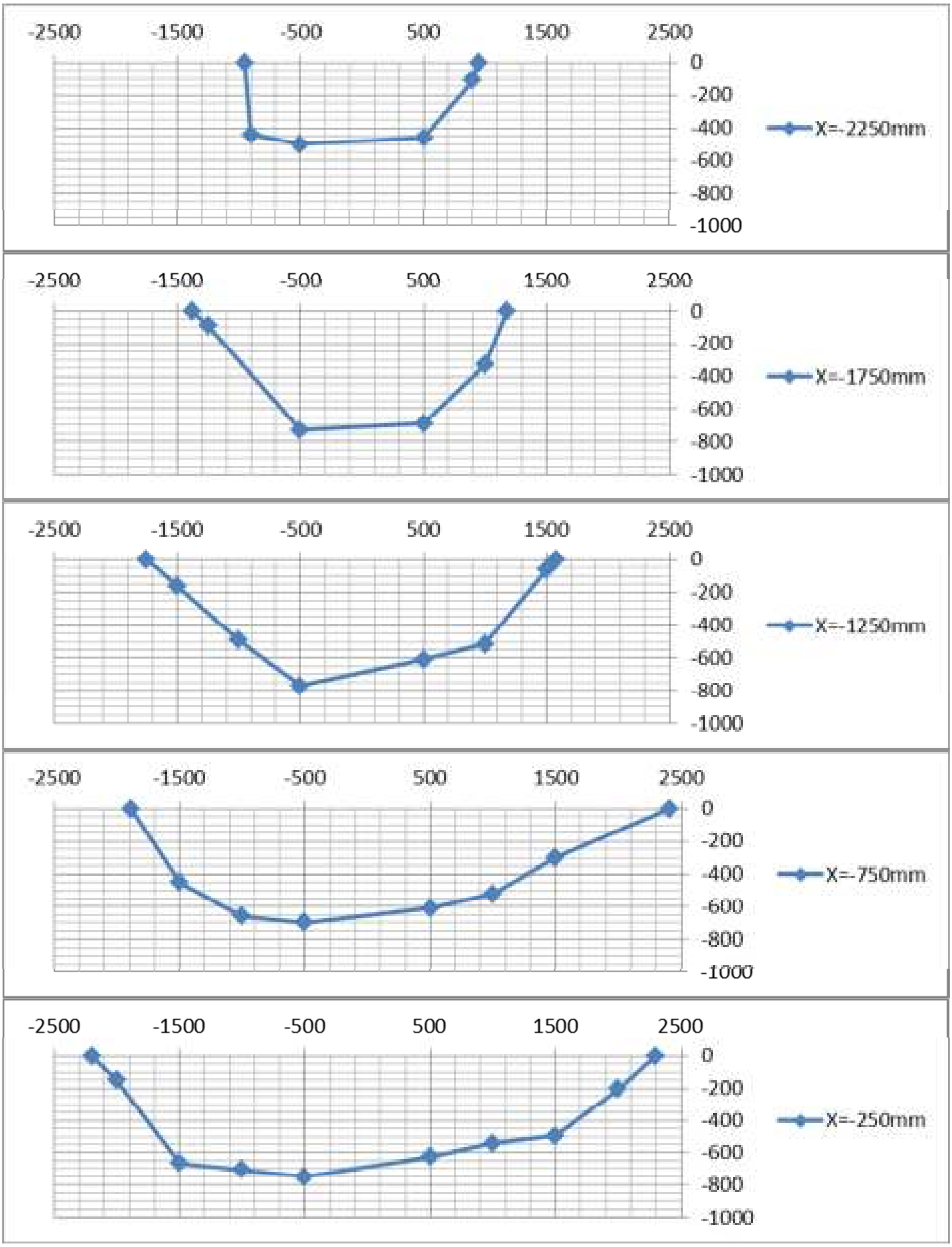


Figure 25: North-South Profiles of the Crater Depth at Several Locations in the X Direction

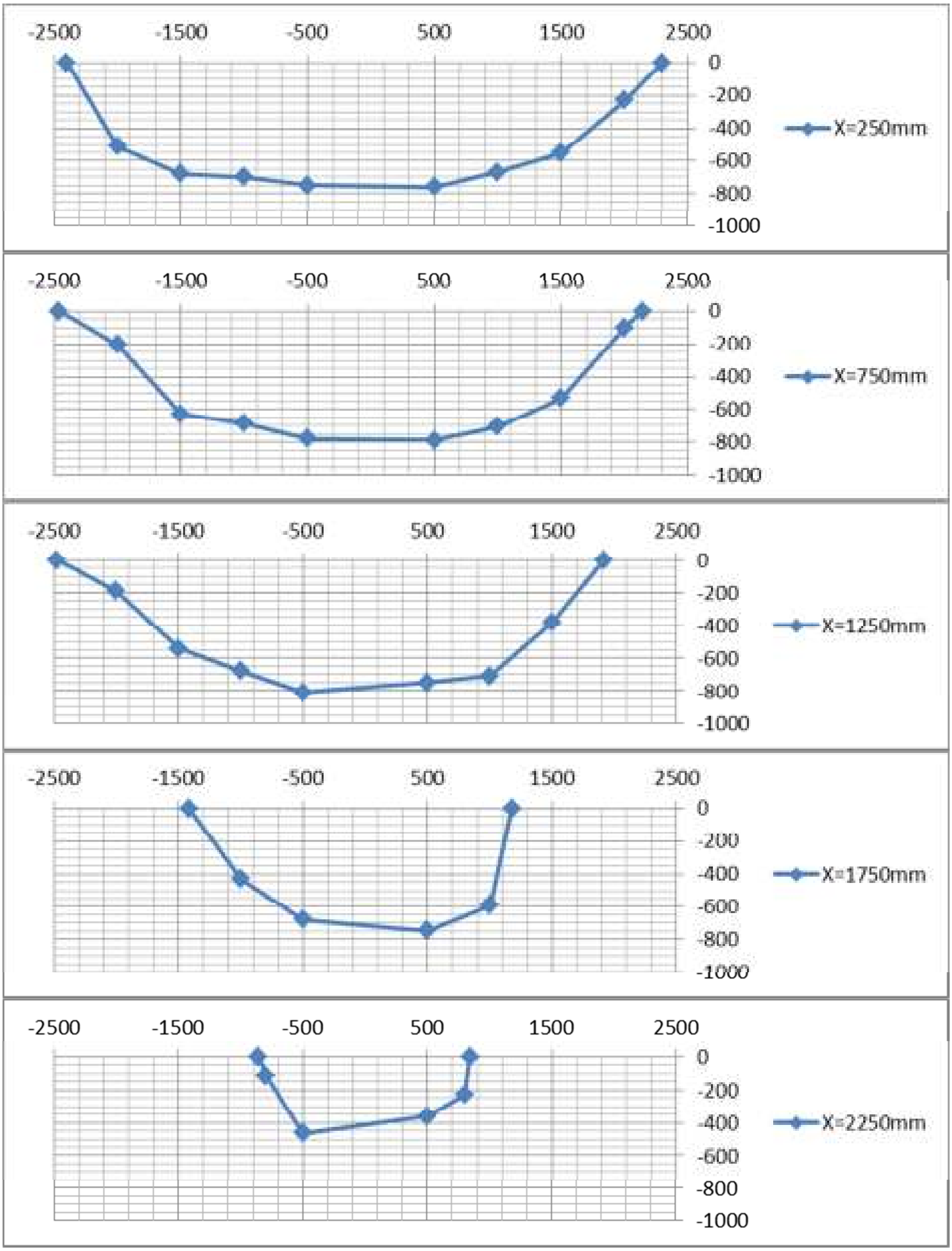


Figure 25 (continued): North-South Profiles of the Crater Depth at Several Locations in the X Direction

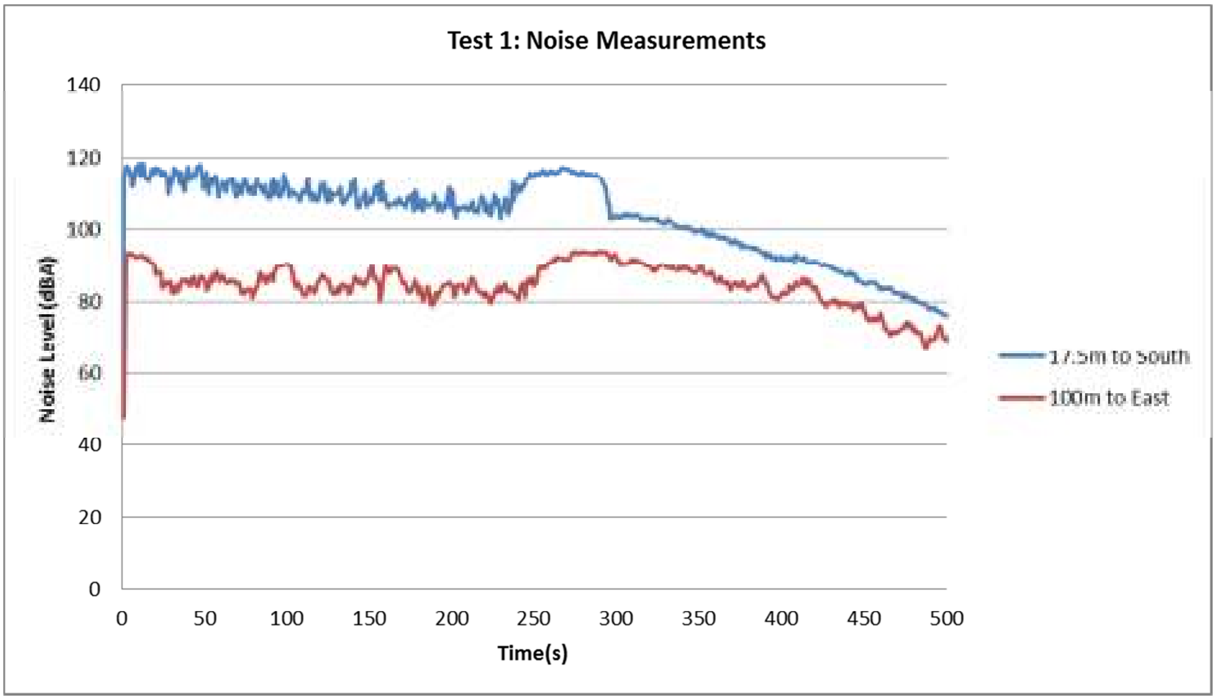


Figure 26: Noise Measurement during the Test

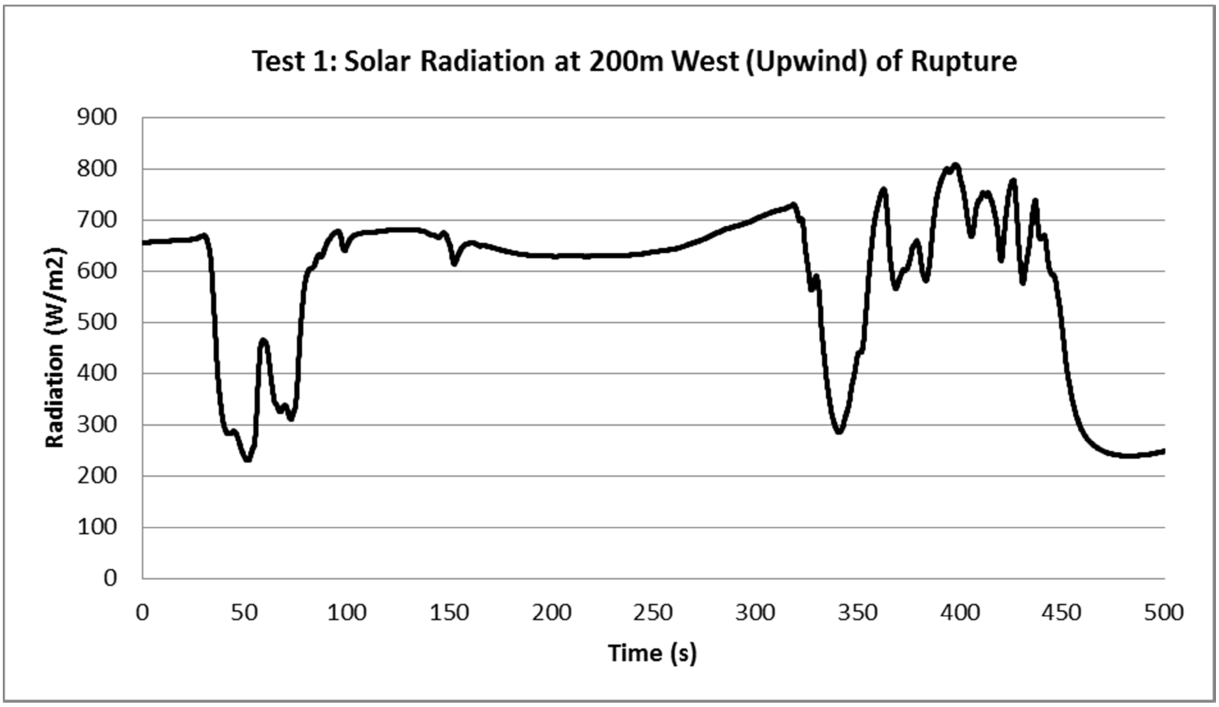


Figure 27: Solar Radiation during the Test

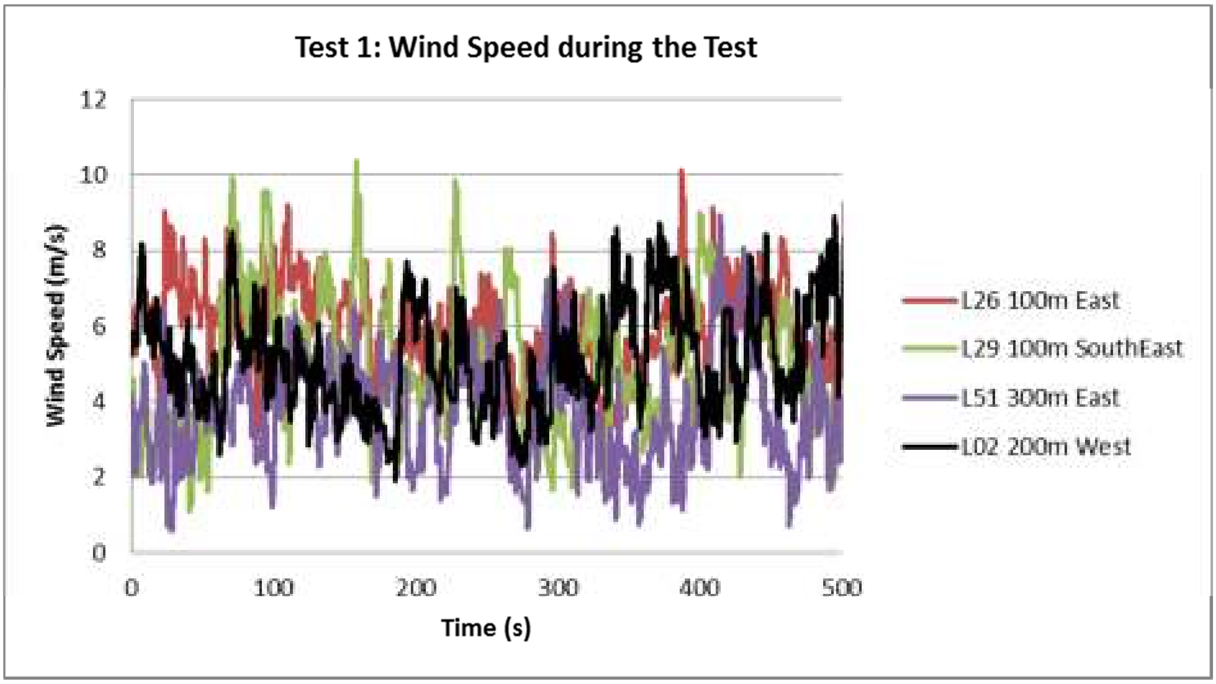


Figure 28: Wind Speed during the Test

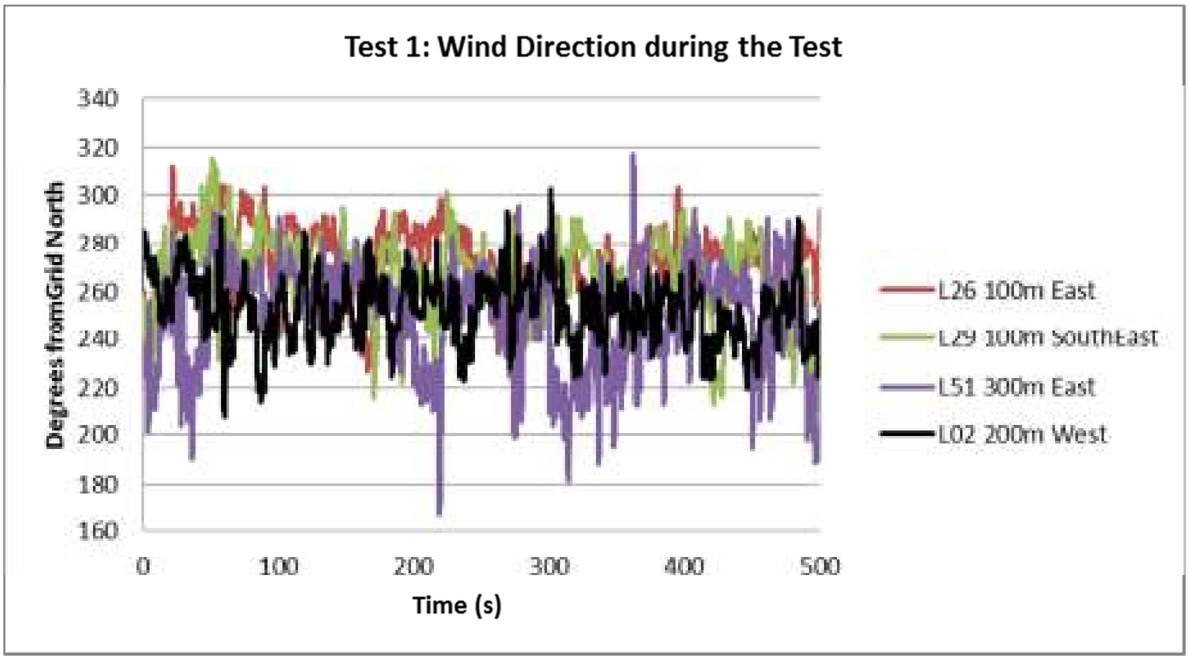


Figure 29: Wind Direction during the Test

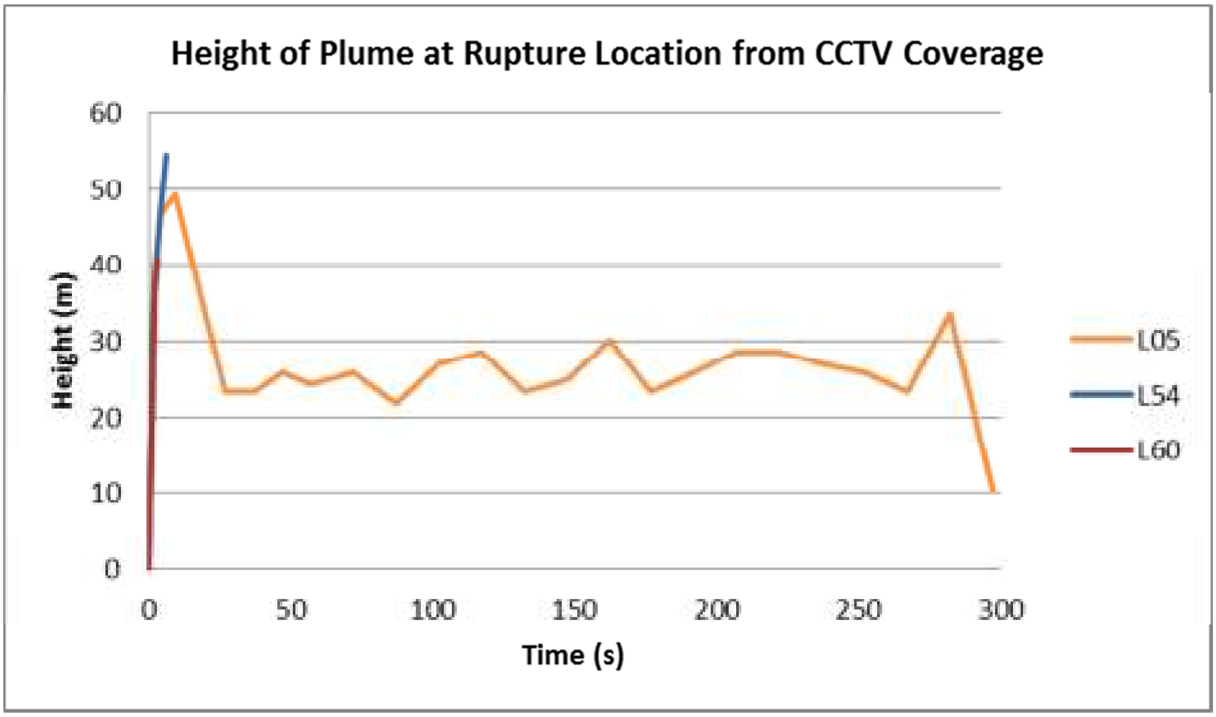


Figure 30: Height of the Visible Plume at the Rupture Location

Figure 31(a): Aerial View at Time 0 s from Rupture

Figure 31(b): Aerial View at Time 10 s from Rupture

Figure 31(c): Aerial View at Time 20 s from Rupture

Figure 31(d): Aerial View at Time 30 s from Rupture

Figure 31(e): Aerial View at Time 60 s from Rupture

Figure 31(f): Aerial View at Time 90 s from Rupture

Figure 31(g): Aerial View at Time 120 s from Rupture

Figure 31(h): Aerial View at Time 150 s from Rupture

Figure 31(i): Aerial View at Time 180 s from Rupture

Figure 31(j): Aerial View at Time 210 s from Rupture

Figure 31(k): Aerial View at Time 240 s from Rupture

Figure 31(l): Aerial View at Time 270 s from Rupture

Figure 31(m): Aerial View at Time 300 s from Rupture

Figure 31(n): Aerial View at Time 360 s from Rupture

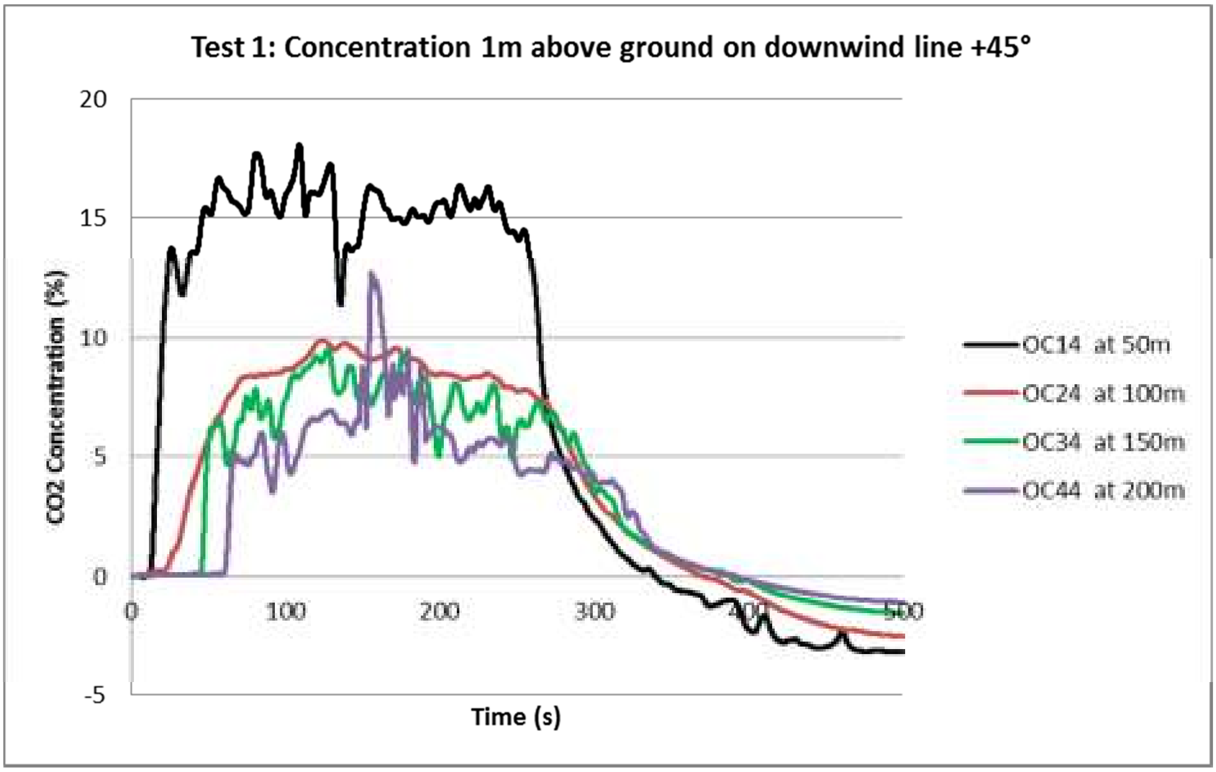


Figure 32(a): Gas Concentration 1m above Ground on Radial Line 45 degree North of X Axis in Downwind Direction

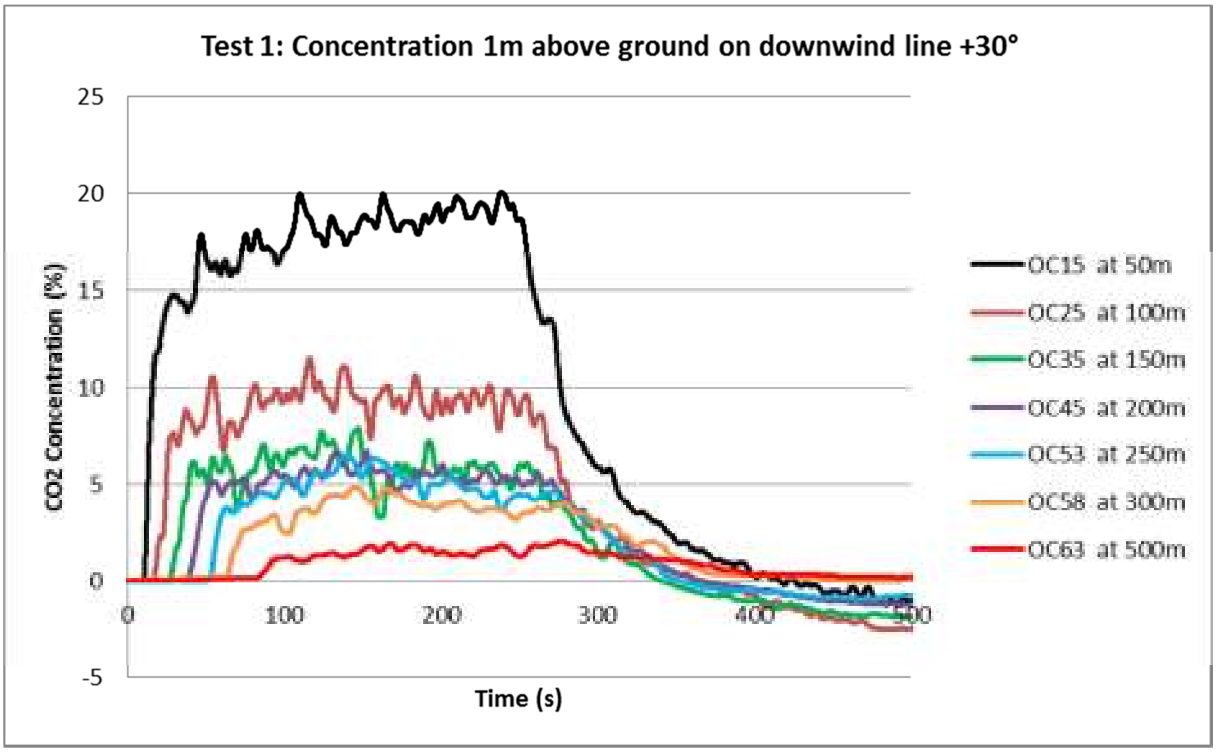


Figure 32(b): Gas Concentration 1m above Ground on Radial Line 30 degree North of X Axis in Downwind Direction

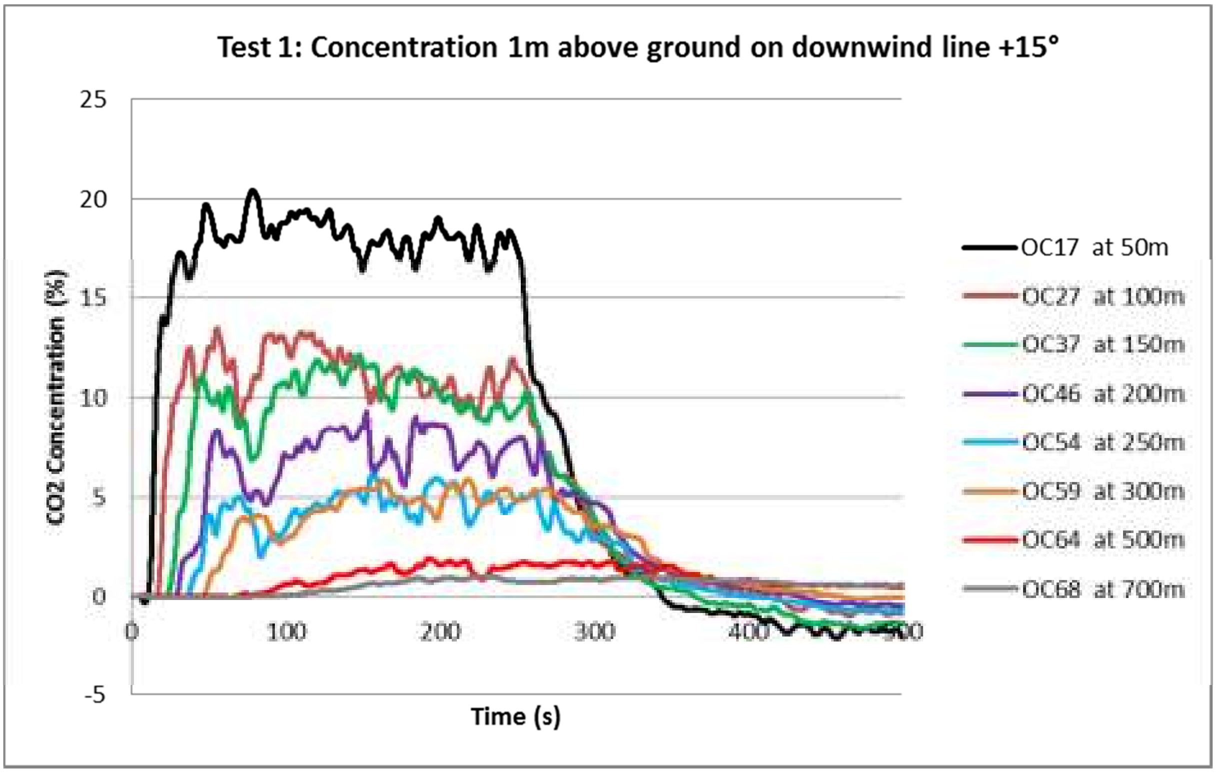


Figure 32(c): Gas Concentration 1m above Ground on Radial Line 15 degree North of X Axis in Downwind Direction

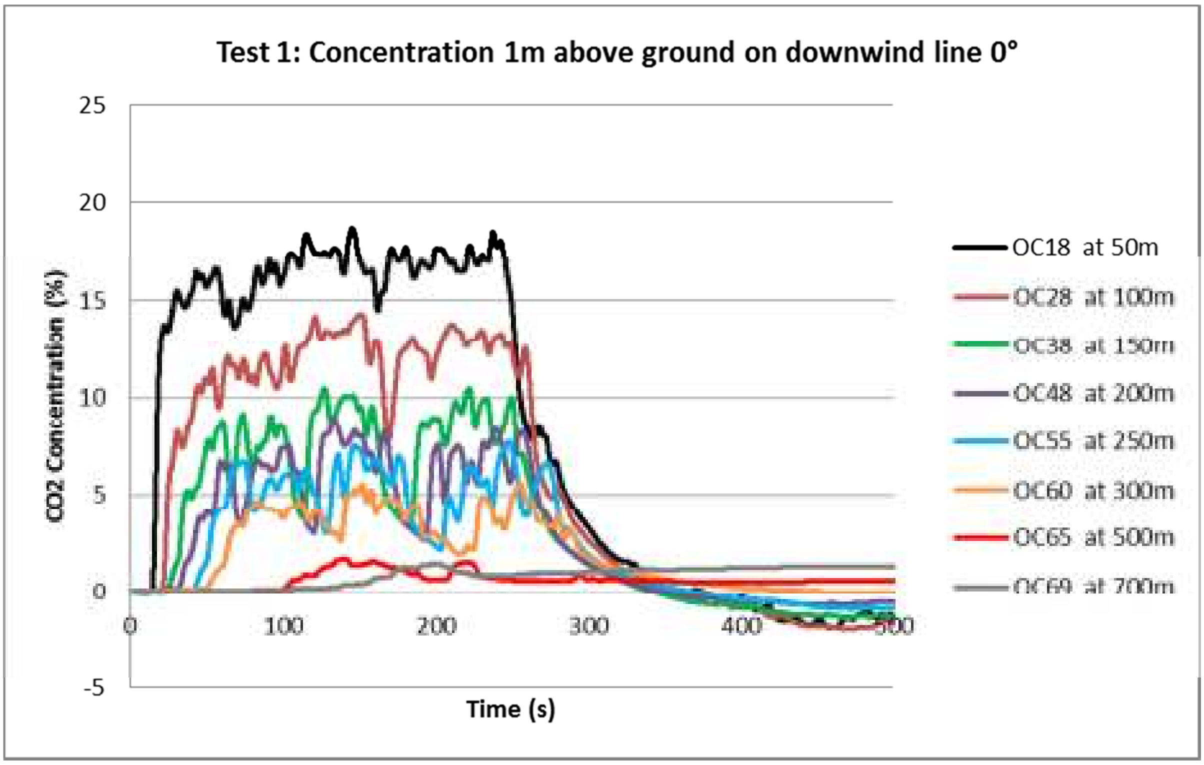


Figure 32(d): Gas Concentration 1m above Ground on Radial Line along the X Axis in Downwind Direction

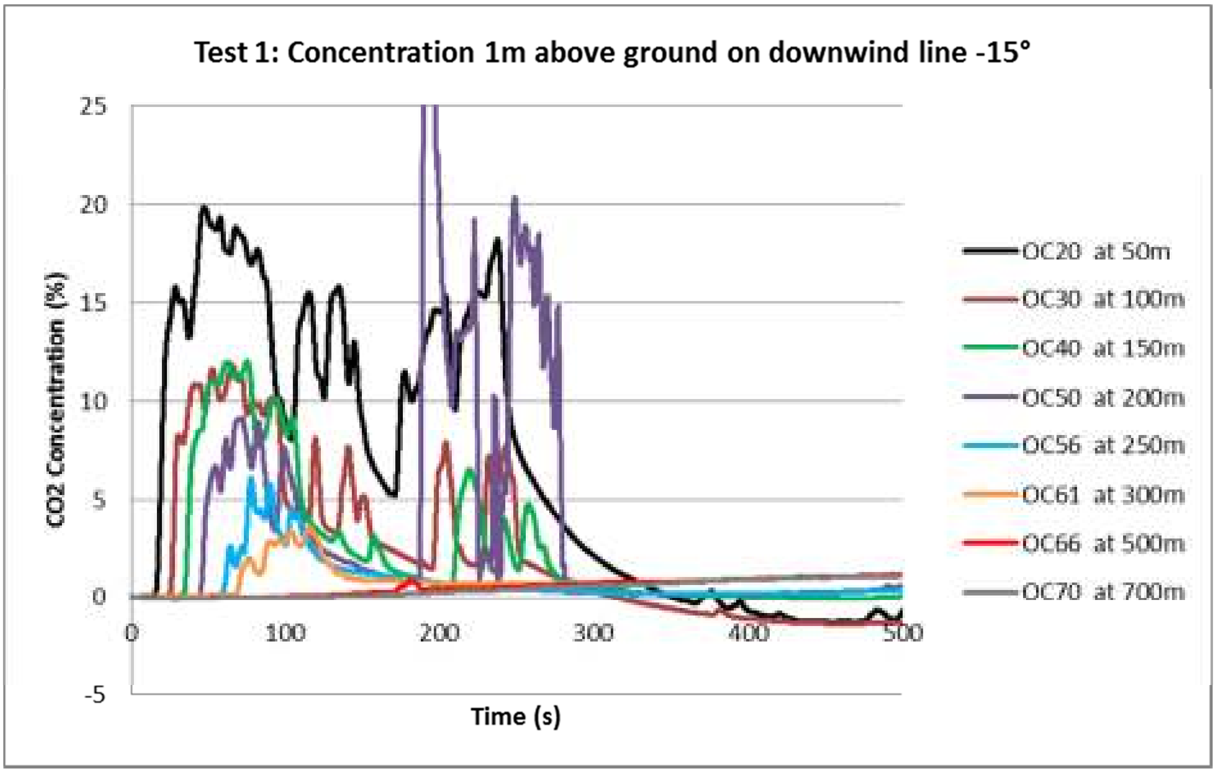


Figure 32(e): Gas Concentration 1m above Ground on Radial Line 15 degree South of X Axis in Downwind Direction

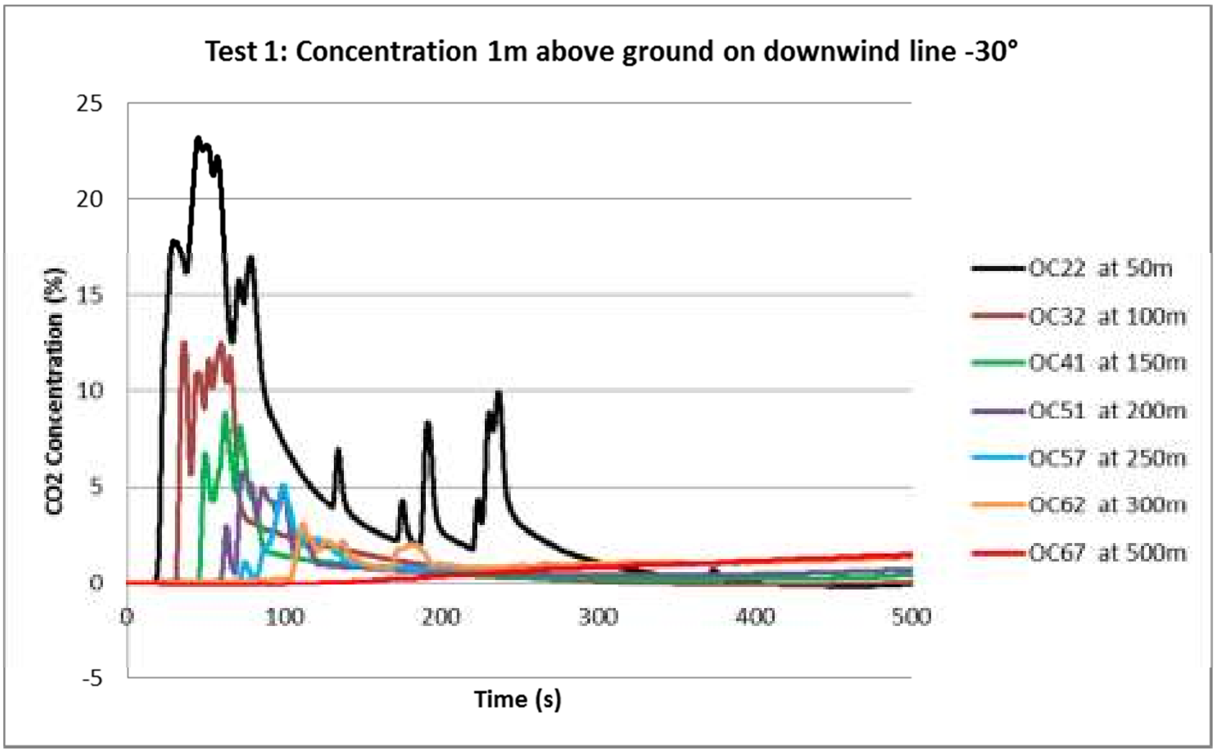


Figure 32(f): Gas Concentration 1m above Ground on Radial Line 30 degree South of X Axis in Downwind Direction

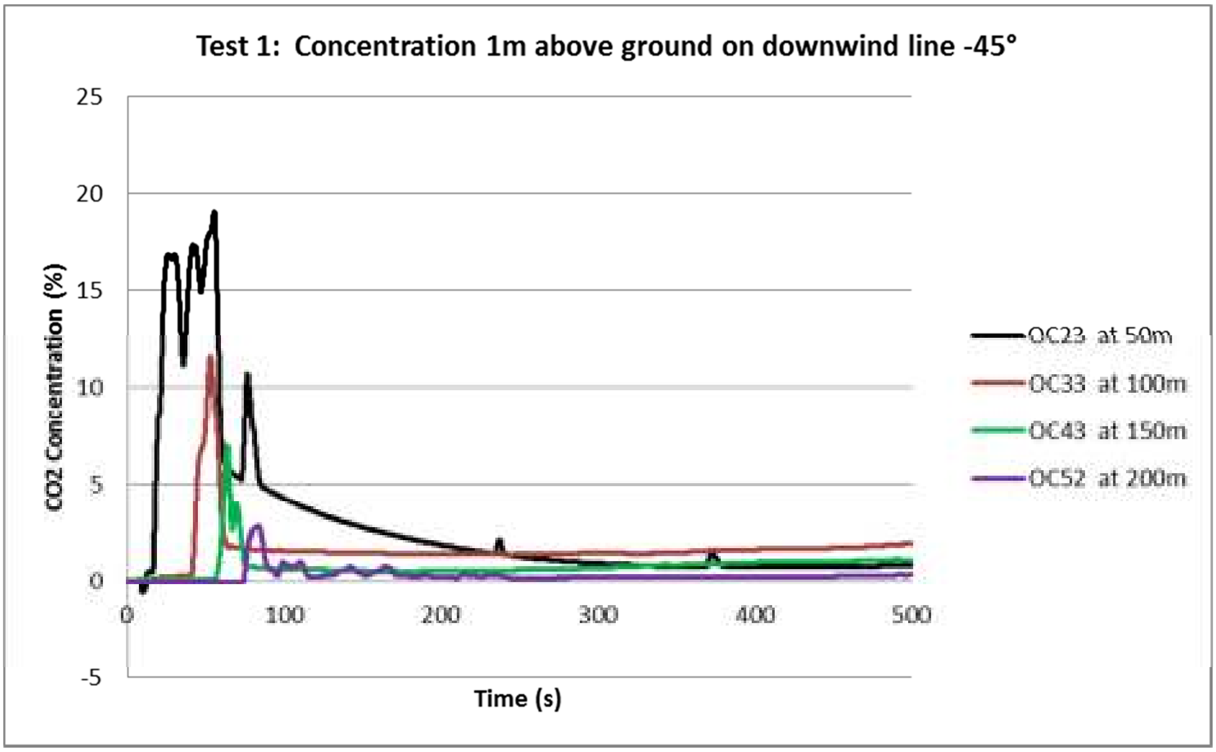


Figure 32(g): Gas Concentration 1m above Ground on Radial Line 45 degree South of X Axis in Downwind Direction

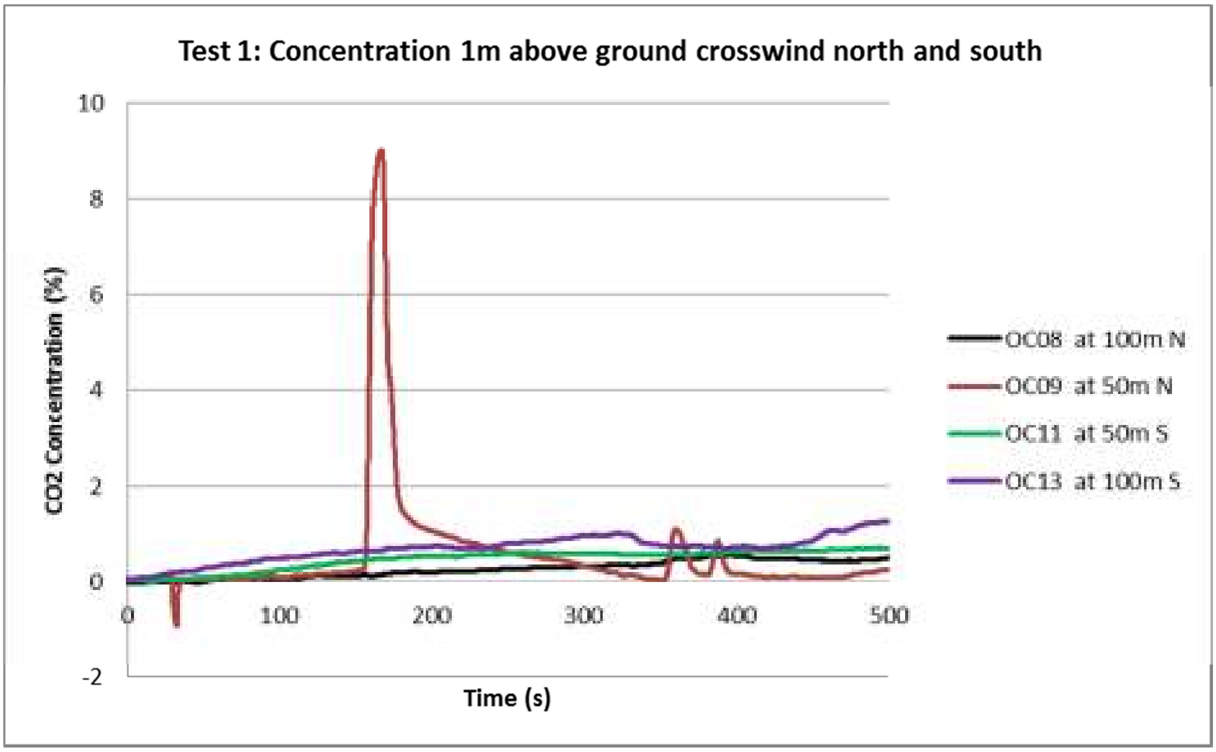


Figure 32(h): Gas Concentration 1m above Ground on Radial Line North and South of Rupture

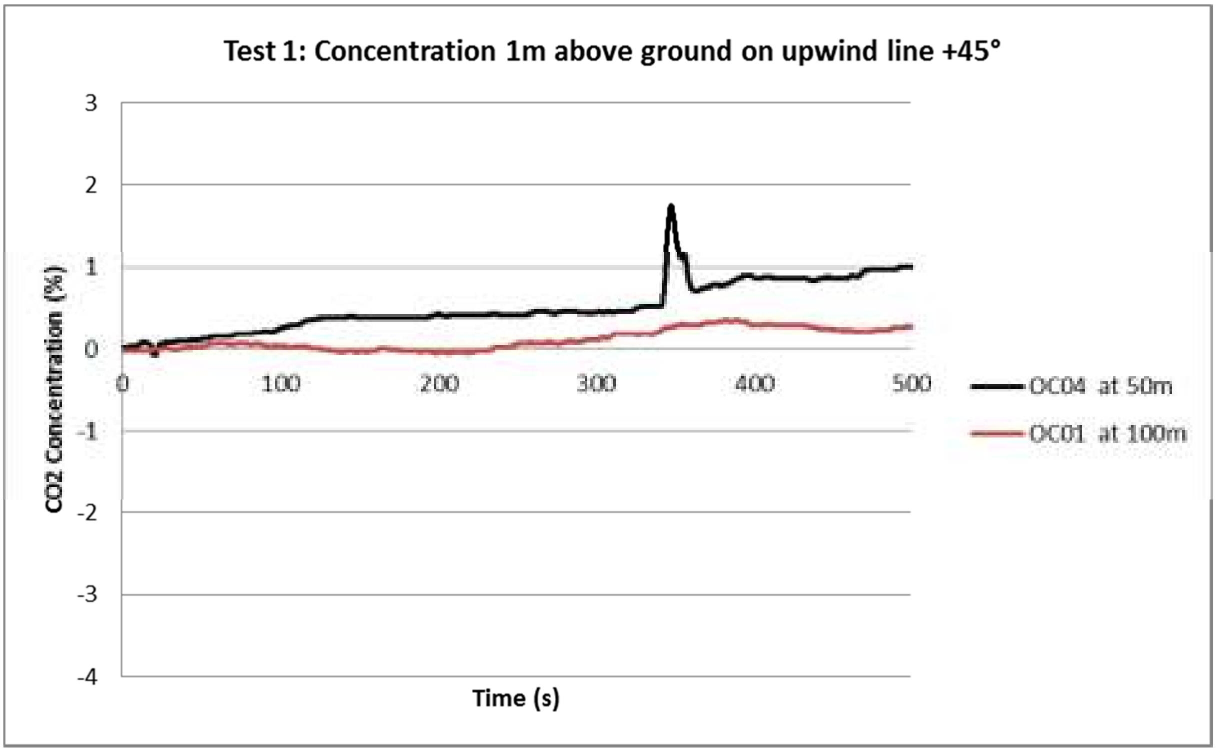


Figure 32(i): Gas Concentration 1m above Ground on Radial Line 45 North of X Axis in Upwind Direction

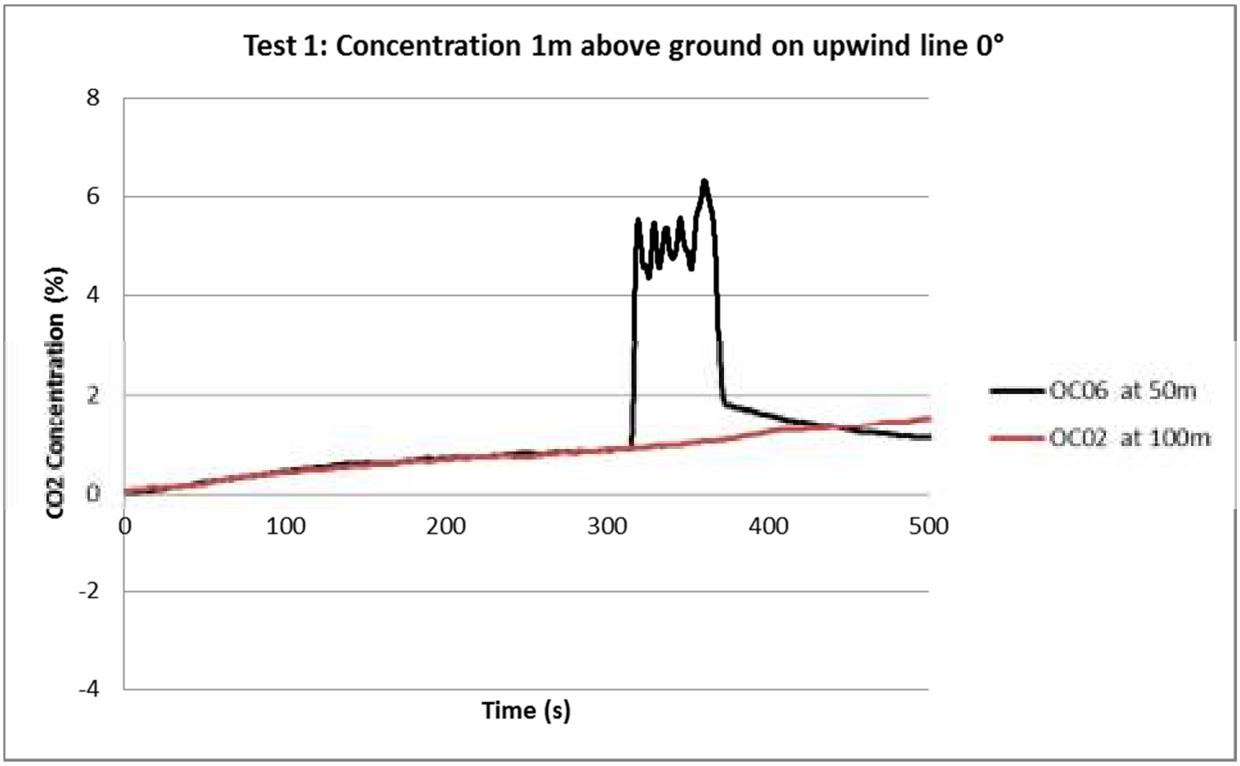


Figure 32(j): Gas Concentration 1m above Ground on Radial Line along X Axis in Upwind Direction

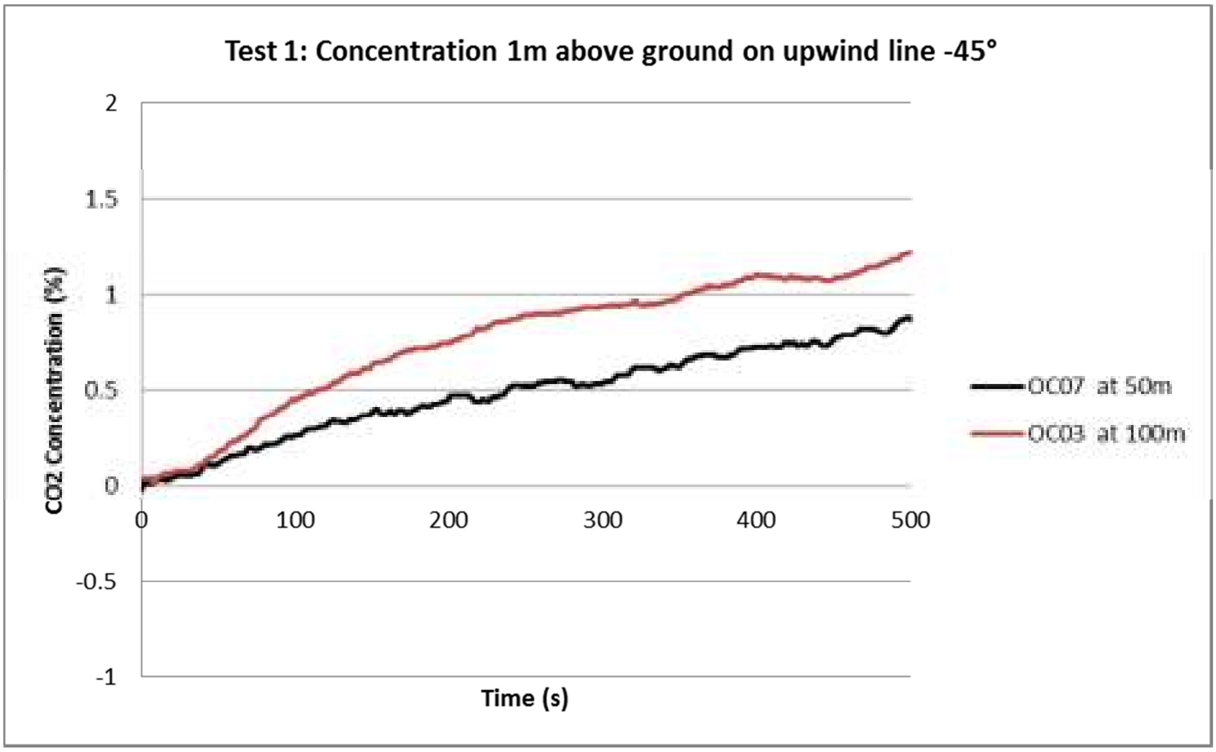


Figure 32(k): Gas Concentration 1m above Ground on Radial Line 45 South of X Axis in Upwind Direction

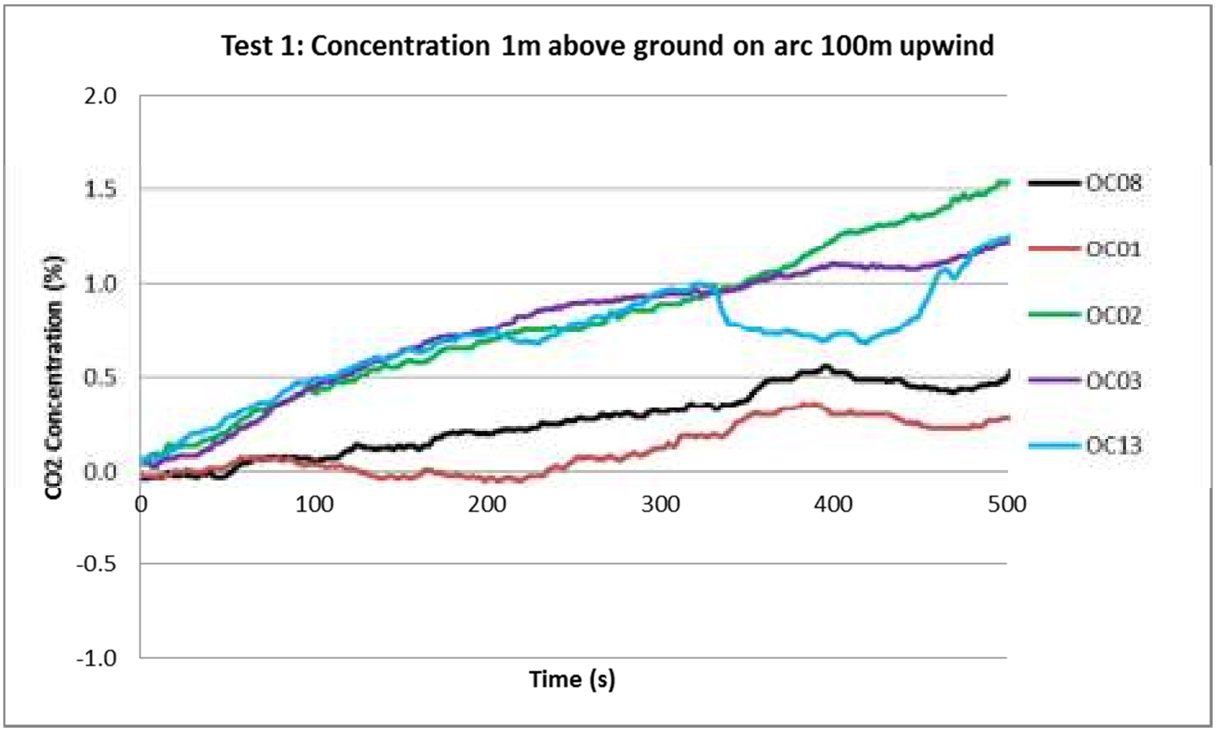


Figure 33(a): Gas Concentration 1m above Ground on an Arc 100m Upwind

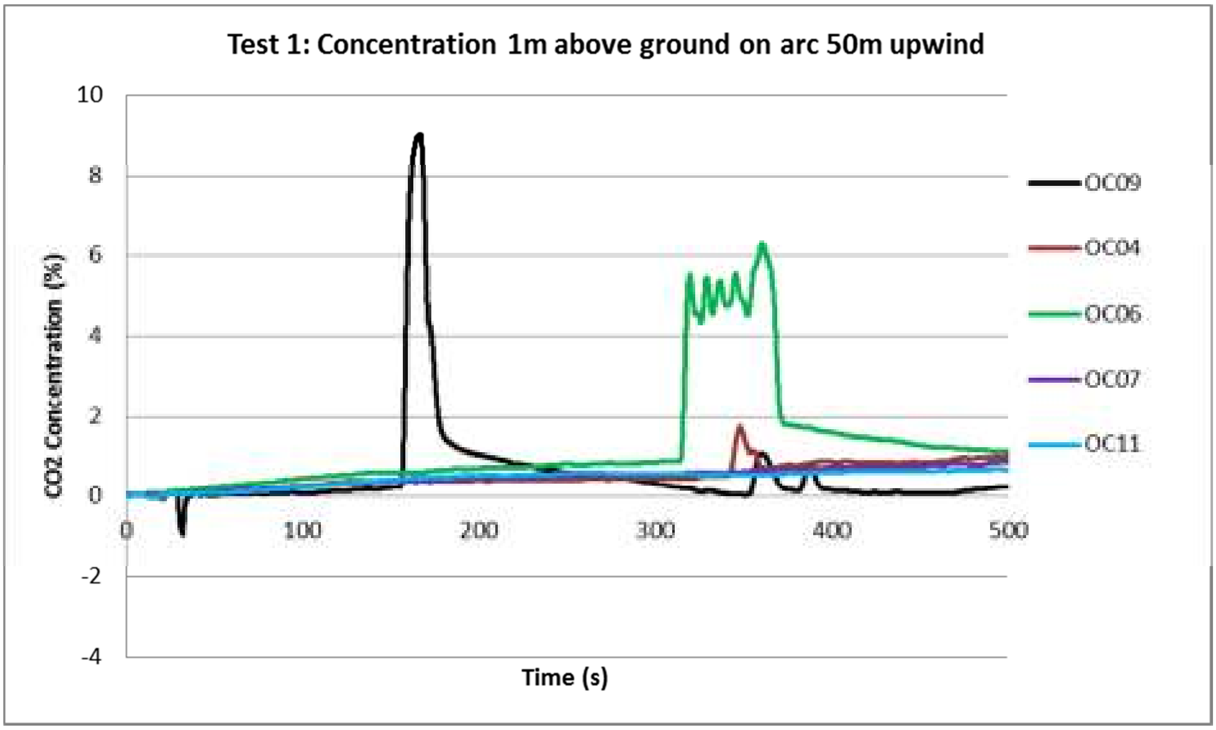


Figure 33(b): Gas Concentration 1m above Ground on an Arc 50m Upwind

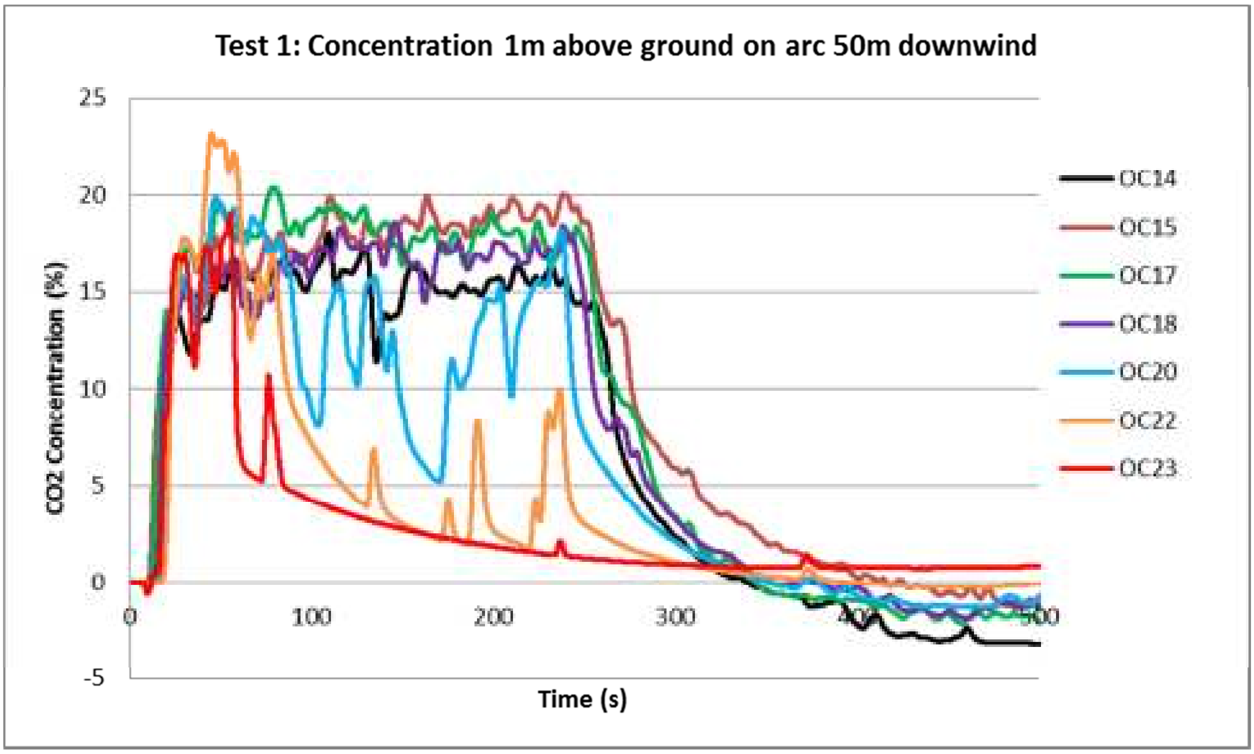


Figure 33(c): Gas Concentration 1m above Ground on an Arc 50m Downwind

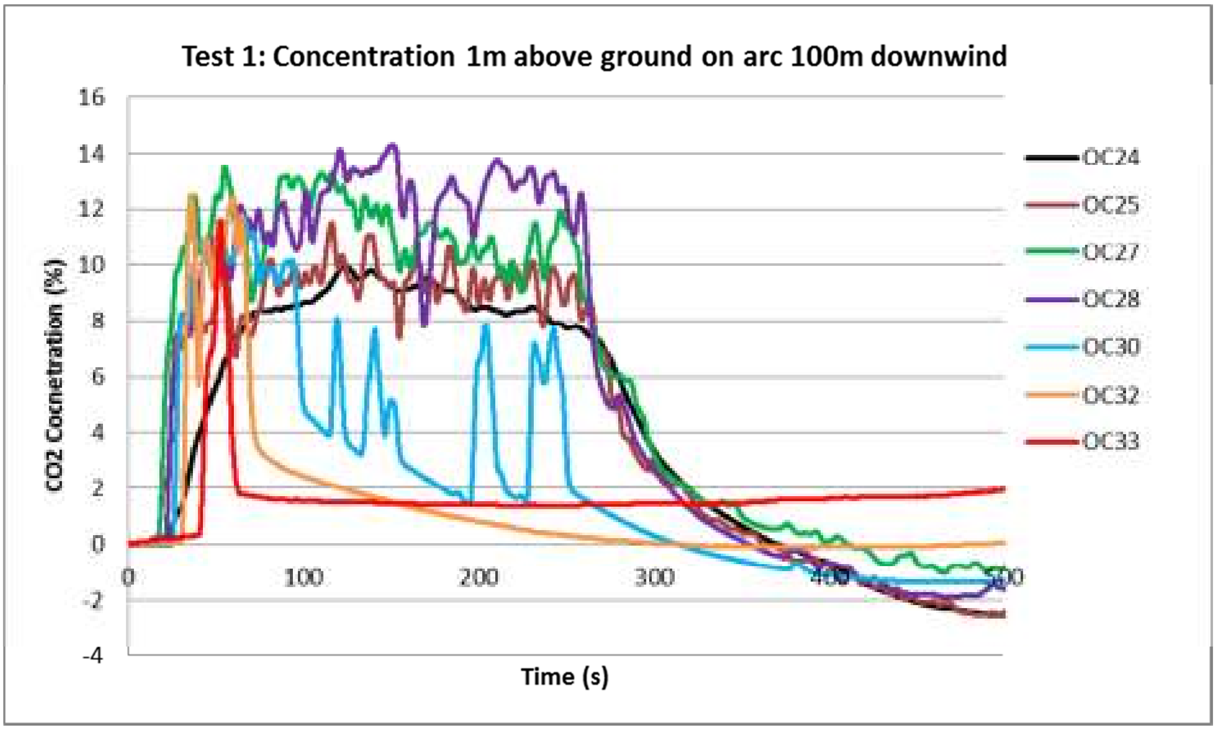


Figure 33(d): Gas Concentration 1m above Ground on an Arc 100m Downwind

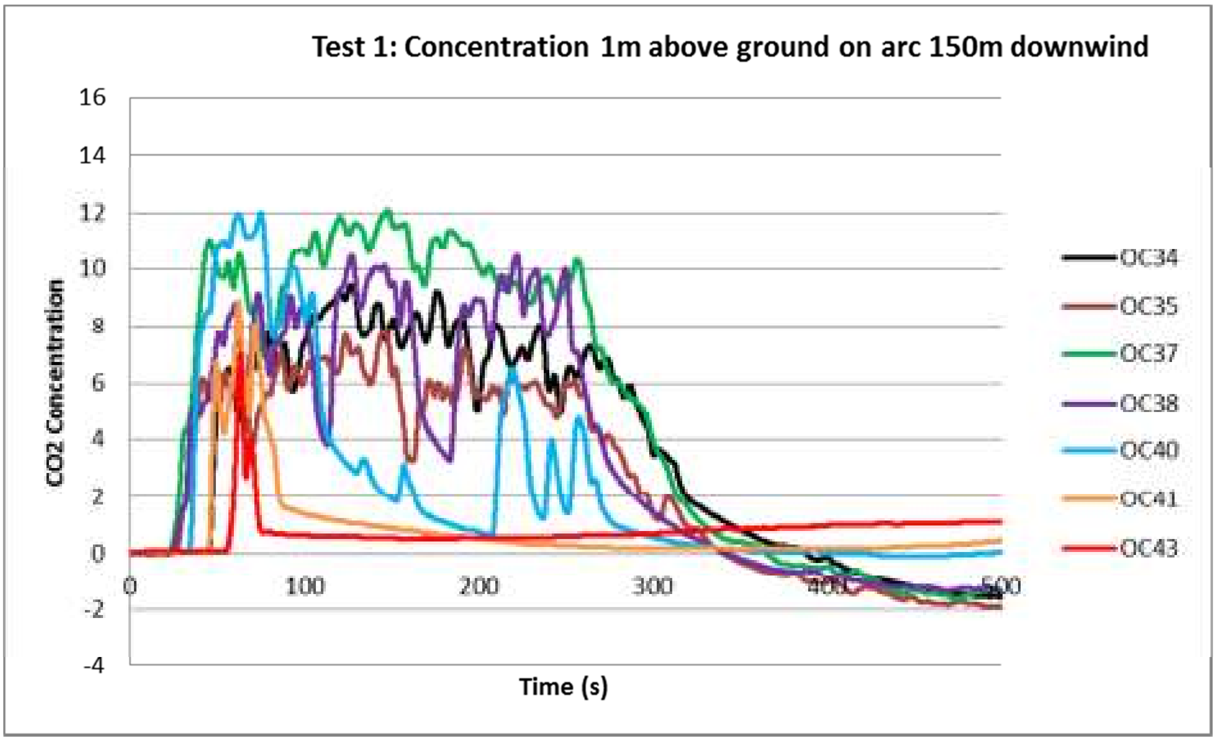


Figure 33(e): Gas Concentration 1m above Ground on an Arc 150m Downwind

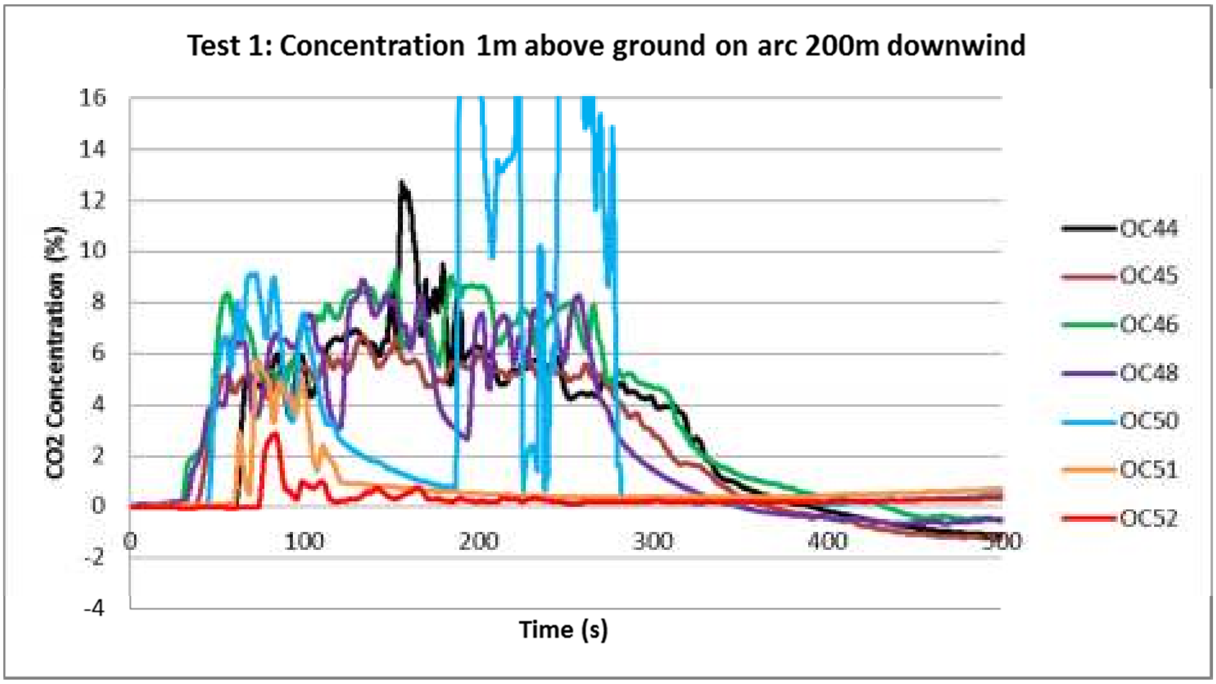


Figure 33(f): Gas Concentration 1m above Ground on an Arc 200m Downwind

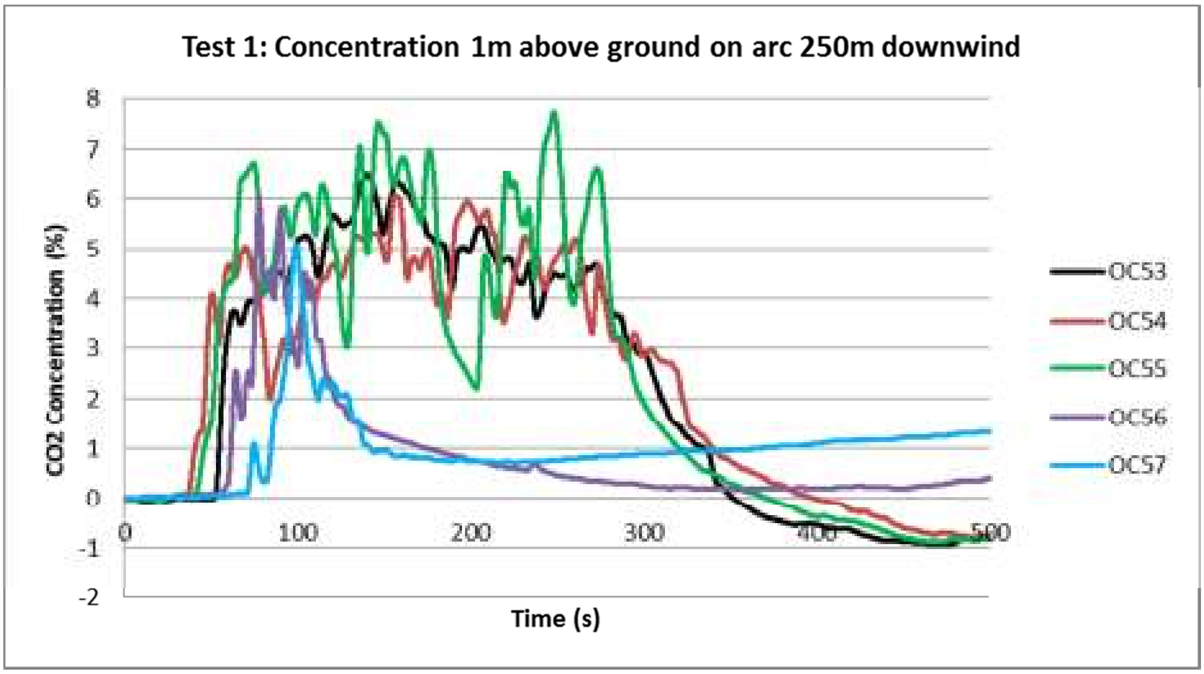


Figure 33(g): Gas Concentration 1m above Ground on an Arc 250m Downwind

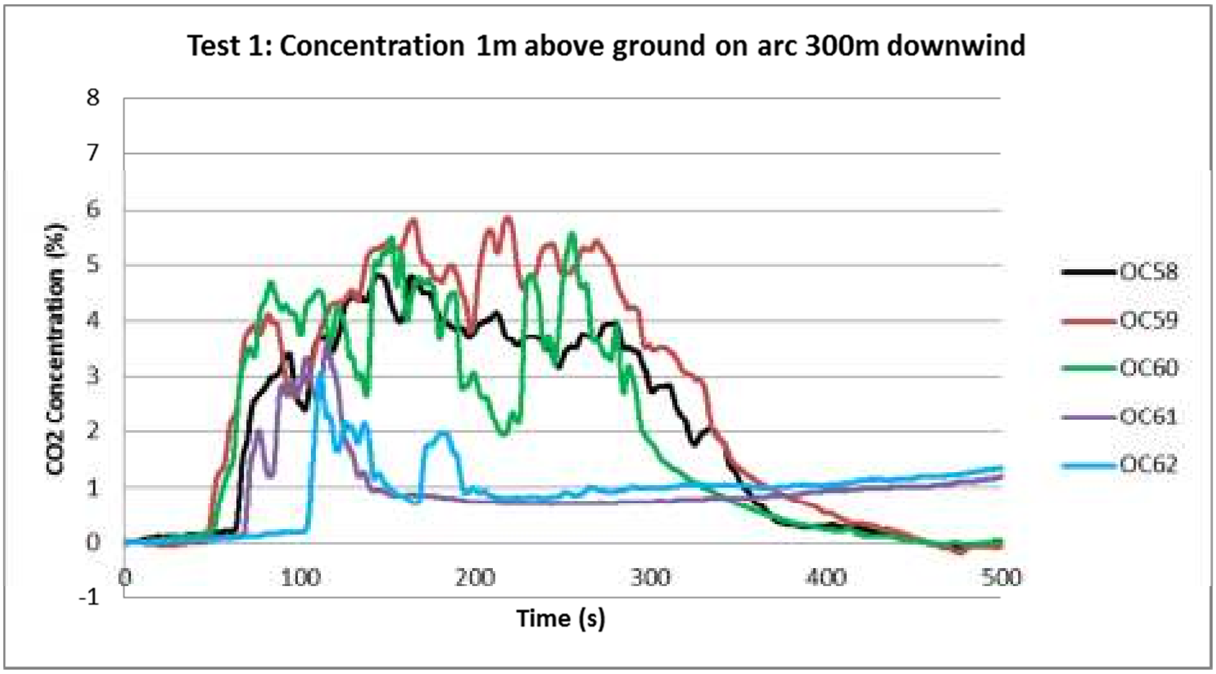


Figure 33(h): Gas Concentration 1m above Ground on an Arc 300m Downwind

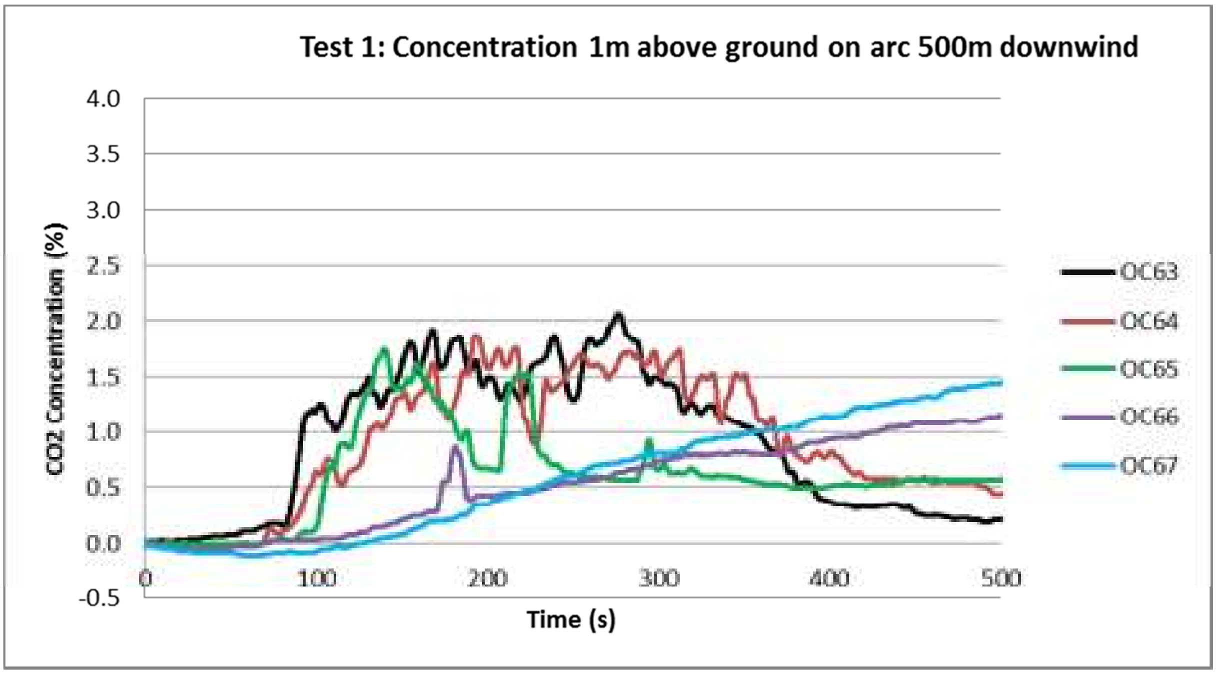


Figure 33(i): Gas Concentration 1m above Ground on an Arc 500m Downwind

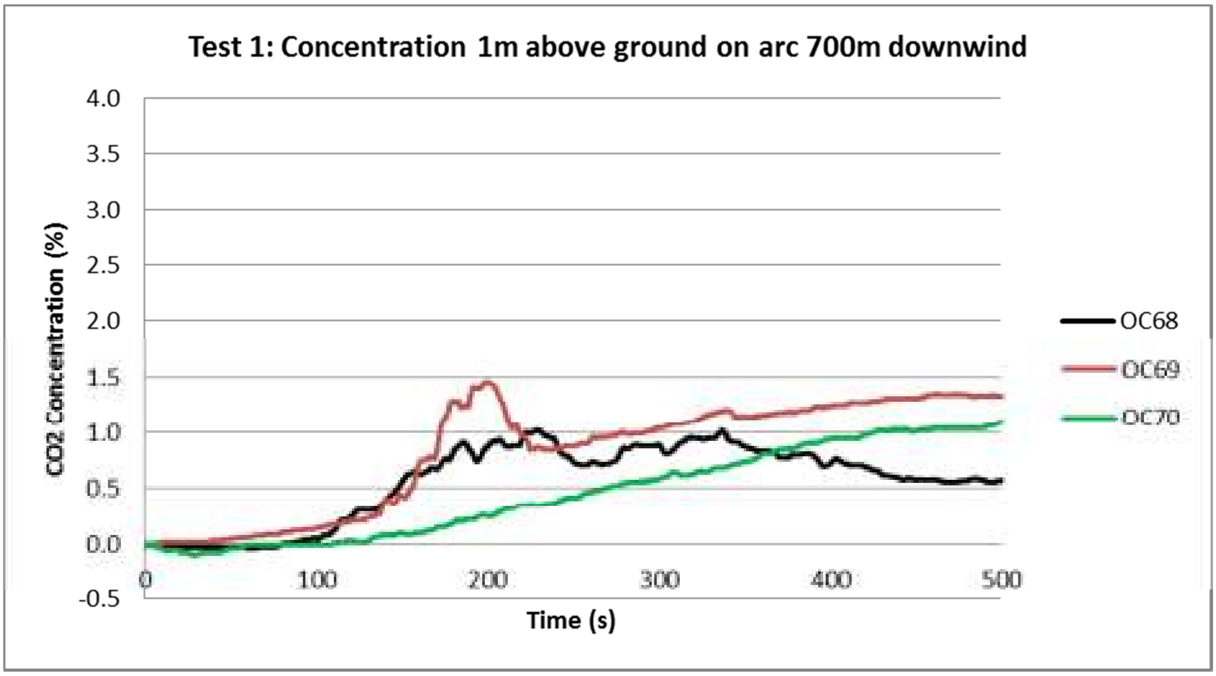


Figure 33(j): Gas Concentration 1m above Ground on an Arc 700m Downwind

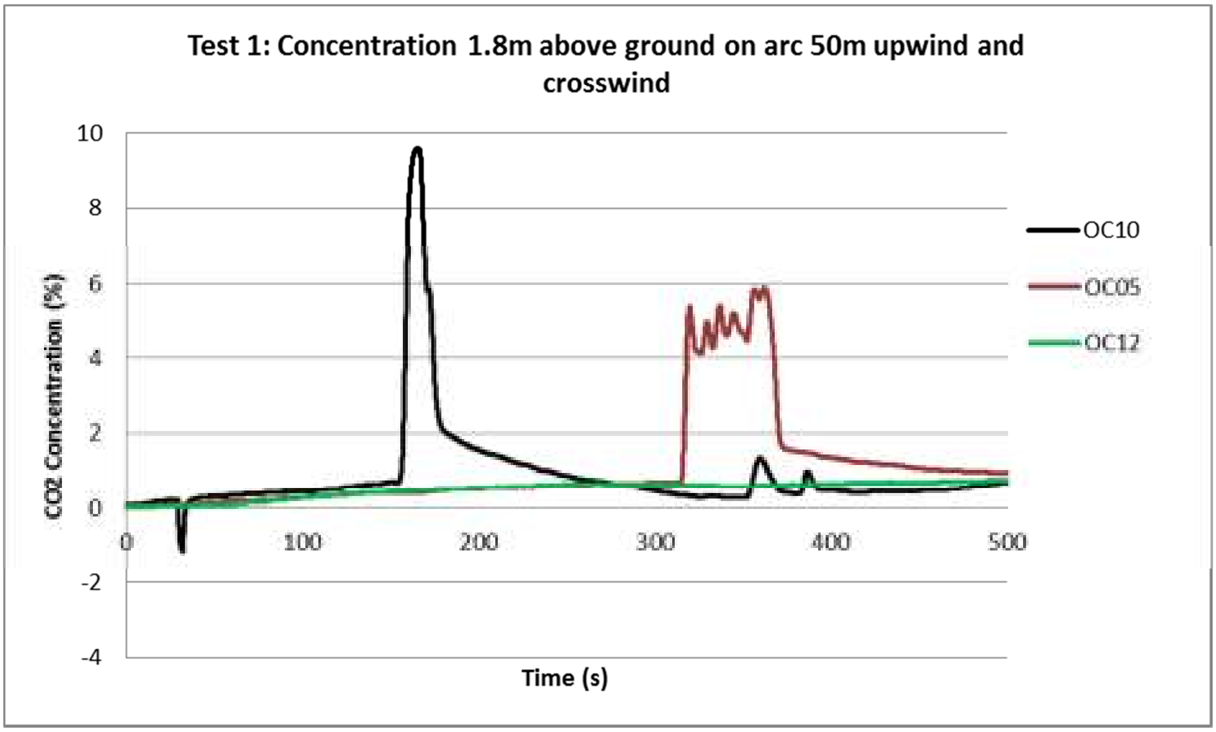


Figure 34(a): Gas Concentration 1.8m above Ground on an Arc 50m Up/Crosswind

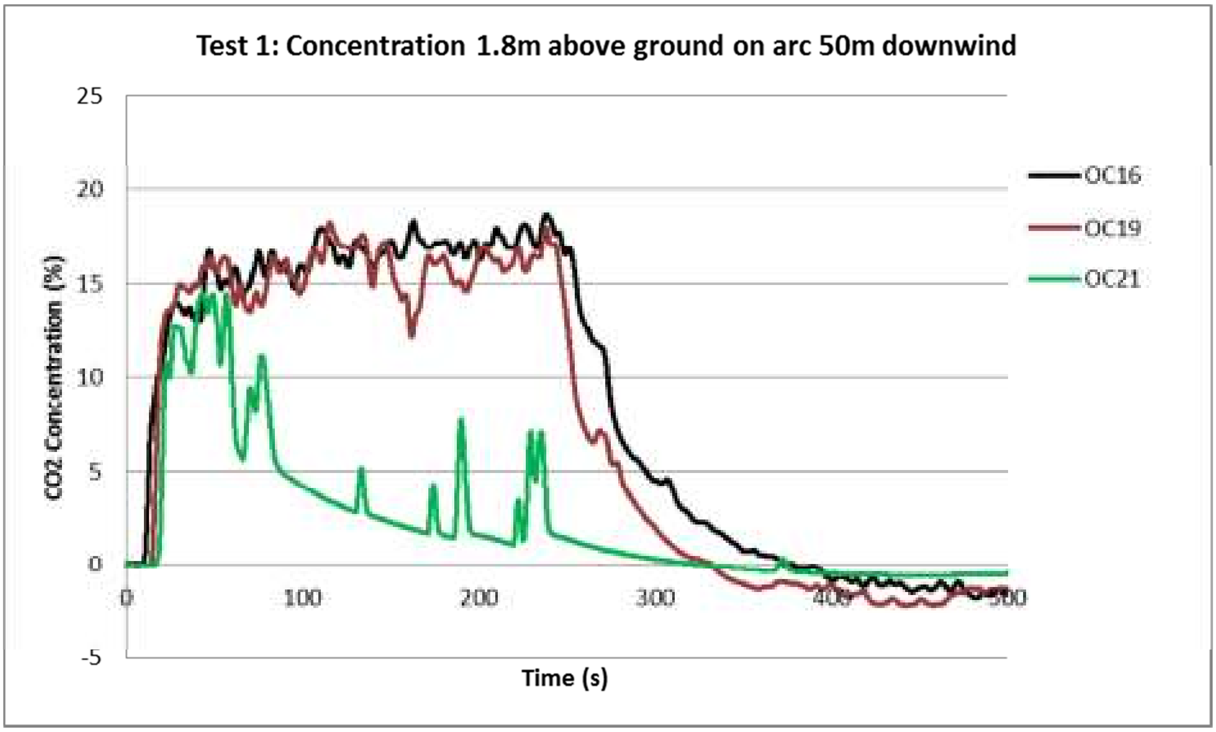


Figure 34(b): Gas Concentration 1.8m above Ground on an Arc 50m Downwind

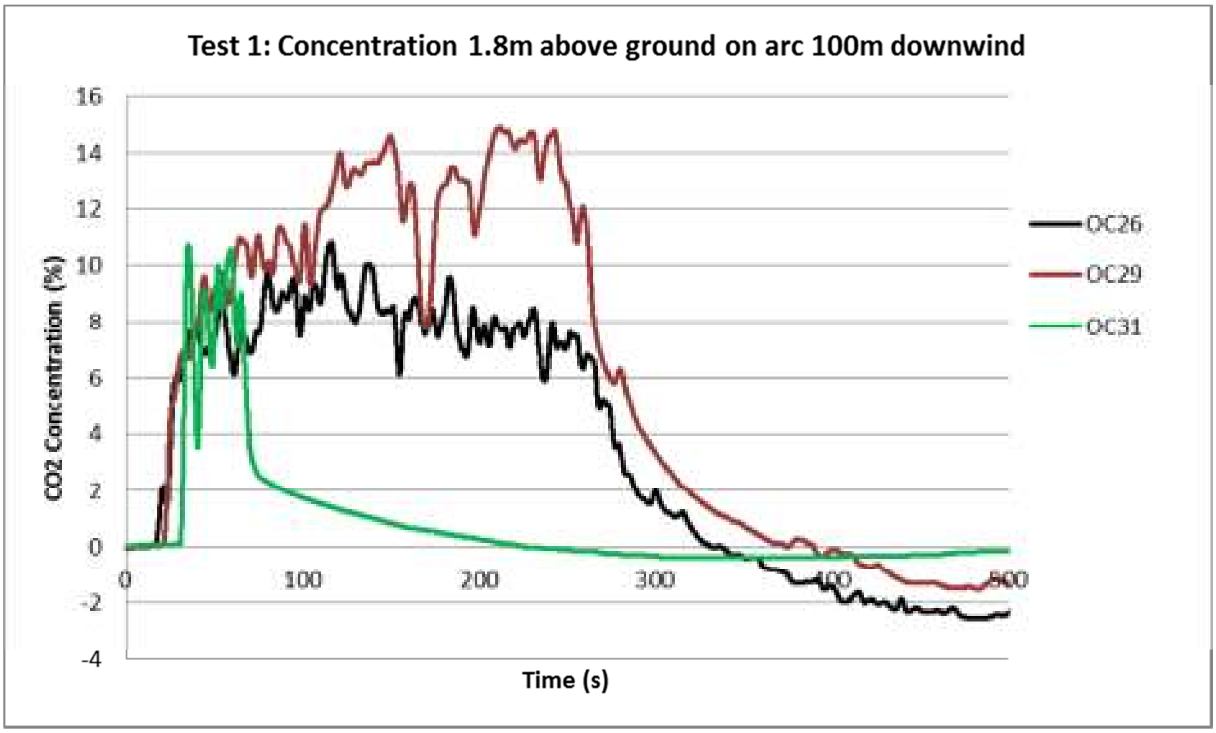


Figure 34(c): Gas Concentration 1.8m above Ground on an Arc 100m Downwind

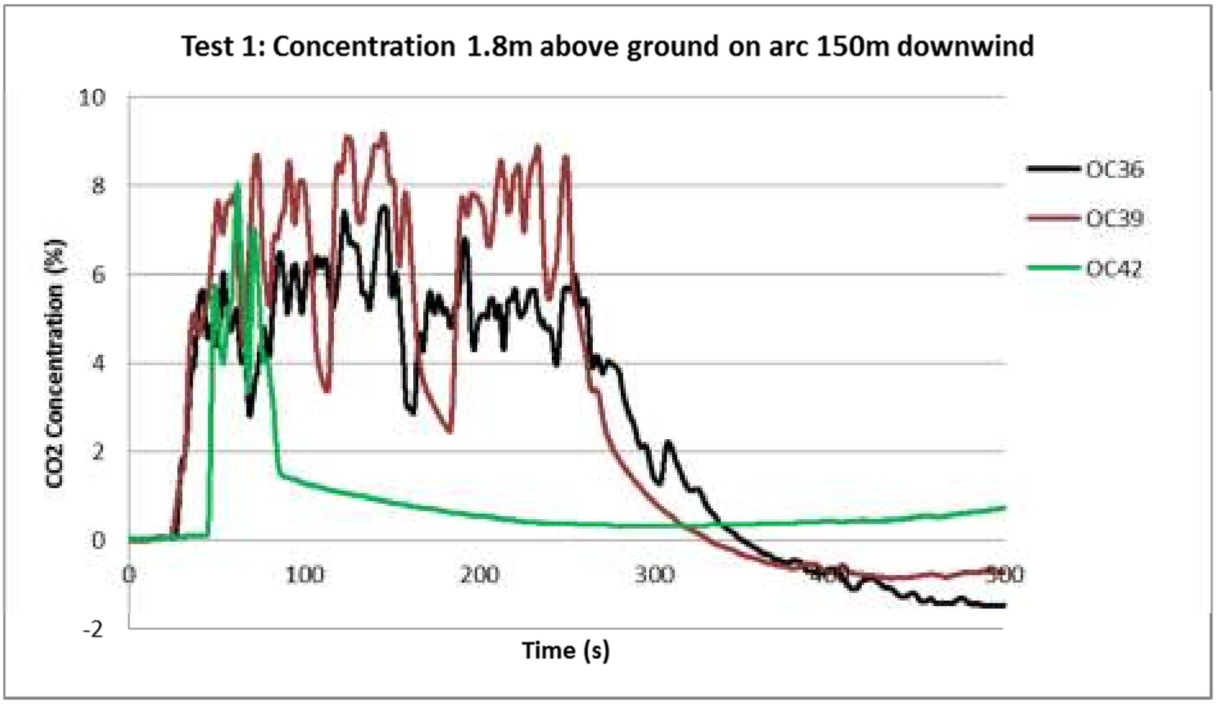


Figure 34(d): Gas Concentration 1.8m above Ground on an Arc 150m Downwind

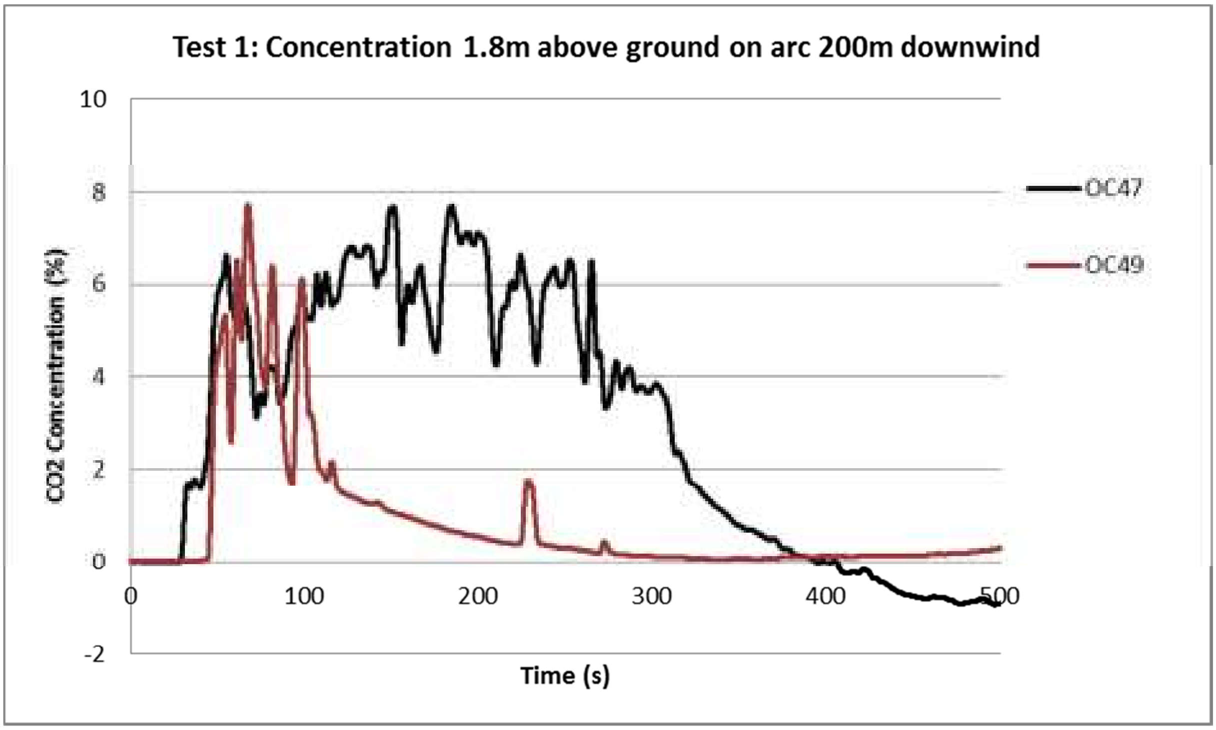


Figure 34(e): Gas Concentration 1.8m above Ground on an Arc 200m Downwind

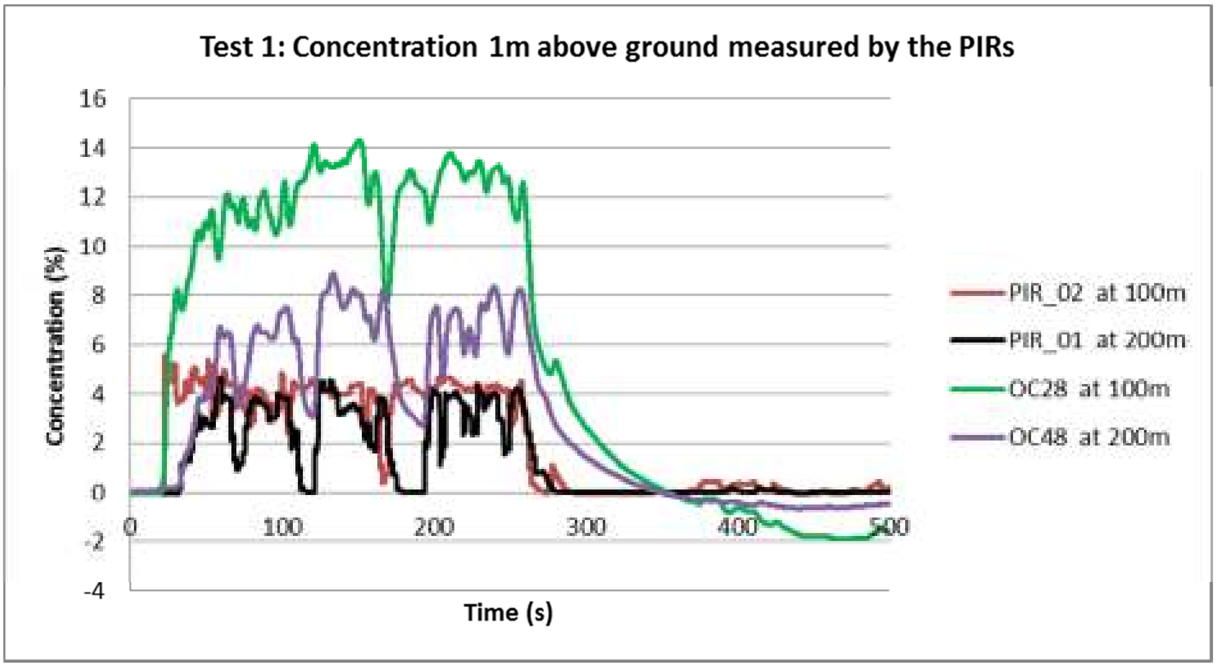


Figure 35: Gas Concentration Measured by the PIRs

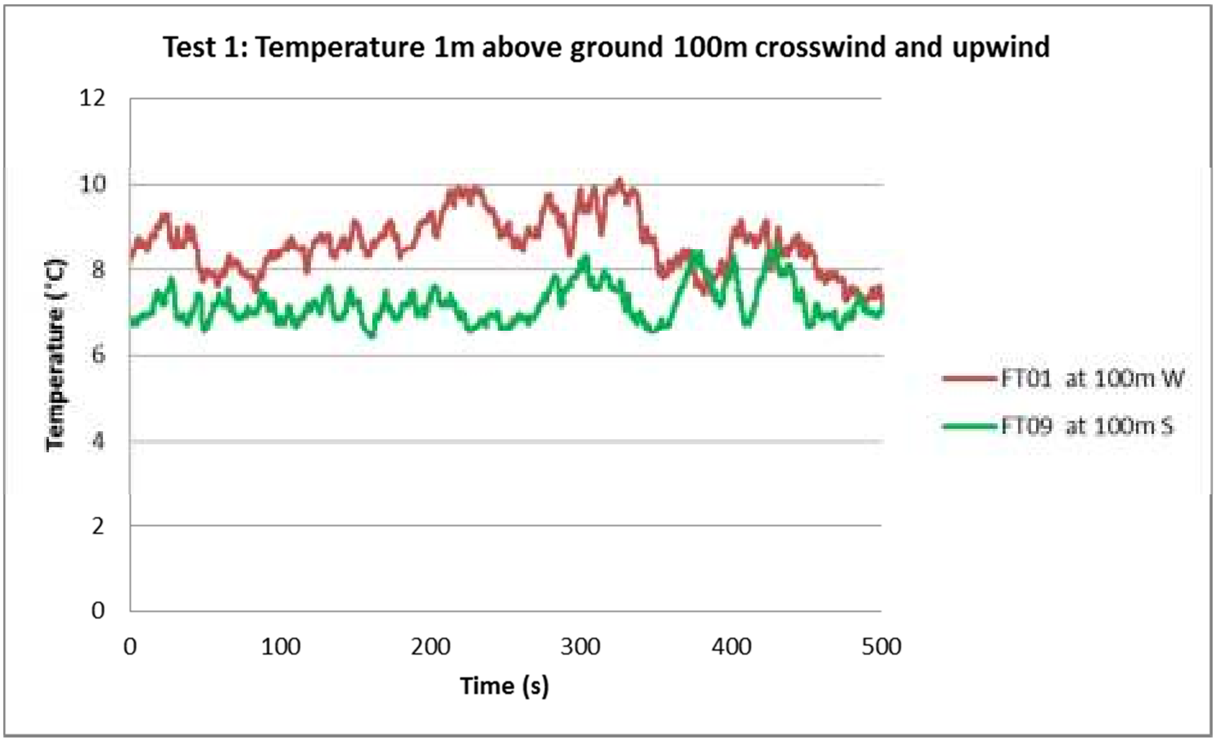


Figure 36(a): Temperature Measured 1m above Ground on an Arc 100m Crosswind/Upwind

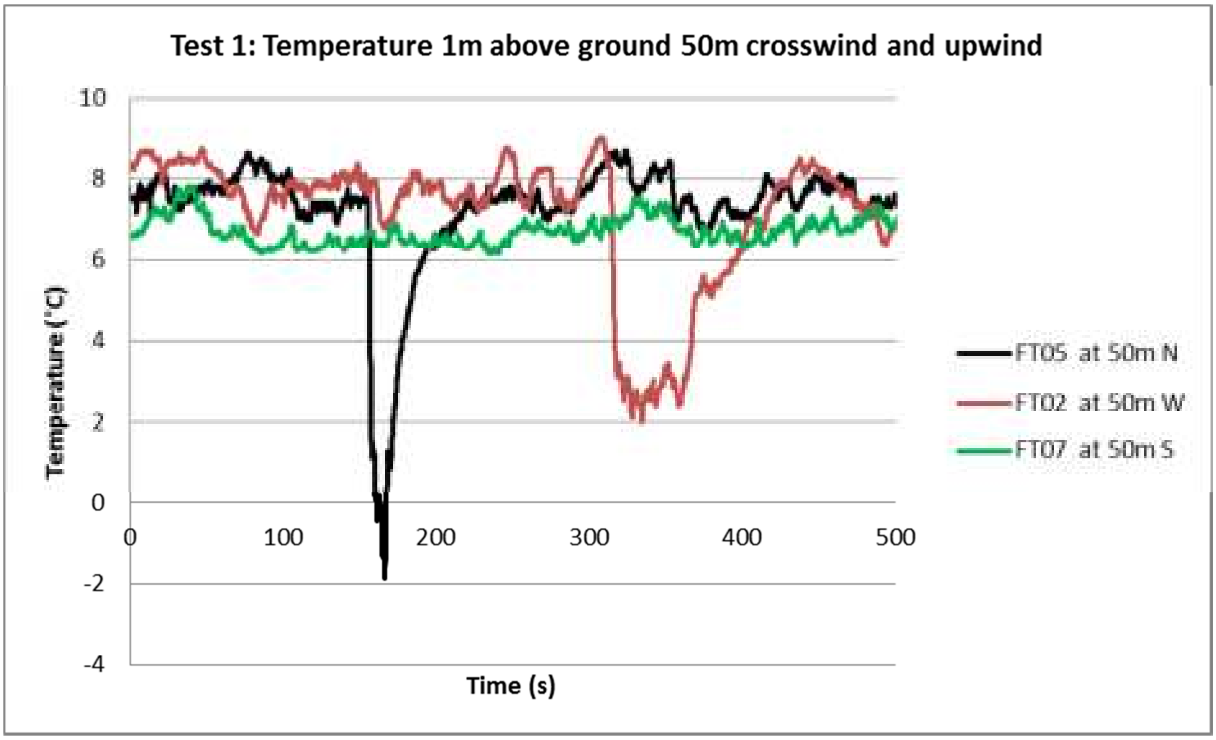


Figure 36(b): Temperature Measured 1m above Ground on an Arc 50m Crosswind/Upwind

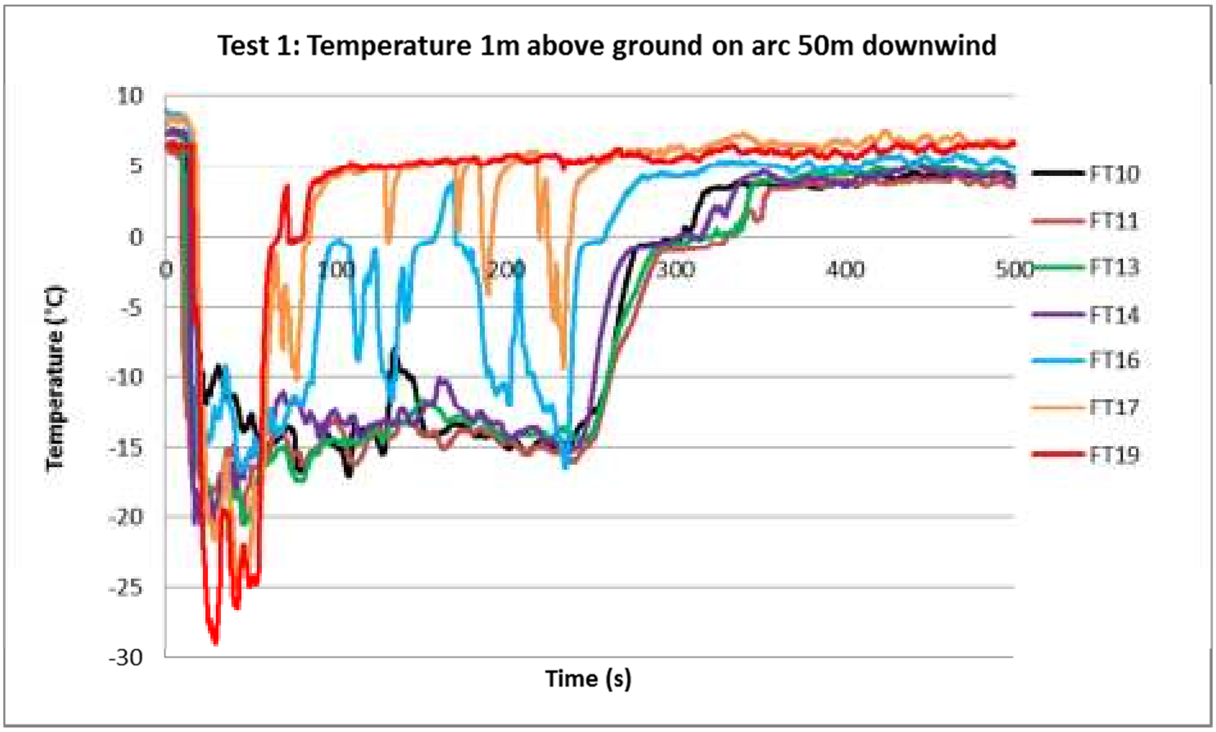


Figure 36(c): Temperature Measured 1m above Ground on an Arc 50m Downwind

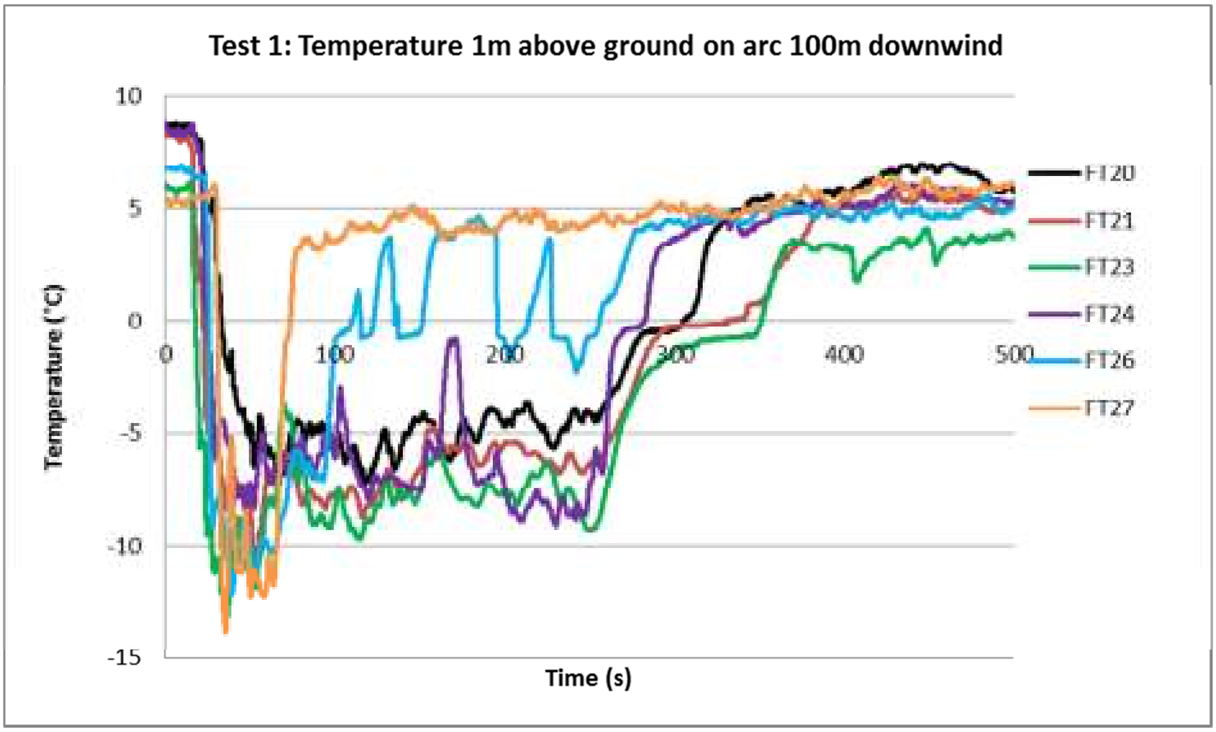


Figure 36(d): Temperature Measured 1m above Ground on an Arc 100m Downwind

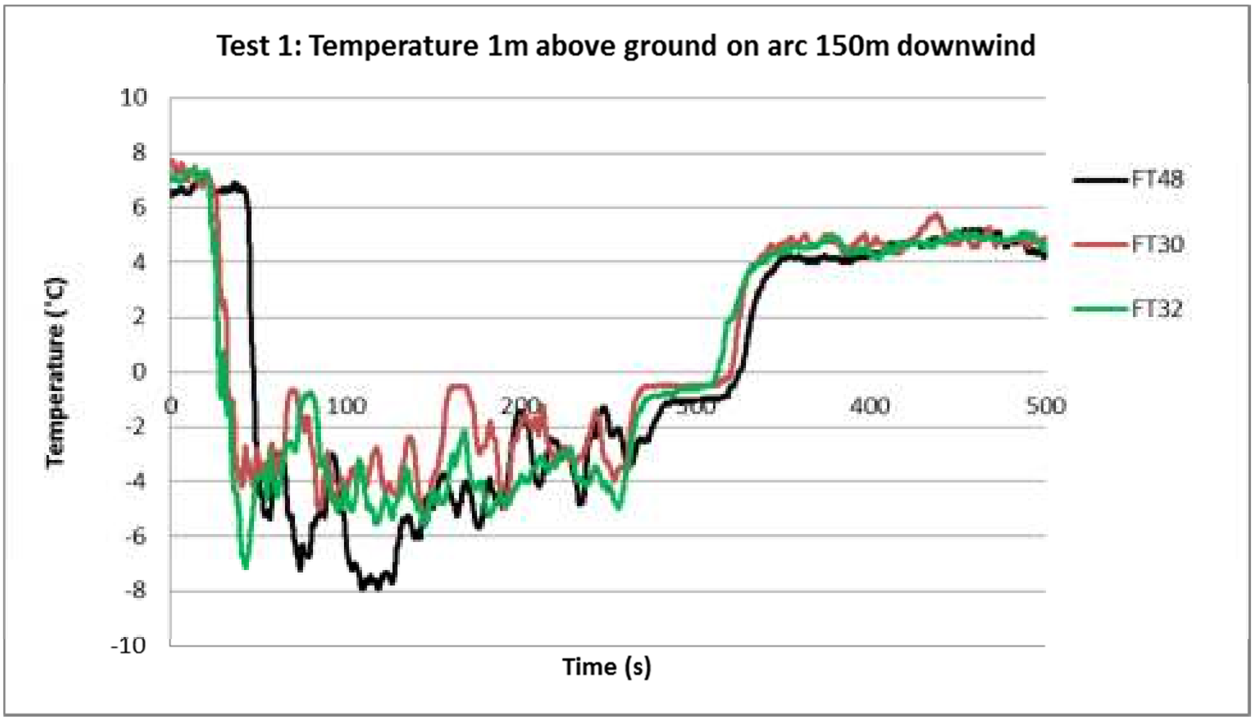


Figure 36(e): Temperature Measured 1m above Ground on an Arc 150m Downwind

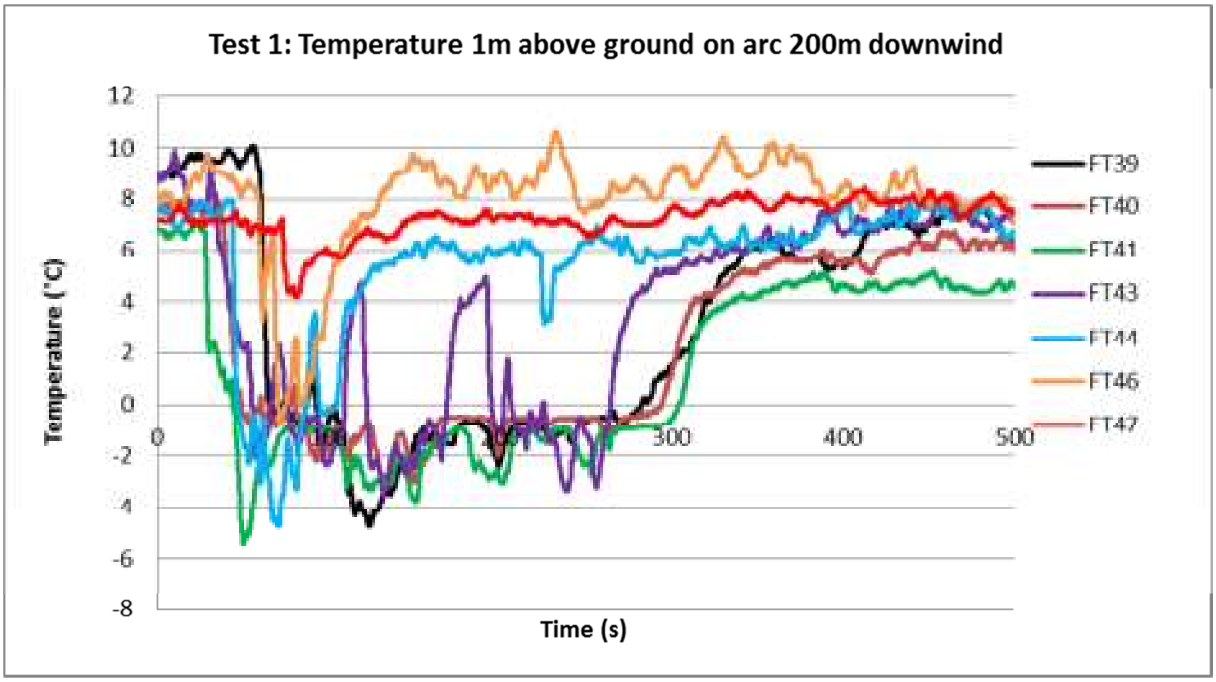


Figure 36(f): Temperature Measured 1m above Ground on an Arc 200m Downwind

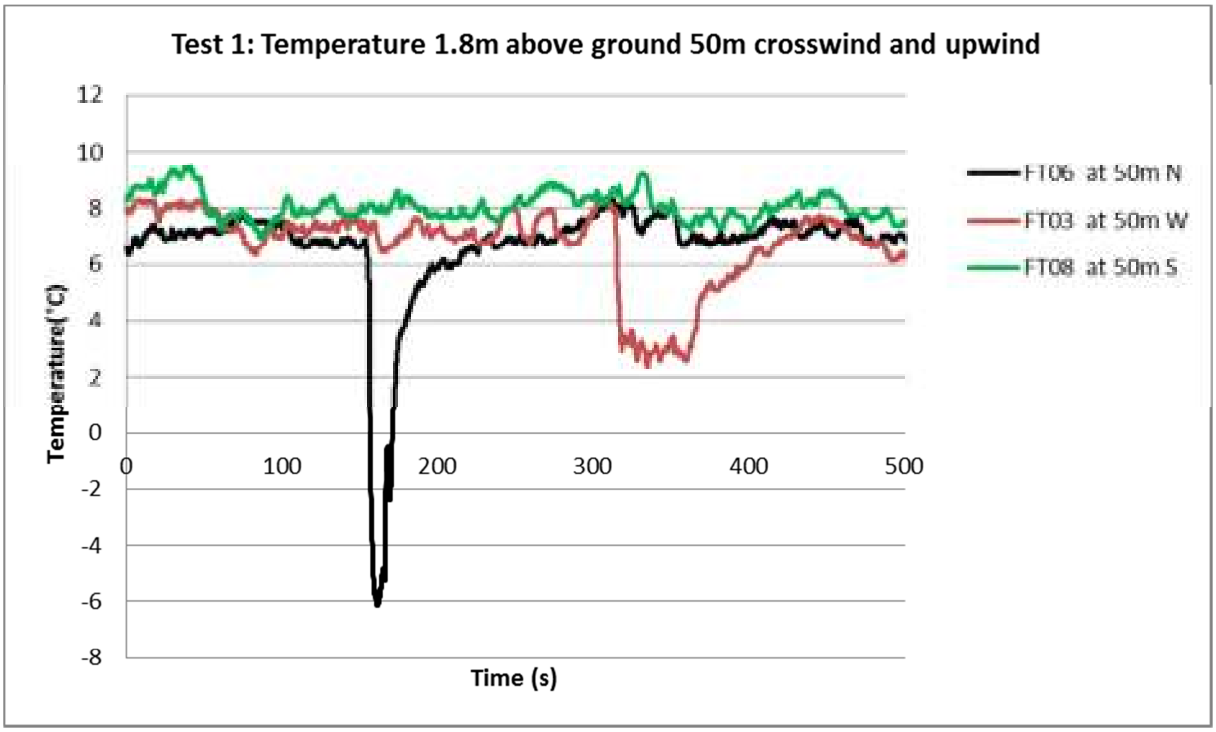


Figure 37(a): Temperature Measured 1.8m above Ground on an Arc 50m Crosswind/Upwind

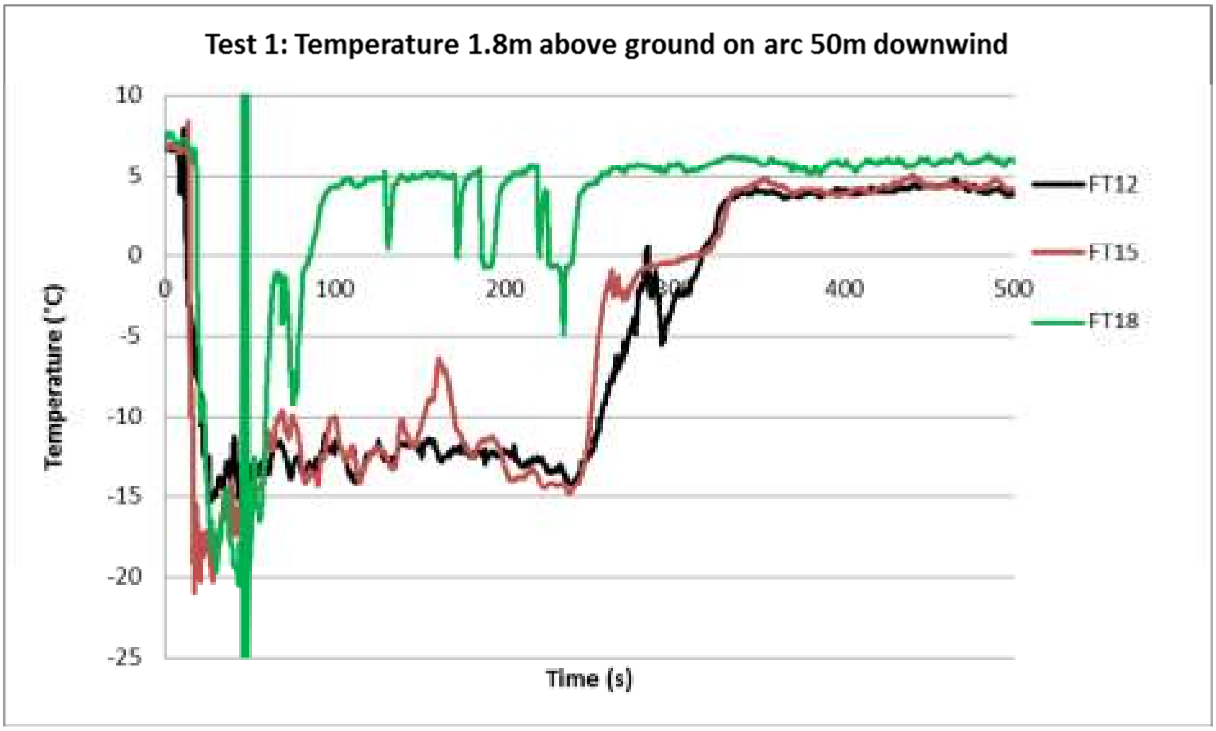


Figure 37(b): Temperature Measured 1.8m above Ground on an Arc 50m Downwind

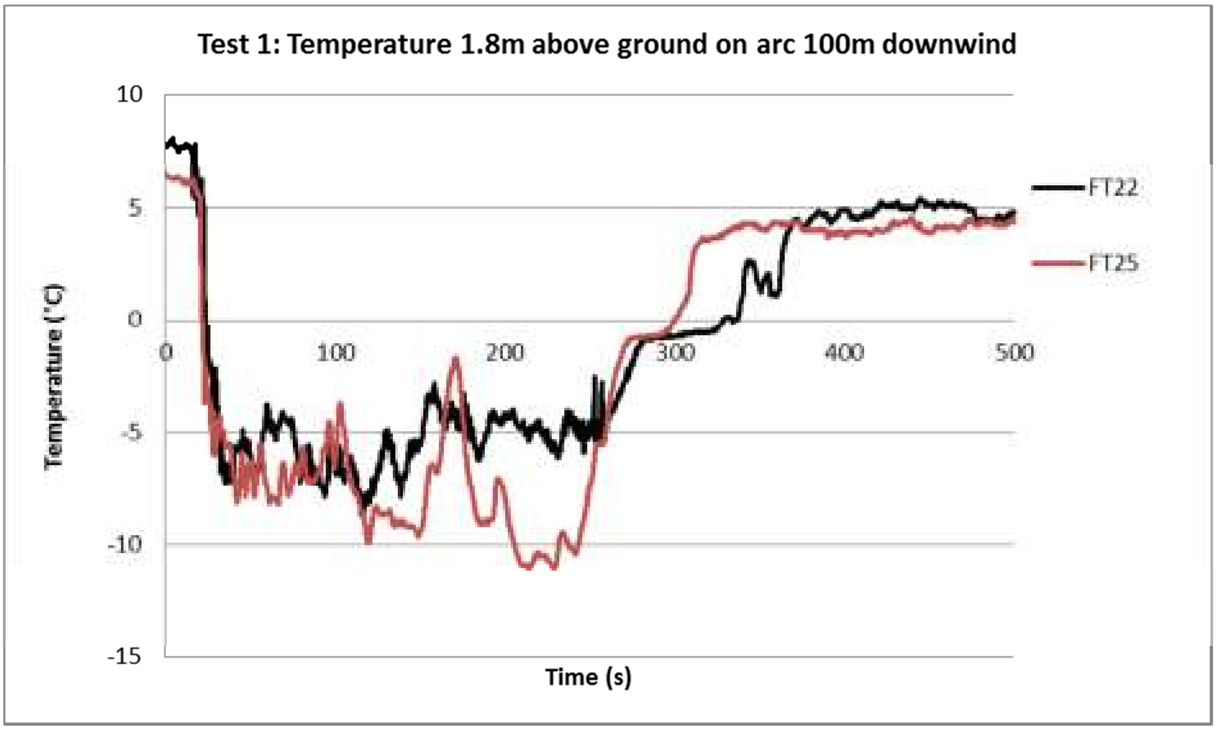


Figure 37(c): Temperature Measured 1.8m above Ground on an Arc 100m Downwind

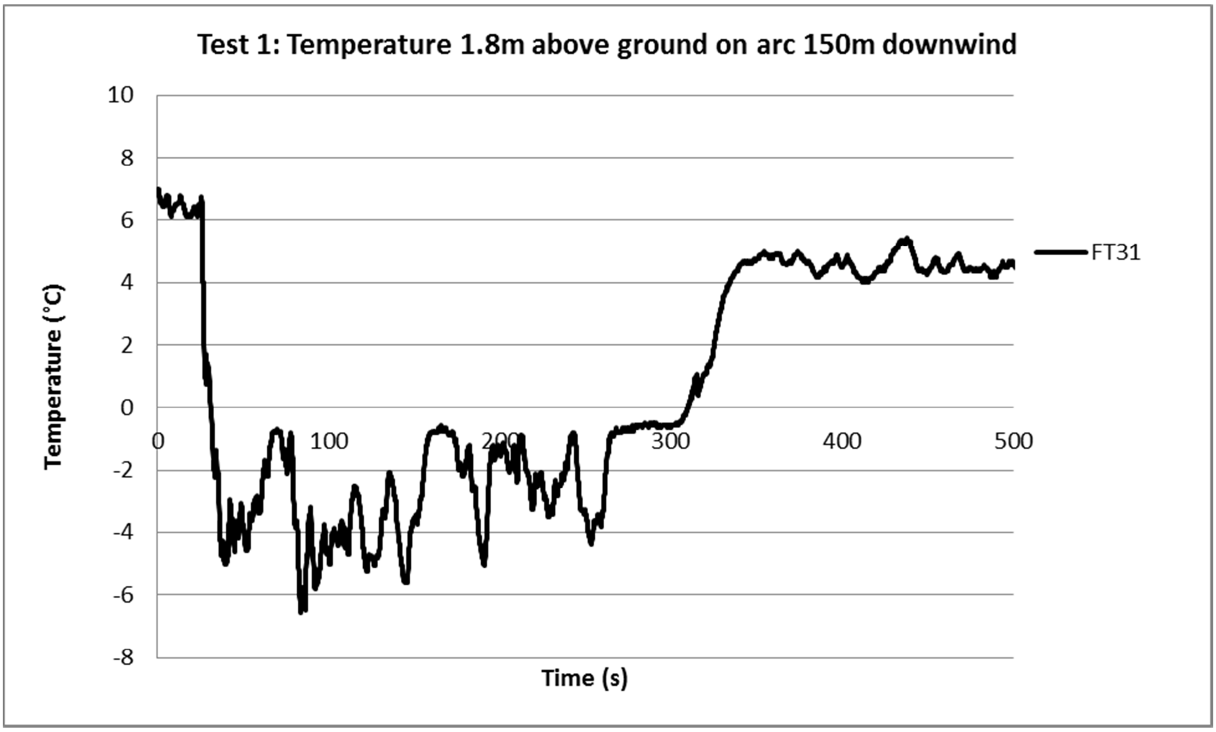


Figure 37(d): Temperature Measured 1.8m above Ground on an Arc 150m Downwind

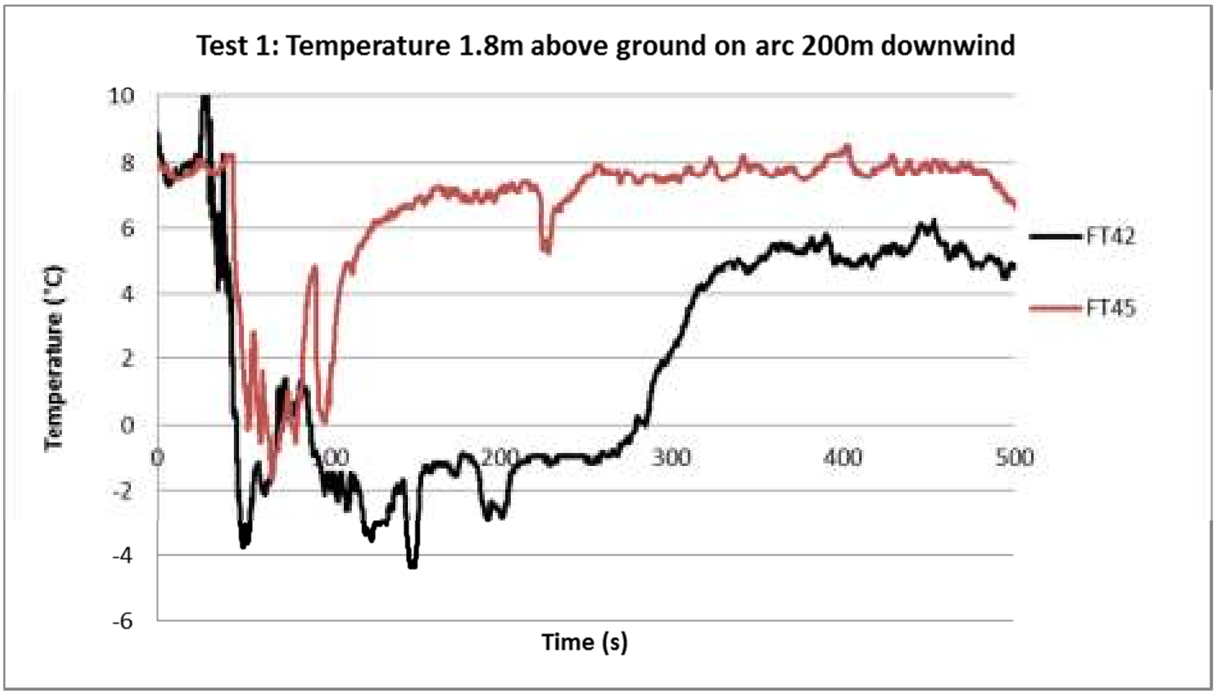


Figure 37(e): Temperature Measured 1.8m above Ground on an Arc 200m Downwind