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T 011 789 7170 E info@eims.co.za W www.eims.co.za

FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE PLAN, INCORPORATING AN ANNUAL REHABILITATION PLAN AND ENVIRONMENTAL RISK ASSESSMENT

TETRA4 PRODUCTION RIGHT – CLUSTER 2

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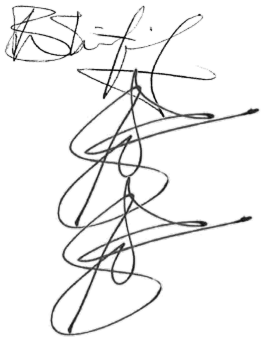
COMPILED:	Brian Whitfield		2022/11/18
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Appendix 2: Cost Quantum Determination detail and supporting documentation

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List of Definitions

Care and maintenance	This involves the maintaining and corrective action as requires as well as conducting the required inspection and monitoring to demonstrate achievement of success of the implemented measures.
Closure	This involves the application for closure certificate and initiation of transfer of on-going care and maintenance to third parties.
Contingencies	This allows for making reasonable allowance for possible oversights/omissions and possible work not foreseen at the time of compilation of the closure costs. Allowance of between 10 percent and 20 percent would usually be made based on the accuracy of the estimations. The South African Department of Mineral Resources Guideline (January 2005) requires an allowance of 10 percent.
Decommissioning	This relates to the situation after cessation of operations involving the deconstruction/removal and/or transfer of surface infrastructure and the initiation of general site rehabilitation.
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FRDCP	Final Rehabilitation, Decommissioning and Closure Plan
IWUL	Integrated Water Use Licence
LOM	Life of Mine- reflective of the current planned extent of the mining operations.
MWP	Mine works programme
NEMA	National Environmental Management Act (Act 107 of 1998)
Post-closure	The period of on-going care and maintenance, as per arrangement with third parties.
Preliminary and General (P&G)	This is a key cost item which is causally related to whether third party contractors are applied for site rehabilitation. This cost item comprises both fixed and time-related charges. The former makes allowance for establishment (and de-establishment) of contractors on site, as well as covering their operational requirements for their offices (electricity/water/communications), latrines, etc. Time-related items make allowance for the running costs of the fixed charged items for the contract period.
Rehabilitation:	The re-instatement of a disturbed area into a usable state (not necessarily its pre-mining state) as defined by broad land use and related performance objectives.
Remediation	To assist in the rehabilitation process by enhancing the quality of an area through specific actions to improve especially bio-physical site conditions.
Scheduled closure	Closure that happens at the planned date and/or time horizon.
Site relinquishment	Receipt of closure certificate and handover to third parties for on-going care and maintenance, if required.
Unscheduled closure	Immediate closure of a site, representing decommissioning and rehabilitation of the site in its present state.

1 EXECUTIVE SUMMARY

Tetra4 (Pty) Ltd (herein referred to as Tetra or the Holder) is the holder of a Production Right for natural gas issued by the Department of Mineral Resources and Energy (DMRE) in association with the Petroleum Agency South Africa (PASA). The Production Right spans an area of approximately 187 000ha in the Free State Province, stretching from Welkom in the north, to Theunissen in the south. The Production Right was issued for a duration of 30 years commencing in 2010. The Holder is continuing with exploration activities and has commenced with production from some initial wells. The Cluster 1 phase of the production has commenced in August 2022, with the production of helium and Liquid Natural Gas (LNG). An expansion of the production activities is being applied for and will constitute Cluster 2 of the gas gathering and production activities within the approved Production Right.

According to the National Environmental Management Act (Act 107 of 1998) and the associated Financial Provision Regulations (2015) (NEMA GNR 1147), every mine[1] must make financial provision for annual rehabilitation, final rehabilitation, decommissioning and closure activities at the end of mining; and remediation and management of latent or residual environmental impacts which may become known in the future. GNR1147 also requires that every holder must annually-

a) Assess his or her environmental liability in a prescribed manner and must increase his or her financial provision to the satisfaction of the Minister responsible for mineral resources; and

b) Submit an audit report to the Minister responsible for mineral resources on the adequacy of the financial provision from an independent auditor.

This report aims to comply with the requirements of the GNR1147 and includes an annual rehabilitation plan, a final rehabilitation, decommissioning and closure plan, and an environmental risk assessment report.

The closure vision for the operation is to conduct the rehabilitation, decommissioning and closure operations and manage the environmental impacts in such a manner to ensure that the landscape is safe, stable and non-polluting over the long term, and that the post closure land use aligns with the surrounding land-use and/or agreed upon end use and does not affect the sustained utilisation thereof.

The determination of the quantum required for adequate financial provision has been determined using the GNR1147 method (i.e. real contractor rates). The GNR1147 quantum is expected to represent a realistic estimation of the required cost for effective decommissioning, rehabilitation, closure, and management of ongoing residual, and potential future latent, impacts. The calculated quantum of financial provision for the Cluster 2 as determined using the NEMA GNR1147 methodology is summarised in Table 1.

Table 1: Summarised consolidated quantum of financial provision.

Closure Cost Item	Scheduled 2022[2]	Unscheduled 2022[3]
Final Decommissioning and Closure Cost	R 278 188 215.92	R 93 804 779.75
Infrastructural Areas	R 54 152 271.61	R 18 050 576.70
Wells	R 170 235 343.60	R 56 744 547.08
General Surface Rehabilitation	R 2 312 197.39	R 770 724.76
Closure phase monitoring	R 1 323 315.19	R 1 323 315.19

[1] In accordance with the MPRDA, reference of a mine would apply to a petroleum production operation.

[2] Scheduled closure refers to the process of decommissioning, rehabilitation and closure of the production operations as at the planned cessation of production activities. This is also referred to as planned closure.

[3] Unscheduled closure refers to the process of decommissioning, rehabilitation and closure of the production activities, assuming all production activities cease as at the date of this report. This is also referred to as unplanned closure.

Closure Cost Item	Scheduled 2022[2]	Unscheduled 2022[3]
P&Gs and Contingencies	R 50 165 088.12	R 16 915 616.02
Annual Rehabilitation Cost	**R -**	**R -**
Post Closure Phase- Residual and Latent Cost	**R 5 918 116.62**	**R 4 858 581.01**
Monitoring	R 4 328 813.20	R 4 328 813.20
Latent and residual risk provision (Redrill and plugging of borehole)	R 1 589 303.42	R 529 767.81
Total Quantum of Financial Provision (Excl VAT)	R 284 106 332.54	R 98 663 360.76

2 INTRODUCTION

Tetra4 (Pty) Ltd (herein referred to as Tetra4 or the Holder) is the holder of a Production Right for natural gas issued by the Department of Mineral Resources and Energy (DMRE) in association with the Petroleum Agency South Africa (PASA). The Production Right spans an area of approximately 187 000ha in the Free State Province, stretching from Welkom in the north to Theunissen in the south.

In 2017, following an Environmental Impact Assessment (EIA), Environmental Authorisation (EA) was issued to Tetra4 to extend gas production operations within the existing Production Right, to amend the existing EMPr, and include the combined helium and LNG plant and any activities not previously authorised to the gas production development. As part of this EIA process a Final Rehabilitation, Decommissioning and Closure Plan (FRDCP) was prepared in accordance with the requirements of the NEMA Financial Provisioning Regulations (2015) (NEMA GNR 1147. GNR1147 also requires that every holder must annually-

a) Assess his or her environmental liability in a prescribed manner and must increase his or her financial provision to the satisfaction of the Minister responsible for mineral resources; and

b) Submit an audit report to the Minister responsible for mineral resources on the adequacy of the financial provision from an independent auditor.

In 2022, Tetra4 has applied to expand the gas gathering network and production facilities as part of the Cluster 2 development. This development would constitute an order of magnitude increase in the Cluster 1 gas gathering and production activities. This report aims to comply with the requirements of the GNR1147 and includes an annual rehabilitation plan, a final rehabilitation, decommissioning and closure plan, and an environmental risk assessment report for the inclusion of the Cluster 2 production activities.

According to the regulations, financial provision must be made for annual rehabilitation, final rehabilitation, decommissioning and closure activities at the end of prospecting, exploration, mining or production operations; and remediation and management of latent or residual environmental impacts which may become known in the future. In order to address these requirements this document includes an annual rehabilitation plan, a final rehabilitation, decommissioning and closure plan, and an environmental risk assessment report. Table 1 below lists the specific requirements that must be contained in each of the three plans as per the NEMA GNR 1147 Appendices 3, 4 and 5, as well as the associated section in the report where each requirement is addressed.

Table 2: NEMA GNR 1147 Appendix 3, 4 and 5 Requirements and Associated Sections Where they are Addressed

No.	Requirement	Relevant Section
Annual Rehabilitation Plan – Appendix 3		
3 (a)	details of the person or persons that prepared the plan, and timeframes of implementation of the current, and review of the previous rehabilitation activities;	Section 3 Section 4.8
3 (b)	the pertinent environmental and project context relating directly to the planned annual rehabilitation and remediation activity;	Sections 4.1 and 4.1
3 (c)	results of monitoring of risks identified in the final rehabilitation, decommissioning and mine closure plan with a view to informing rehabilitation and remediation activities;	Section 5.1
3 (d)	an identification of shortcomings experienced in the preceding 12 months;	Section 5.2
3 (e)	details of the planned annual rehabilitation and remediation activities or measures for the forthcoming 12 months;	Section 5.3
3 (f)	a review of the previous year's annual rehabilitation and remediation activities;	Section 5.2
3 (g)	costing;	Section 5.4
Final Rehabilitation, Decommissioning and Mine Closure Plan – Appendix 4		
3 (a)	details of the person or persons that prepared the plan;	Section 3
3 (b)	the context of the project, including material information and issues that have guided the development of the plan, an overview of the environmental context, the social context regarding closure activities and post-mining land use, stakeholder issues and comments, and the mine plan and schedule for operations;	Section 4.1
3 (c)	findings of an environmental risk assessment leading to the most appropriate closure strategy;	Sections 4.3 and 4.4
3 (d)	design principles, including the legal and governance framework, the closure vision, objectives and targets, alternative closure and post closure options, a motivation for the preferred closure action, details of the closure and post closure period, details associated with any on-going research on closure options, and details of assumptions made to develop closure actions;	Section 4.4
3 (e)	a proposed final post-mining land use;	Section 4.6
3 (f)	closure actions required;	Section 4.7
3 (g)	a schedule of actions for final rehabilitation, decommissioning and closure;	Section 4.8
3 (h)	an indication of the organisational capacity that will be put in place to implement the plan, including the organisational structure;	Section 4.9

No.	Requirement	Relevant Section
Annual Rehabilitation Plan – Appendix 3		
3 (i)	an indication of gaps in the plan;	Section 4.10
3 (j)	relinquishment criteria for each activity or infrastructure in relation to environmental aspects with auditable indicators;	Section 4.11
3 (k)	the closure cost estimation procedure;	Section 4.12
3 (l)	monitoring, auditing and reporting requirements which relate to the risk assessment, legal requirements and knowledge gaps;	Section 4.13
3 (m)	motivations for any amendments made to the final rehabilitation, decommissioning and mine closure plan, given the monitoring results in the previous auditing period and the identification of gaps as per 2(i).	n/a
Environmental Risk Assessment – Appendix 5		
3 (a)	details of the person or persons that prepared the plan;	Section 3
3 (b)	details of the assessment process used to identify and quantify the latent risks;	Section 6.1
3 (c)	management activities;	Section 6.2
3 (d)	costing;	Section 6.2.3
3 (e)	monitoring, auditing and reporting requirements.	Section 6.2

3 DETAILS OF THE SPECIALIST

The details of the professionals who contributed to the preparation of the annual rehabilitation plan (ARP), final rehabilitation, decommissioning and mine closure plan (FRDCP) and environmental risk assessment (ERA) are provided in Table 3.

Table 3: Details of Specialist[4]

Name	Role	Qualifications/ Experience	Professional registrations
Liam Whitlow	Environmental Scientist	BSc Hons Environmental Management with ~20 years environmental consulting experience.	South African Council for Natural Scientific Professions- Registered Professional Natural Scientist (Environmental Science). Registered Environmental Assessment Practitioner. Member of Land Rehabilitation Society of Southern Africa.

[4] According to GNR1147, "specialist" means an independent person or persons who is qualified by virtue of his or her demonstrable knowledge, qualifications, skills or expertise in the mining, environmental, resource economy and financial fields.

Name	Role	Qualifications/ Experience	Professional registrations
Brian Whitfield	Environmental Scientist	BSc Hons (Botany and Zoology) with 18 years of environmental consulting experience.	South African Council for Natural Scientific Professions- Registered Professional Natural Scientist (Environmental Science). Registered Environmental Assessment Practitioner.
Douglas Richards	Environmental Engineer	BEng Tech Civil Engineering	13 years environmental engineering experience Member of South African Institution of Civil Engineering (SAICE) Member of Land Rehabilitation Society of Southern Africa.

4 FINAL REHABILITATION, DECOMISSIONING AND MINE CLOSURE PLAN (FRDCP)

According to GNR 1147 the objective of the final rehabilitation, decommissioning, and closure plan, is to identify a post-production land use that is feasible through-

- Providing the vision, objectives, targets and criteria for final rehabilitation, decommissioning, and closure of the project;
- Outlining the design principles for closure;
- Explaining the risk assessment approach and outcomes and link closure activities to risk rehabilitation;
- Detailing the closure actions that clearly indicate the measures that will be taken to mitigate and/or manage identified risks and describes the nature of residual risks that will need to be monitored and managed post closure;
- Committing to a schedule, budget, roles and responsibilities for final rehabilitation, decommissioning and closure of each relevant activity or item of infrastructure;
- Identifying knowledge gaps and how these will be addressed and filled;
- Detailing the full closure costs for the life of project at increasing levels of accuracy as the project develops and approaches closure in line with the final land use proposed; and
- Outlining monitoring, auditing, and reporting requirements.

This section of the report aims to achieve these objectives.

4.1 PROJECT CONTEXT

This section aims to provide context and focus attention on the material information and issues that have guided the development of this FRDCP. Further details on the project and environmental context can be obtained from the Environmental Impact Assessment (EIA) Report and associated Environmental Management Programme (EMPr).

The description and definition of the environmental context is critical to ensure that the ultimate closure objectives and associated end land-use are achieved. This content of this section is sourced primarily from the available EIA Reports, and the previous FRDCP.

The key environmental aspects related to the project area and specifically the closure and rehabilitation strategies are summarised in the remainder of this Section. The production activities, which would require inclusion in the FRDCP are presented herein and are derived from the available information on the historic operations and the current conditions on site.

4.1.1 LOCATION

The granted Production Right spans approximately 187 000 hectares and was awarded to Tetra4 (then Molopo South Africa) in 2012 to develop gas fields around the town of Virginia in the Free State Province (refer to Figure 1). Whilst the application for Production Right has been issued for the entire conceptual full field development area, the environmental permissions, only apply to the areas with certified reserves (refer to the red area). The certified reserves area spans a total area of approximately 104 659 ha, as presented in Figure 1. When in full production, should conditions warrant it, the following was originally included in the Production Right:

- Approximately 260 production wells (also referred to as blowers) with associated infrastructure;
- A combined helium (He) and LNG (Methane) processing facility;
- Approximately 500km of intra field pipelines;
- Approximately 4 main high-pressure gas compressors; and
- Approximately 18-20 pipeline booster compressors.

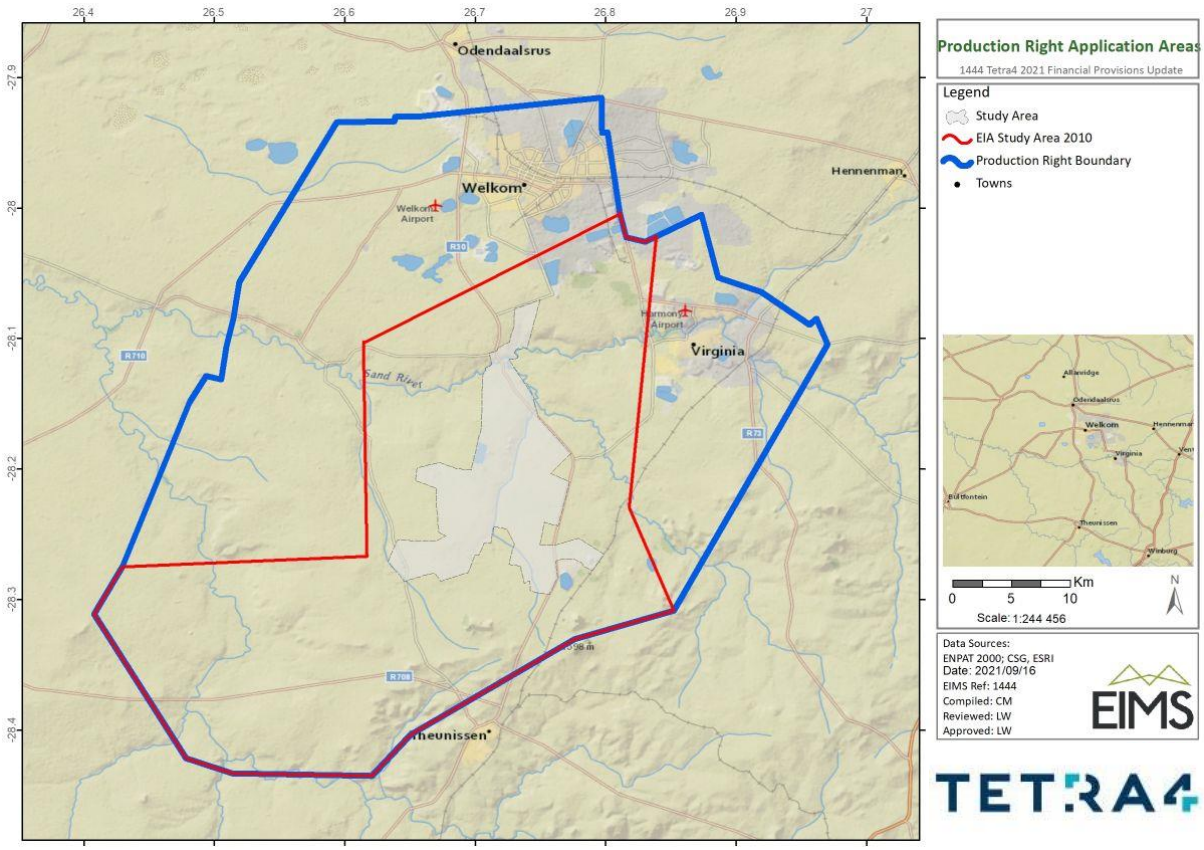

Figure 1: Locality map

4.1.2 GAS PRODUCTION

The Tetra4 Production Right is located within the Sand River Play or Virginia Gas Field. Despite not being clearly defined, the field is composed predominantly of Karoo, Ventersdorp and Witwatersrand Supergroup lithologies complete with younger dolerite intrusions. Major fault systems associated with closely spaced zones of fractures and joints provide for preferential pathways for a combination of abiogenic and biogenic gas to reach the

surface. As such, the resulting gas at the surface is a direct emission from the major fault or from minor secondary faults linked to a major fault. In this regard, it is thought that the primary source of gas originates from the Witwatersrand Supergroup or shallower Karoo. As an unconventional resource, the gas is presumed to be a mantle mix of both abiogenic and biogenic hydrocarbons originating from ancient fissure waters, coal beds of the Ecca Group of the Karoo Supergroup as well as ancient algal mats within the shallow marine/lacustrine Witwatersrand Supergroup deposits. The feed gas will be available at a pressure of ~0.4 barg (gauge pressure) and with a temperature in the range between 10º and 30ºC. The feed gas will be compressed upstream of the helium process units by a compressor station. A gas pre-treatment will remove condensate as well as traces of sulphur, mercury and C3+ gas components (e.g. propane, butane, pentane), which could cause possible damage to the downstream process equipment.

4.1.3 GAS PRODUCTION METHOD

The gas field production method to be employed entails the extraction of gas at individual well sites identified through ongoing exploration activities within the Production Right area. Gas extracted from the wells is sent via pipeline to infield compressors and then piped through to the combined helium and liquid natural gas (LNG) plant for processing. The final product includes helium and LNG, both of which are temporarily stored and trucked away via trailer to be sold to end users. Each component, namely well sites, pipelines, infield centralised compressors and the processing plant is described below in more detail.

3.1.1.4.1 Exploration Drilling

Exploration drilling entails the use of a truck, trailer or skid mounted drill rig to drill to varying depths in order to strike the gas reserve. Percussion and diamond drills typically require clearance of an area of 50 m x 50 m in order to set up the rig and begin drilling activities. All exploration boreholes to be drilled in accordance best industry best practice and Tetra4 internal procedures and will be sealed with a combination of casing and grouting to ensure vertical isolation of the gas from both the surrounding geology and hydrological regime. In addition to the drill rig, lined sumps will be required to store and recirculate water for the drilling process.

In the event that an exploration borehole proves unsuccessful it will be plugged and sealed (in accordance with industry best practice and Tetra4 internal procedures) and the area rehabilitated. A distinction is made between wells which intersect gas inflows, and / or alternatively both fresh and saline groundwater flow zones (i.e. deep as well as shallow aquifers), and those wells which do not. In the event that no gas or saline water flow zones are intersected then a conventional borehole closure process will be implemented (i.e. no need for plugging of full well bore).

In the event that the exploration borehole proves successful it will be converted into a production well (as described below) and added to the network of gas producing wells. The drilling of exploration boreholes is a temporary and short-duration activity and the equipment to be used during drilling activities includes a truck/trailer or skid mounted diamond/percussion drill rig, excavator, dozer, grader water cart, light motor vehicle for transport of personnel and chemical toilets.

The Cluster 2 project entails a total of ~ 300 production wells (~400 exploration wells) which, when combined, will produce a total of ~45 MMSCFD. The wells will be located within the identified zones in Figure 2 with the number of wells informed by the total gas requirements and expected well gas capacity. The current plan is to drill vertical or incline wells ~300m apart along the fault lines and within the identified and assessed well transect areas.

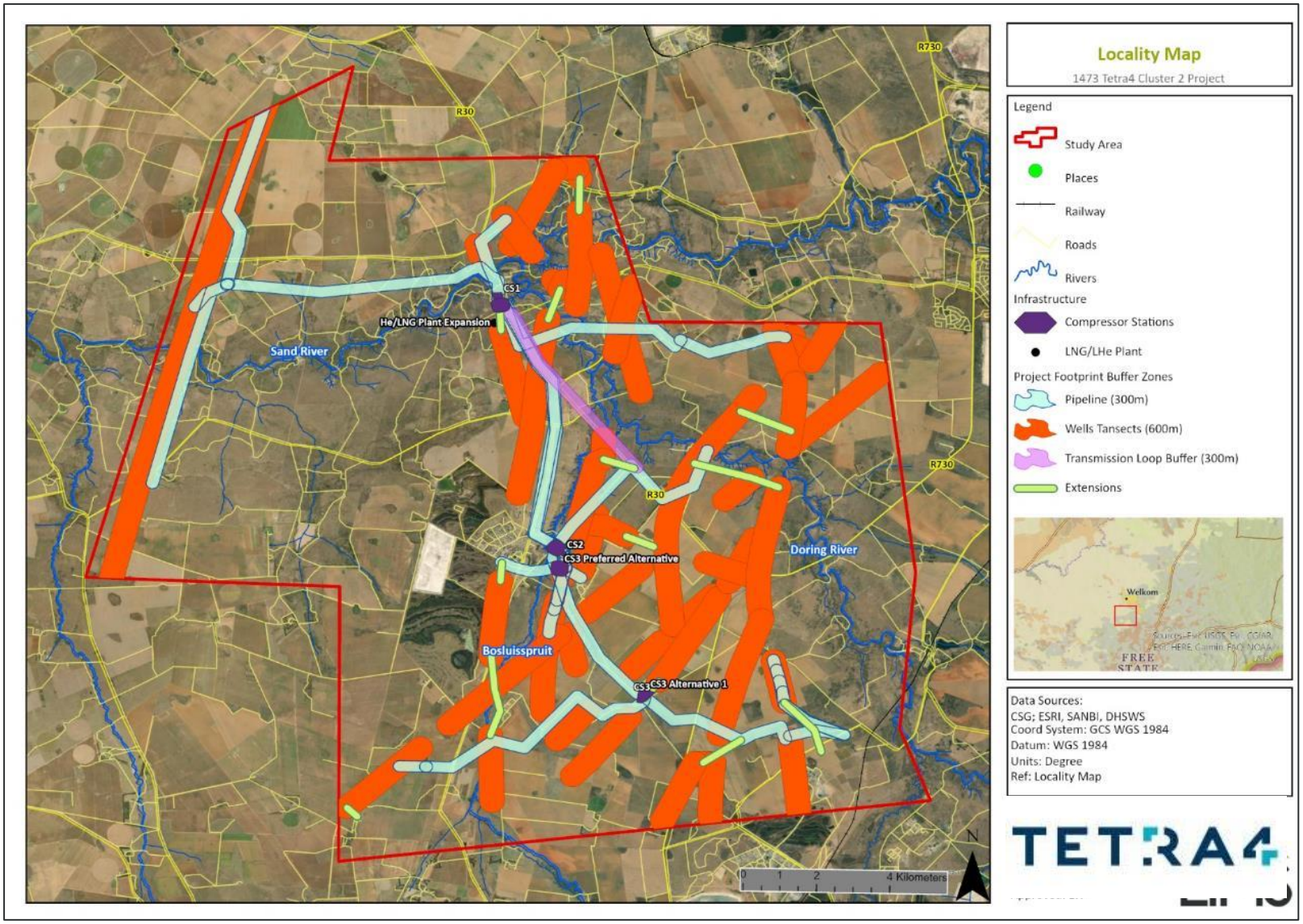

Figure 2: Cluster 2 study area and proposed infrastructure footprint transects.

3.1.1.4.2 Well Site Connection

All wells that are drilled and used for production purposes are strengthened with a combination of casing and grouting to average depths of 300m. The casing and grouting ensure that the gas and other fluids are isolated from surrounding geology and promotes the preferential flow of gas from the formation through the well and up to the surface. As the gas is naturally lighter than air, it rises naturally to the surface and no well stimulation is required. The combination of casing and grouting also serves to ensure that gas is isolated and prevented from interacting with the geohydrological regime.

Due to low gas pressures, each well will likely be equipped with an electrical or gas driven wellhead which boosts gas recovery by creating necessary pressure differentials through vacuum suction. From the wellhead, the blower will be connected via pipeline to an inline gas booster or a centralised infield reciprocating gas compressor. Pipelines will be a combination of high-pressure steel as well as low pressure high density polyethylene (HDPE) and is installed at a minimum depth of 1.5m or below the plough line. Where piping (e.g. for the compressors and driers) will be brought to surface, steel piping will be utilised instead. Based on experience with security issues and maintenance of these typical production well designs in Cluster 1, the Cluster 2 production well designs are planned to be largely subterranean (within concrete "bunkers") with the surface infrastructure for the manhole being only a 1,4 m x 1,1 m concrete structure and the manhole surface height will be 0,25 m. Figure 3 shows the typical designs of a precast well chamber to be used in the Cluster 2 gas field development.

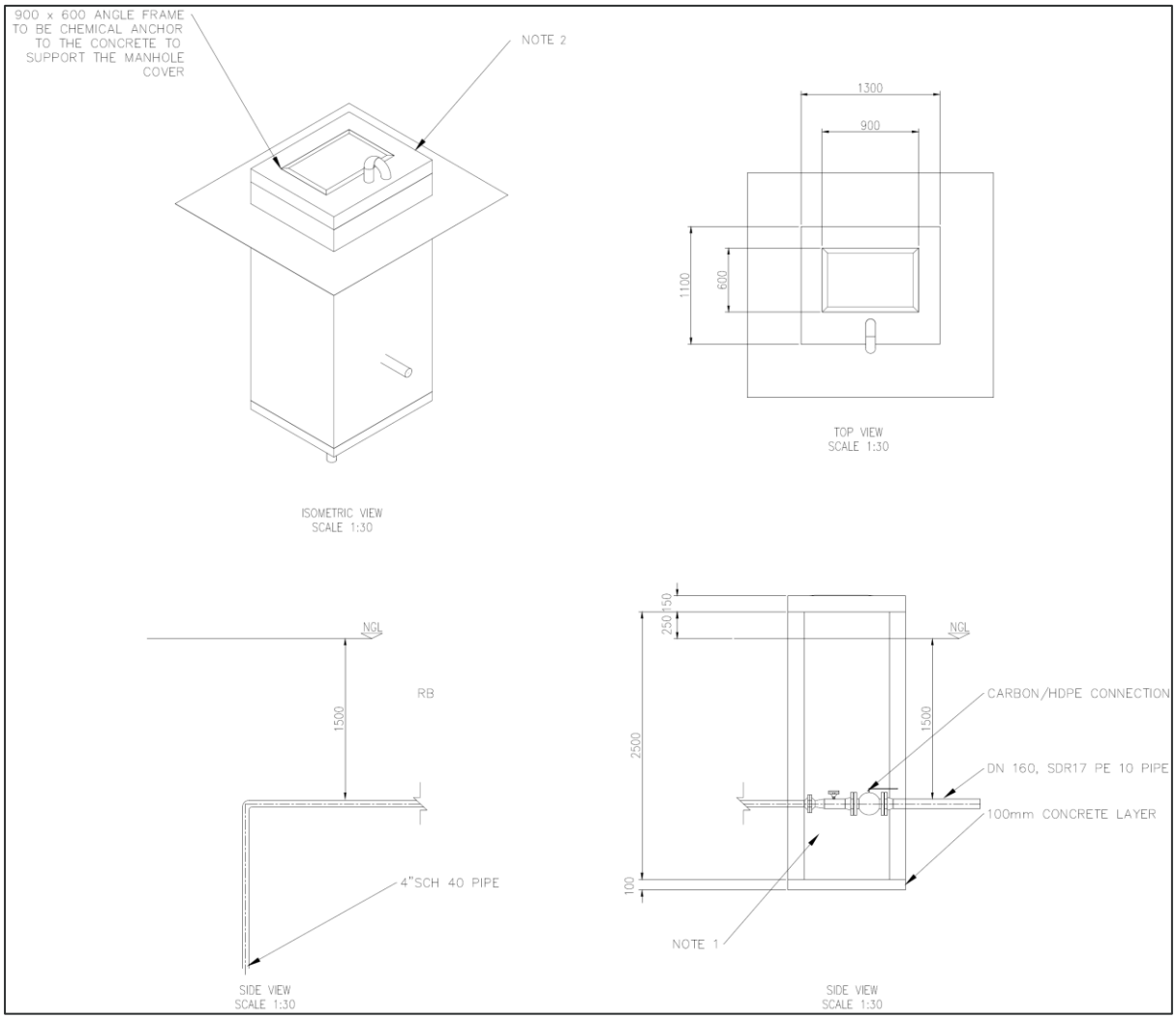

Figure 3: Typical layout of Cluster 2 production well head.

3.1.1.4.3 Gas Booster and Reciprocating Infield Compressors

Once the feed gas exits the wellheads the gas is transported via pipeline via the centralised infield reciprocating compressors to the processing plant. Due to low gas pressures in the wells, groups of ~10-12 wells will be included as an inlet to a booster station to provide vacuum suction. The booster stations will be connected via the pipelines to the centralised infield reciprocating gas compressor stations.

In order to transport gas via pipelines from the wellheads to the Plant in the Cluster 2 development, various inline infrastructure is required to monitor, measure and control gas flow through the pipelines and this includes booster stations, pigging stations and compressor stations. Localised inline gas booster stations will be installed for each cluster of 7-10 wells which will feed pressurised gas via pipelines from the production wells to the compressor stations. The booster stations will occupy an area of 10 m x 14 m (Figure 6) and a total of 28 booster stations are expected to be constructed.

Inline pigging stations (Figure 4) are installed near river crossings to allow for regular cleaning and inspection of the pipelines. The pigging stations allow for insertion of probes or cleaning pigs (plugs) in order to perform regular maintenance. There are approximately 4 major river crossings but with multiple pipe branches. In total there should be approximately 14 pig launcher/receiver pairs. Pigging stations occupy an area of approximately 5 m x 5 m (~25 m^2) each.

Low Point Drains (Figure 5) are installed along the pipeline to allow periodic maintenance of the pipeline whereby any condensate is able to be removed from the pipeline where the pipeline has a low point (gravity collection of condensates). Approximately 240 low point drains will be installed, and each occupies an area of ~1.5 m^2.

Figure 4: View of an existing pigging station constructed as part of Cluster 1.

Figure 5: View of an existing low point drain constructed as part of Cluster 1.

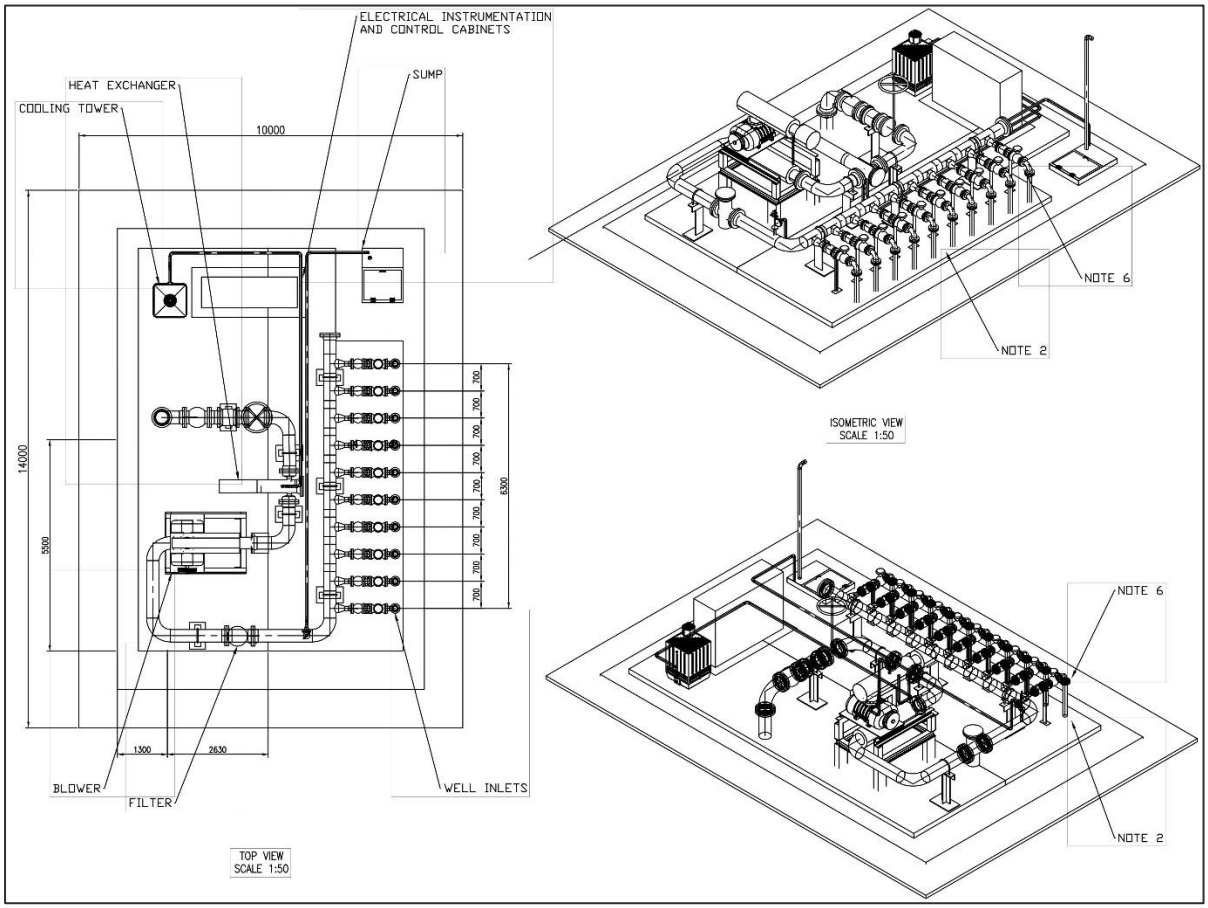

Figure 6: Typical booster station layout

Raw gas received at the compressor stations will be filtered to remove dust and moisture using a combination of a water filter and an activated carbon filter that absorbs dust and unwanted organic compounds. Once filtered, the gas from the compressors will be dried to 7 pounds per MMSCF adjacent to the compressor stations, and then piped for final processing to the LNG/LHe Plant. The footprint for a compressor station including the gas drier station will be approximately 60 m x 60 m (Figure 7 and Figure 8).

Figure 7: Example of Compressor Station constructed as part of Cluster 1.

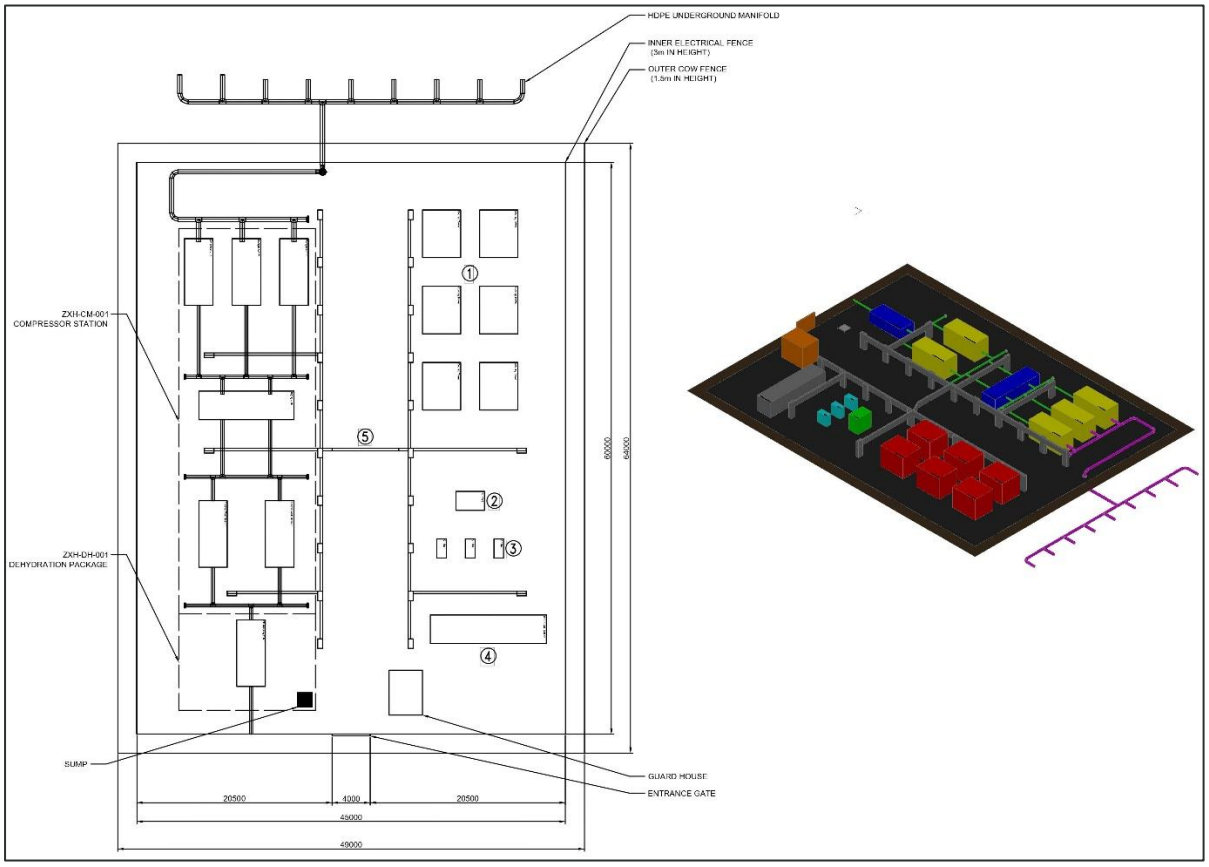

Figure 8: Typical compressor station layout.

3.1.1.4.4 Combined Helium and LNG Plant

Feed gas from either the booster compressors located at each of the well sites or from the centralised reciprocating infield compressors which will have driers in their vicinity, will be discharged into the combined

LNG/LHe plant. In order to achieve the required volumes of purified helium, the compressed feed gas is fed into a further installed gas pre-treatment unit which removes any additional condensate, traces of sulphur, mercury and hydrocarbons before entering the helium separating membranes and pressure swing adsorption (PSA) unit. Once separated by the combination of membranes and the PSA unit, the plant will separate feed gas to a minimum of 99.999 Vol% helium. Purified helium is then liquefied and placed into dispensing units for transport off-site via trailer. Natural gas removed of helium content is then re-circulated back into the plant where it is processed to form LNG. The LNG is then also placed into dispensing units for transport off-site also via trailer.

4.1.4 SURFACE INFRASTRUCTURE

The project requires other surface infrastructure not specifically described in the preceding sections. Such additional infrastructure includes:

- Access roads (temporary / permanent);
- Pipelines and powerlines;
- Coalescer filter or knockout drum at each booster station;
- Pipe markers (approximately every 100 m of the pipeline, where feasible);
- Wellheads;
- Booster pumps (where required);
- Inline booster compressors or infield reciprocating compressors;
- Gas driers;
- Fencing and security (limited to gas producing wells, compressor stations and LNG/LHe Plant infrastructure);
- Combined helium and LNG plant;
- LNG/LHe storage and dispensing units;
- Chemical storage;
- Temporary hazardous waste storage (including but not limited to waste water recirculation at drill sites and waste containing hydrocarbons such as used oil and filters, diesel, lubricants, grease, etc.);
- Temporary general waste storage;
- Contractors' laydown areas around the LNG/LHe Plant area; and
- Permanent offices, storage areas and workshops.

Figure 9 to Figure 18, provides a recent visual representation of the site infrastructure.

Figure 9: Typical example of exploration drilling.

Figure 10: Typical example of production well.

Figure 11: Centralised Compressor station.

Figure 12: Low point drain.

Figure 13: Pigging Station.

Figure 14: Rehabilitated pipeline route.

Figure 15: Typical example of culvert on access road.

Figure 16: Typical example of access road flume pipe.

Figure 17: Typical example of helium / LNG Plant construction.

Figure 18: HDR1 Production well and associated facility.

4.2 ENVIRONMENTAL AND SOCIAL CONTEXT

The description and definition of the pre-exploration/production environmental context is critical to ensure that the ultimate closure objectives and associated end land-use are achieved. In this regard please refer to Section 9 of the EIA report (Environmental Impact Management Services (Pty) Ltd, 2022) for a detailed description of the receiving environment applicable to this specific project. An overview of the broader environmental context is summarised in this section.

4.2.1 CULTURAL AND HERITAGE

The Free State has a rich archaeological and historical history going back millions of years and includes significant aspects such as Later Stone Age rock art, Battlefields and Iron Age stonewalled enclosures. Based on the historical and archaeological overview, the previous assessments undertaken in the area as well as the fieldwork undertaken as part of the Cluster 2 application, the heritage assessment findings are summarised below:

- Thirty-five (35) heritage sites which were previously identified for a 2016/2017 assessment, fall within the footprint areas of the current proposed Tetra4 Cluster 2 Gas Production Project. These comprised:

- 10 graves and burial grounds (TET 1, TET 7-8, TET 11, TET 15, TET 19, TET 22, SSL/BET/72, SITE 2, SITE 19);
- 11 structures (TET 2-3, TET 9, TET 27, SSL/BET/25-26, SSL/BET/36, SITE 1A, SITE 1B, SITE 20-21); and
- 14 historic to recent sites with possible graves (TET 4-6, TET 13-14, TET 25a, TET 25b, TET 26, SSL/BET/37-39, SSL/BET/53, SSL/BET/60, SSL/BET/66).

- During the current field assessment, a further thirty-seven (37) heritage sites were recorded as detailed below:
  - 6 sites containing burial grounds and graves (T0003, T0009, T0010, T0013, T0024, T0029);
  - 8 sites historic to recent sites with possible graves (T0007, T0008, T0011, T0015, T0023, T0026, T0027, T0028); and
  - 23 structures (T0001, T0002, T0004, T0005, T0014, T0016, T0017, T0018, T0019, T0020, T0021, T0022, T0025, T0030, T0031, T0033, T0034, T0036, T0037, T0038, T0039, T0040, T0041).

The combined seventy-two (72) identified heritage sites (as described above) were then assigned a sensitivity rating as either high, medium, low or none as follows:

- 37 sites were rated as having high heritage significance (IIIA): TET 1, TET 7-8, TET 11, TET 15, TET 19, TET 22, SSL/BET/72, SITE 2, SITE 19, TET 4-6, TET 13-14, TET 25a, TET 25b, TET 26, SSL/BET/37-39, SSL/BET/53, SSL/BET/60, SSL/BET/66, T0003, T0009, T0010, T0013, T0024, T0029, T0007, T0008, T0011, T0015, T0023, T0026, T0027, T0028;
- 12 sites were rated as having medium heritage significance (IIIB): TET 2, TET 3, TET 9, SITE 1A, SITE 1B, SITE 20, SITE 21, T0014, T0015, T0021, T0040, T0041;
- 13 sites were rated as having low heritage significance (IIIC): TET 27, SSL/BET/25, SSL/BET/26, SSL/BET/36, T0016, T0017, T0018, T0019, T0020, T0022, T0025, T0037, T0038; and
- 10 sites were rated as having no research potential or other cultural significance (NCW): T0001, T0002, T0004, T0005, T0030, T0031, T0033, T0034, T0036, T0039.

A Palaeontological study was undertaken by Elize Butler (February 2022) and the study indicates the proposed Cluster 2 development is underlain by Quaternary sediments as well as Permian aged sandstone and shale of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments in this area is Moderate, while that of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) is Very High. No visible evidence of fossiliferous outcrops was found in the development footprint and thus an overall medium palaeontological significance is allocated to the development footprint.

4.2.2 SOCIO-ECONOMIC

The project area covers a large part of the Free State gold fields, and hence an understanding of its economic baseline is important to scope the Economic Impact Assessment (ECIA). The immediate receptor area is the population of Matjhabeng Municipality, which is one of five local municipalities in Lejweleputswa District in the Free State. The major towns located in Matjhabeng are Allanridge, Hennenman, Odendaalsrus, Ventersburg, Virginia and Welkom. The Cluster 1 project is located in Wards 23 and 24 of the Matjhabeng Local Municipality and Ward 6 of the Masilonyana Local Municipality that forms part of the Lejweleputswa District Municipality in the Free State Province. The proposed Cluster 2 project area is located in Wards 9 and 24 of the Matjhabeng Local Municipality and Ward 6 of the Masilonyana Local Municipality.

The main towns in the Matjhabeng Local Municipality are Welkom, Odendaalsrus, Virginia, Hennenman, Allanridge and Ventersburg (www.matjhabeng.fs.gov.za). The municipality has a combined population of more than 500 000 people. The economy of the municipality is centred on mining activities in, and around Welkom,

Allanridge, Odendaalsrus and Virginia. Manufacturing aimed at the mining sector exists to a limited extent in the above towns, with other activities being limited. Agriculture is a primary economic activity in the region, and ranges from farming, to hunting and fishing. The unemployment rate within this municipality is around 23.2%. (Matjhabeng LM IDP 2015/2016)

The main towns in the Masilonyana Local Municipality are Theunissen, Brandfort, Winburg, Verkeerdevlei and Soutpan (www.masilonyana.fs.gov.za). The economy of the municipality is largely dependent on agriculture with predominantly livestock farming in the southern and western parts and crop production combined with livestock farming predominantly in the northern and eastern parts. Mining activities are situated north of Theunissen and secondary mining activities (salt and diamonds) are also found in the area. The unemployment rate in the Masilonyana Local Municipality is around 17.7% (Masilonyana LM IDP 2015/2016).

The Lejweleputswa District Municipality (LDM) is situated in the north western part of the Free State and borders the North West Province to the north; the Fezile Dabi and Thabo Mofutsanyane District Municipalities to the north-east and east respectively; the Motheo and Xhariep District Municipalities to the south; and the Northern Cape Province to the west. The LDM is accessible from Johannesburg, Cape Town, Klerksdorp and Kimberley through one of South Africa's main national roads, the N1. The district covers the second largest area (24.3%) in the province and consists of the Masilonyana, Matjhabeng, Nala, Tokologo and Tswelopele Local Municipalities (www.lejweleputswa.co.za).

The main economic activities in the district are mining and agriculture (www.led.co.za). Most of the mining activity takes place in the Matjhabeng LM and the recent economic downturn in the gold mining industry lead to retrenchments. Most of the retrenched labourers, who are mostly unskilled, are remaining in the region, adding to the social problems that are associated with declining conditions. Due to a number of factors including drought and market conditions, the agricultural sector is also experiencing negative growth. Furthermore many farmers are mechanising their operations, leading to job losses and migration of workers to urban areas. The economies of the smaller towns are based on business supporting agriculture and as such this is impacting on the economy of the small towns negatively.

As is to be expected in any economic observation of Matjhabeng, gold production and the mining industry loom large. The mining industry is still the dominant sector of the local economy. The wellbeing of the Matjhabeng economy is therefore knitted together with the state of its mining industry. In the past two decades, this industry has unfortunately declined in output, affecting employment especially. However, the decline in economic value added (EVA) of the mining industry has not been as severe as that of the job losses in the industry.

Matjhabeng has a relatively large economy compared to that of other SA municipalities, but its Gross Geographic Product (GGP) has been declining for years. This means the local economy still has a measure of critical mass that could provide continued private consumption expenditure which could sustain it for quite some time. However, any economy requires new investment to grow sustainably, and based on continued mine closures and declining population in the region, it is doubtful that there will be robust economic growth for some time to come.

The Matjhabeng economy is probably a mirror of any mineral-resource based region in SA. Employment in most of these economies has declined due to a weak global economy, corresponding decline in commodity prices, and reductions in the mine workforce. Across most regions in SA the unemployment rate has increased, and many semi-urban regions are experiencing an exodus of people in search of jobs in the cities. The Matjhabeng economy is by all accounts finding a new equilibrium, one where mining employment continually declines, and its population migrates out. The increase in government expenditure and perennial agricultural activities are keeping the municipality's decline in check, but if more mines close down its GGP and formal employment is set to decline more. The prognosis for the municipality's economy is not favourable unless large-scale economic investment comes back to the region.

4.2.3 GEOLOGY AND TOPOGRAPHY

The area is characterised by a flat surface with sparse vegetation. An analysis of topographical data indicated a slope of less than 1:10 over most of the project area. The surface geology within the study area comprises mainly

Aeolian sands, with dolerite and shale outcrops. The thickness of the unconsolidated material could be inferred from the Tetra4 geological logs and suggests that the sand and alluvial material is on average 11m thick.

The unconsolidated sediments are underlain by shales and mudstones with subordinate coarse-grained sandstone of the Ecca and Beaufort Groups of the Karoo Supergroup. The Beaufort Group mudstones, shales and fine-grained sandstones are anisotropic in nature due to their fluvial deposition. These sediments are on average 400m thick in the study area. None of the geological logs reported fault zones in the Karoo sediments. This does not necessarily mean that fault zones do not exist, simply that they were probably not recorded during the historical drilling programme.

Dolerite sills in the Karoo formations are sheetlike intrusions that tend to follow bedding planes. A dolerite sill has intruded near the base of the Karoo sediments across the length of the study area. The sill undulates slightly but is present from an average depth of around 350m and has an average thickness of 30m. Dwyka tillites were not recorded in every exploration well. The regional extent of the Dwyka formation cannot be confirmed with certainty, but the borehole logs suggests that it occurs at an average depth of around 400m below surface and reaches an average thickness of 65m.

The Ventersdorp Supergroup volcanics that underlie the Karoo aquifers consist of felsic and mafic lavas with very low anticipated permeabilities. As such, these formations are assumed to act as aquitards or aquicludes and limit the vertical movement of groundwater. The volcanics are on average about 1km thick over the area. It is noted that the thickness of the lavas varies over the study area. In the north, the lavas thin out to a thickness of around 250m. The exploration logs made available by Tetra4 indicate the presence of fracture and shear zones in the Ventersdorp lavas. These zones were encountered at elevations of 1000 to 400 mamsl. No information regarding the permeability of the fracture and shear zones is available from the geological logs. The exploration logs suggest that these fracture and shear zones are overlain by unfractured lava, which is expected to have a low permeability and therefore retard the vertical movement of groundwater between the production zone and the overlying potable Karoo aquifers. The potable Karoo aquifers are also separated from the deep-seated fracture and shear zones by a 30m thick dolerite sill that extends across the study area, as mentioned above. The sill is expected to have low permeability and to act as an aquitard or aquiclude. It is unlikely that significant vertical groundwater movement would take place naturally between the fracture and shear zones and the overlying shallow potable Karoo aquifers.

The Witwatersrand Supergroup sediments that underlie the Ventersdorp lavas comprises mainly quartzites of the Central Rand Group (CRG). The depth of the CRG quartzites was not available from the Tetra4 geological logs, as the drilling was stopped in the quartzites. Dolerite sills have also intruded the lavas and CRG quartzites. The extent to which these sills are interconnected across the study area cannot be confirmed from the exploration logs.

4.2.4 CLIMATE

The study area has warm summers and cold winters. Frost is a common phenomenon and the coldest periods (usually from June to August) are exacerbated by seasonal aridity. The daily minimum temperatures for the coldest months are below freezing, and, along with the regular occurrence of frost, are therefore a potentially limiting factor for plant growth.

The study area is situated in a summer rainfall area, with rainfall peaking in January and at its lowest during July. Rainfall data was obtained from rainfall station 0365058 (Hennenman) and the Mean Annual Precipitation (MAP) was calculated at 612 millimetres per annum (mm/a) over a 36 year period. The 95th percentile is 884 mm/a and the 5th percentile 408 mm/a. Annual rainfall is approximately 450 mm/a, which is considered to be relatively dry for an area of grassland.

4.2.5 ECOLOGY

The site is primarily within two regional vegetation types called Central Free State Grassland and Vaal-Vet Sandy Grassland, with other parts of the study area falling within Winburg Grassy Shrubland, Bloemfontein Karroid Shrubland, Highveld Alluvial Vegetation or Highveld Salt Pans. Vaal-Vet Sandy Grassland is considered in the scientific literature to be Endangered and is also listed as Endangered in the National List of Ecosystems that are

Threatened and need of protection (GN1002 of 2011), published under the National Environmental Management: Biodiversity Act (Act No. 10, 2004). Central Free State Grassland is considered in the scientific literature to be Vulnerable but is not listed as Endangered in the National List of Ecosystems that are Threatened and need of protection (GN1002 of 2011).

The most recent vegetation assessment was conducted throughout the extent of the Cluster 2 application area. A total of 122 tree, shrub, herbaceous and graminoid plant species were recorded in the application area during the field assessment. Invasive Alien Plants (IAPs) tend to dominate or replace indigenous flora, thereby transforming the structure, composition and functioning of ecosystems. Therefore, it is important that these plants are controlled by means of an eradication and monitoring programme. Some invader plants may also degrade ecosystems through superior competitive capabilities to exclude native plant species. Fourteen (14) IAP species were recorded within the application area. These species are listed under the Alien and Invasive Species List 2020, Government Gazette No. GN1003 as Category 1b. Category 1b species must be controlled by implementing an IAP Management Programme, in compliance of section 75 of the NEMBA. Several individuals of protected plant species that are protected by the Free State Nature Conservation Ordinance 8 of 1969 were observed in various parts of the application area. These include *Ammocharis coranica*, *Boophone disticha*, *Eucomis autumnalis*, *Aloe dominella*, *Schizocarphus nervosus*, *Gladiolus crassifolius* and *Gladiolus permeabilis*.

Eighty-nine (89) (37.7 % of expected) avifaunal species were recorded in the application area during the survey based on either direct observation, vocalisations, or the presence of visual tracks & signs. Four (4) species are rated as Species of Conservation Concern (SCC), whereas 75 were listed as protected provincially.

Twenty-two (22) mammal species were observed during the survey of the application area based on either direct observation or the presence of visual tracks and signs. Three (3) of the species recorded are regarded as SCC. Four (4) mammal species are considered 'captive' species as these were only present within the game farm areas.

Eleven (11) species of reptiles were recorded in the application area during survey period. One SCC, namely *Smaug giganteus* (Sungazer/Giant Dragon Lizard) was recorded during the field assessment. However, there is the possibility of more species being present, as certain reptile species are secretive and require long-term surveys to ensure capture.

Four (4) amphibian species were recorded in the application area with only one of these species recorded is a SCC.

Significant parts of the study area are cultivated or have been previously cultivated and are therefore not considered to have high sensitivity or biodiversity value. There is also an area that is currently being mined and contains mining infrastructure. Natural habitats are considered for various reasons to have high biodiversity value and are avoided during planning phases for the proposed activities, where possible.

4.2.6 SOILS, LAND COVER AND LAND CAPABILITY

There are a number of land types in the study area with the most common land types in the study area being Bd, Dc and Ca (Land Type Survey Staff, 1987). The Bd and Ca, land types are found on the flat to undulating plains. The Bd land type consists of plinthic soils over more than 10% of the area, soils are eutrophic and red soils are not widespread (MacVicar et al. 1974). The Ca land type indicates land that qualifies as a plinthic catena but which has, in upland positions, margalitic and/or duplex that together cover more than 10% of the total area. The Dc landtype consists of duplex soils (sandier topsoil on clay subsoil) in which more than 10% of the land type is made up of soil forms that have one or more of vertic, melanic or red structured diagnostic horizons. These are the soils of the wide alluvial valleys of the study area.

There is a large variation in the class of agricultural potential within the study area. The apedal (structureless) soils (Av, Bd, Bv, Gc, Hu, Pn, Oa) are generally of high potential, although where there is a subsurface gley or plinthite horizon at a shallow depth, this will fall to moderate/high or even moderate. The more structured soils (Se, Ss, Sw, Tu, Va), especially with some subsurface wetness, are generally classed as moderate or low potential. Where very shallow soils (Dr, Ms) or wetland soils (Ka) occur, the potential is low.

4.2.7 WETLANDS

There are a variety of different wetland habitats on site, including riparian areas, stream channels, floodplains, a number of pans, open water areas and seepage areas. Aquatic systems in the study area are in a *Largely Natural to Largely Modified* state (B Category – D Category) with a *Moderate* to *High* EIS values, and reflect impacts associated with agriculture, mining and moderate rural development and associated impacts on aquatic ecosystem drivers. The most important feature to address for the health of the ecosystem and the surrounding ecosystem is the highly erosive nature of the systems, which at present makes the system highly vulnerable. Implementation of suggested mitigation measures to control further physical decline of the systems is required to maintain the Present Ecological Status (PES) and meet the Resource Quality Objective (RQO's) for the study area. All of the delineated watercourses, along with their buffer zone, are regarded as sensitive features that should be protected from impacts.

4.2.8 SURFACE WATER

According to the DHSWS water management areas delineations, the Cluster 2 Gas Production Project is situated in primary catchment (C) of the Vaal River drainage system which covers a total area of approximately 246 674.5 km^2. The resource management falls under the Vaal Water Management Area (WMA5) which spans portions of the North West Province, northern Free State as well northern sections of the Northern Cape. The application area is situated within quaternary catchments C42K (nett surface area of 668.0 km^2) and C42L (nett surface area of 510.8 km^2), falls within hydrological zone E and has an estimated mean annual runoff (MAR) of between 10.0 to 13.0 mcm (million cubic metres) (WR 2012). The main drainage features traversing the project site include the Bosluisspruit River, Doring River and the Sand River. The Allemanskraal dam is located 21km south of Ventersburg, however, it is outside the exploration/production area. The area surrounding the Allemanskraal Dam is also the only protected area in the vicinity, according to the Department of Water and Sanitation GIS data.

4.2.9 GROUNDWATER

Two aquifer systems were characterised with field data as part of the geohydrological study. Shallow fractured rock aquifers are formed in the upper 150 – 300m of the Karoo sediments. These aquifers are typically low-yielding but are important to local groundwater users as they form the sole source of water supply in the region. Groundwater occurrence is associated with faults, fractures and contact zones with dolerite intrusions. A primary aquifer is associated with the alluvium deposited in the flood plains of the main rivers and streams and/or with the aeolian sands that cover a large portion of the study area. Groundwater level measurements taken during the study suggests that the unconsolidated sediments do carry groundwater. The alluvial aquifer, specifically, is vulnerable to surface sources of contamination due to its unconfined nature, expected shallow groundwater table, direct connection with rivers and streams and high permeability.

The shallow potable Karoo aquifers are separated from deep aquifer systems associated with the Ventersdorp and Witwatersrand Supergroup formations by the 30m thick dolerite sill that extends across the study area and, by the 65m thick Dwyka Tillite. The sill and tillite is expected to have low permeability and to act as barrier to vertical groundwater flow. Unfractured Karoo Supergroup shales found at depths greater than 300m are also expected to act as a barrier between the deep aquifer systems and the potable Karoo aquifers. The deep aquifers are formed by fractures and shear zones in the Witwatersrand quartzites. These zones can yield large volumes of water that is associated with the underground workings of the deep gold mines. The water in the deep aquifers is naturally saline due to their marine depositional history.

In order to characterise the shallow Karoo aquifers, Tetra4 drilled five monitoring boreholes near two of the existing gas wells and three in the region of future gas well targets. These boreholes were sited using geophysical methods to ensure that preferential groundwater flow paths like fractures, faults and contact zones are targeted. Each borehole was drilled to a depth of 50m. The available logs indicate that the boreholes intercepted unconsolidated sand and shale. One borehole intersected a dolerite contact zone. This was the only monitoring borehole that struck groundwater and Tetra4 therefor cased only this borehole. The other four boreholes intercepted seepage and were left uncased. The depth to groundwater level in the monitoring boreholes varies between 7 and 26m below surface. The deeper groundwater level is representative of the dry boreholes where

groundwater slowly seeps into the borehole. Only one pumping test and one slug test could be completed on the new monitoring boreholes due to deep groundwater levels and the fact that four of the boreholes were dry. The results confirm that the permeability of the shales is very low ($9E^{-4}$m/d). The permeability of the dolerite contact zone intercepted is higher (0,6m/d) and analysis of the pumping test results suggests that the sustainable yield of this borehole is around 0,35l/s.

Groundwater quality analyses in the new monitoring boreholes and in existing boreholes monitored at Tetra4 indicate that the groundwater in the region is naturally saline, with Total Dissolved Solid (TDS) concentrations exceeding 800 mg/l on average. The main salts that contribute to elevated TDS concentrations are sodium and chloride, which is typical of the natural groundwater quality in the region. The TDS concentrations increase towards the north of the study area with highest concentrations recorded in boreholes near the Doring River. The reason for this phenomenon cannot be confirmed with certainty but is most probably related to the geology in this part of the study area. Elevated nitrate concentrations were recorded in all but one of the hydrocensus boreholes identified during the Scoping Phase of the study. This is most probably attributed to the impact of agricultural activities on groundwater quality.

The dissolved methane and ethane concentrations in the hydrocensus boreholes were all below the laboratory detection limit of 0,007 and 0,013 mg/l respectively. With reference to the ongoing regional water monitoring as well as the post-authorisation baseline monitoring undertaken by Tetra4 it is specifically noted that there are sampled boreholes which show high dissolved methane concentrations (as high as 23mg/l) prior to any local Tetra4 activities and/or at significant distance from the Tetra4 activities.

Tetra4 has undertaken a review and update of the numerical groundwater model to incorporate newly acquired information and monitoring data (Tetra4 (Pty) Ltd, 2021). The model update included additional supplemental fieldwork, including groundwater monitoring, groundwater level monitoring, slug testing, pump testing/dewatering, incorporation of lithological data obtained from exploration drilling, and refined facility design and production-related activities. The updated groundwater model also included an update of the impacts assessments and identified and described the following specific impacts:

- “The impact of removing produced water from gas production wells during the operational phase of the project. Based on the fact that the gas producing structures which are targeted, are situated within the Ventersdorp and Witwatersrand formation, it is most likely that no water will be produced from the gas resource, as there are only a few wells which indicated water intersections at this depth. Due to extensive mining in area, the Witwatersrand basin has been dewatered for extended periods of time. However, based on the fact that one of the gas wells, well 2057, produced a large volume of water, an assessment of the impact of produced water on the overlying potable Karoo aquifers was included in the groundwater study. In order to determine the impact of all eventualities and to evaluate the worst-case scenario, a groundwater impact assessment was undertaken to establish the zone of influence of removing produced water at depth on the shallow Karoo aquifers. Simulations indicated that there is a 5% risk of impacting on the overlying Karoo aquifers at pump rates higher than 1m3/d. Dewatering from the deeper quartzites may also increase the risk of dewatering the Karoo aquifers if the wells are pumped at higher rates. Simulations suggest that the chance of dewatering the Karoo aquifers is also around 5% risk, but most likely lower as it is unlikely that this activity will impact the shallow aquifers.

- The drilling and operation of gas production wells could result in the migration of stray gas from the deep-seated fracture zones to formations higher up in the geological sequence. Stray gas could leak from the deep-seated fracture zones into private boreholes as a result of poorly sealed gas wells, or an overpressure event that could damage the casing and cementation or due to migration of gas along fractures and faults. In the event of gas leakage as a result of an overpressure event, with the complete failure of the casing and cementation in the well, formation water and dissolved gas will migrate preferentially along the fracture zone that is targeted during gas production and vertically up the well. Under high-pressure conditions, the migration of plumes from a well could be much faster and the radius of impact would be directly related to the strike and distance over which the fault zone prevails. The geological logs suggest that the fault zones that will be targeted are associated with the Witwatersrand quartzites and the Ventersdorp lavas. These formations are found on average deeper

than 400m below surface. Unless the fault zones extend vertically across the younger sediments to the shallow Karoo aquifers, the migration of plumes as a result of complete failure in a gas production well is expected to be restricted to the Ventersdorp and Central Rand formations. In addition, gas wells within the Virginia Production Right, produces gas as low pressures, thus reducing the likelihood that stray gas will migrate over extended distances.

- Production well dewatering will impose a stress on the surrounding aquifers, drawing water from further afield towards a well. This flow towards the well will occur preferentially from water-bearing structures that are intersected near the depth of pumping. Continued pumping from a well may therefore result in the dewatering of the water-bearing structure if it has a low storage capacity and the pumping rate is high enough. Typically, the water level in the production well will drop to below the dewatered structure in this case. In this event, the well may start to attract water either from further afield, from overlying sediments or it may pump dry. Which of these will transpire will depend on a number of factors, including the interconnected porosity and permeability of the aquifer, the permeability of the cement and the quality of the installation of the cement seal in the casing and the pumping rate. It is unlikely that deep-seated saline water will migrate to the overlying aquifers while production wells are dewatered. This is due to the fact that the flow of water will be reversed towards the depth of pumping, not allowing saline water to migrate vertically up the well.

- The numerical model was used to assess the impact of surface spills on the underlying aquifers. An evaluation of the activities that will take place during gas production indicates that the combined Production Facility pose the largest threat in this regard. Spills associated with gas transfer pipelines, compressor stations will most probably be small and will be addressed immediately, limiting impacts on groundwater quality. It is further not possible to predict where such spills would occur, making it difficult to simulate the associated impacts. Simulations were undertaken using TDS concentrations to provide an overall groundwater quality impact assessment. Due to the fact that high porosity is assumed for the unconsolidated material, potential contamination may move at a comparatively slow rate, as larger interstitial spaces must be filled to allow contamination to migrate. It is estimated that the plume will take 55 - 96 years (20 000 – 35 000 days) to reach the Sand River north of the plant area. TDS concentrations may increase by up to 50 – 60 mg/l in the groundwater component of baseflow to the streams. This scenario represents the worst-case scenario obtained from the stochastic modelling. Modelling results also suggest that the potential pollution plume may not reach the Sand River during the 100-year simulation period, or that TDS concentrations increase by less than 10 mg/l at the river. As the baseflow component to the Doring River is expected to be a small volume, probably no more than 10 m3/d over the extent of the simulated plume, the maximum salt load to the stream is estimated to be 0,6kg/d" (Tetra4 (Pty) Ltd, 2021).

4.2.10 AIR QUALITY

The area is dominated by winds from the north, northeast and east, with an average wind speed of 3.9 m/s. Long-term air quality impacts are therefore expected to be the most significant to the south and southwest of the project area. Ambient air pollutant levels in the project area are currently affected by the following sources of emission: agricultural activities, gold mining and ore processing, fugitive and process emissions, vehicle tailpipe emissions, household fuel combustion, biomass burning and windblown dust from exposed areas.

AQSRs within the Project area include residences, farmsteads and Holdings, as well as a mine village. The closest towns in the immediate region of the project include Welkom (located about 9 kilometres south of the Project boundary), Virginia (located about 5 kilometres east of the Project boundary) and Theunissen (located about 16 kilometres south of the Project boundary).

4.2.11 NOISE

As per the noise study conducted in the project area, all the measurements indicated a site with a very complex sound character. Areas away from busy roads and mining activities are very quiet, with measurement locations closer to houses, busy roads and mining activities indicating higher sound levels. Vegetation growth closer to

dwellings creates habitat, attracting birds and insects, which in turn make sounds that increases the ambient sound levels. The vegetation also increased wind-induced noises. The larger area, away from roads, dwellings and mining activities can be rated as Rural as per the SANS 10103:2008 criteria.

4.2.12 VISUAL

The sensitivity of visual receptors and views is dependent on the location and context of the viewpoint, the expectations and occupation or activity of the receptor or the importance of the view. Travellers along the roads within and through the study area, would catch glimpses of the proposed gas production infrastructure (more so the stationary surface infrastructure rather than the pipeline which will be underground) and activities when driving along the roads. These views are, however, temporary in nature and regarded as having a moderate sensitivity. People engaged in work activities within the study area are regarded as having a low sensitivity because their attention would be focussed on their work activity. Permanent views would be those from the farmsteads and residences within the immediate area and would be classified as having a high sensitivity.

Due to the nature of the gas production operations and related activities, some of the related infrastructure (e.g. well-heads, combined helium and LNG plant, etc.) may stand out from the natural setting of the study area. This could also possibly occur as a result of the construction activities such as the clearance of vegetation, which at present may be acting as a screen within the study area.

The gas production infrastructure will be visible from various parts of the study area; however this is largely in relation to the above ground infrastructure connecting the existing and proposed new gas well. It should be noted that the pipeline will be underground, and the footprint of the well sites will be relatively small, and thus the visibility of these structures will be of low sensitivity. The higher visibility sensitivity will be with regards to the combined helium and LNG plant.

4.2.13 STAKEHOLDER ISSUES AND COMMENTS

The initial version of this plan was made available for public review during the Cluster 1 EIA process in 2016-2017 and again during the Cluster 2 EIA process (2022). The comments and issues raised through that public participation were considered and, where applicable, informed the compilation of this FRDCP. As per the Financial Provisioning Regulations (2015) this FRDCP forms a component of the EMPr submitted in terms of section 24N of the NEMA and the Environmental Impact Assessment Regulations, 2014 and is subject to stakeholder review and comment.

Table 4 provides extracts from the individual stakeholder's submissions from the Issues and Responses Report (IRR) for the Cluster 1 and Cluster 2 EIA processes which relate specifically to final rehabilitation, decommissioning and closure activities. In addition, where comments have been raised by stakeholders during the project's construction and implementation phase, these have also been presented in Table 4.

Key rehabilitation, decommissioning and closure comments raised by stakeholders included:

- Safety and security concerns.
- Long-term groundwater impacts and impacts to boreholes.
- Long-term impacts similar to mining impacts.
- Future maintenance (security concerns, access to farms, impacts on roads, etc).
- Impacts of production on the environment.
- Future benefits for landowners in terms of monitoring boreholes.
- Rehabilitation guarantee.
- Long-term impacts on ecological aspects.
- Future plans in terms of roads, infrastructure and maintenance.

- Long-term impacts on land productivity and agricultural potential.

Table 4: Key Stakeholder issues related to closure (Cluster 2 application)

Interested and Affected Party	Issue Raised	Response to Issue	Closure Aspect
Mr Gert Oosthuizen (landowner)	Impact on groundwater and water quality. (Statement that "*Cluster 1 is not even properly up and running yet.*")	Impact on groundwater and water quality. – Tetra4 implements and extensive water monitoring programme to identify any potential water impacts from its activities. To date, no evidence of impact from the Tetra4 activities have been observed.	Long-term impacts on groundwater

4.3 ENVIRONMENTAL RISK ASSESSMENT

The NEMA Financial Provisioning Regulations requires that an environmental risk assessment must be undertaken for all areas of infrastructure or activity or aspects for which a holder of a right or permit has a responsibility to mitigate an impact or risk at closure. The findings of this risk assessment aim to guide the appropriate closure strategies. This FRDCP has been updated to include reflect the current understanding of the project and the associated risks related to rehabilitation, decommissioning and closure. The risk assessment aims to reflect the risks associated with the current activities as well as the planned activities which have been approved by the Competent Authority (i.e. activities for which relevant EA's are in place). As such, the content of this section has been extracted from the associated EIA/s and adapted where relevant. This risk assessment will, as per the NEMA Financial Provision Regulations, be revised and amended during the future annual review process to ensure that the ongoing risk and risk ratings are relevant to the mine moving forward.

4.3.1 RISK ASSESSMENT METHODOLOGY

Environmental risks have been identified through review of the proposed and existing production activities and the existing production right environment. The identification of risks was undertaken as follows:

- A team of specialists including an Environmental Assessment Practitioner, wetland specialist, soils and land capability specialist, a hydrogeological specialist, and a team of environmental engineers, as part of the relevant EIA process;
- If and where, risks or impacts are identified through the ongoing monitoring and stakeholder engagement process these are included and assessed.

The impact significance, or risk rating methodology as presented herein is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. The ER is determined for the pre- and post-mitigation scenario.

The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$\boldsymbol{C = \frac{(E + D + M + R) * N}{4}}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 5 below.

Table 5: Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary)
	3	Local (i.e. the area within 5 km of the site)
	4	Regional (i.e. extends between 5 and 50 km from the site)

Aspect	Score	Definition
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years)
	3	Medium term (6-15 years)
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction)
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural, and social functions and processes are not affected)
	2	Low (where the impact affects the environment in such a way that natural, cultural, and social functions and processes are slightly affected)
	3	Moderate (where the affected environment is altered but natural, cultural, and social functions and processes continue albeit in a modified way, moderate improvement for +ve impacts)
	4	High (where natural, cultural, or social functions or processes are altered to the extent that it will temporarily cease, high improvement for +ve impacts)
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts)
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact.

Once the C has been determined, the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/ scored as per Table 6.

Table 6: Probability Scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or

	5 Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

$$ER = C \; x \; P$$

Table 7: Determination of Environmental Risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of possible scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 8.

Table 8: Environmental Risk Scores

ER Score	Description
<9	Low (i.e. where this impact is unlikely to be a significant environmental risk/ reward).
≥9 ≤17	Medium (i.e. where the impact could have a significant environmental risk/ reward),
>17	High (i.e. where the impact will have a significant environmental risk/ reward).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

4.3.2 IMPACT AND RISK IDENTIFICATION

The identification of management and mitigation measures are guided by the hierarchy of mitigation. The ultimate aim being to avoid or mitigate detrimental impacts on the environment, and to optimise positive environmental impacts, and for matters pertaining thereto. Table 9 lists the environmental impacts and risks identified which relate to final rehabilitation, decommissioning, and closure. The relevant management and mitigation measures are listed. The applicable conceptual closure strategy to avoid, manage and mitigate the impacts and risks are also included in Table 9, together with the reassessment of the environmental risk after mitigation. The environmental risk assessment of the impacts associated with final rehabilitation, decommissioning and closure has informed the most appropriate closure strategy for the project. Impacts that are classified as high-risk post-mitigation are likely to represent either latent or residual environmental impacts and financial provision will be provided to remediate these specific impacts. Please see Section 6 for further details.

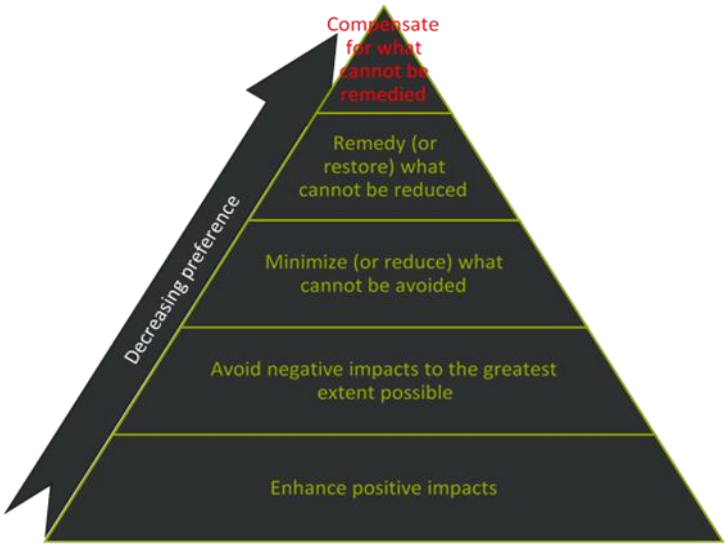

Figure 19: Hierarchy of mitigation and management.

The ER scores are defined as Low (<9); Medium (≥9; ≤17); and High (> 17) and are colour-coded as follows: Low – Green, Medium – Orange, and High – Red. Positive impacts have not been colour-coded. It is important to note that the environmental risk assessment will be revised and updated on an annual basis to ensure that this FRDCP remains applicable to the actual and predicted environmental impacts and risks. The EMPr addresses the management and mitigation of environmental impacts associated with the construction and operational phases whilst the three reports and plans as prescribed in the Financial Provisioning Regulations, 2015 (to be reviewed annually) will provide for the planning and financial provisioning for the concurrent rehabilitation and final closure of the production activities.

For the purpose of report, the following broad phasing definitions apply:

- Planning/Pre-construction refers to the phase in which planning takes place, namely: exploration, environmental studies, finalising designs, etc.;
- Construction refers to the phase in which the site is prepared and infrastructure is established (e.g. vegetation clearance, access road preparation, construction camp establishment, infrastructure placement, etc.);
- Operation refers to the phase in which physical production takes place – this phase will include where relevant on-going progressive rehabilitation efforts;
- Decommissioning and rehabilitation refers to the inter-linked phases in which existing infrastructure is removed and final rehabilitation efforts are applied and their success monitored;
- The closure phase commences once the gas-extracting activities have ceased, and final decommissioning and mine rehabilitation is being completed. This phase usually ceases 3-5 years after physical closure activities and would culminate with the issuance of a closure certificate; and
- Post-closure refers to the phase in which maintenance and rehabilitation monitoring are undertaken to ensure that the closure objectives are met. Post-closure typically commences once a closure certificate has been received. The duration of the post-closure phase is defined by the duration of the applicable residual and latent environmental impacts.

4.3.3 ENVIRONMENTAL RISK ASSESSMENT FOR REHABILITATION, DECOMISSIONING AND CLOSURE.

This risk assessment identifies and assesses the environmental risks and potential impacts associated with the current approved production activities. Where practical the mitigation hierarchy is applied to limit the post mitigation risk or impact significance. However certain impacts will perpetuate beyond the closure period and are identified described and assessed as residual and/or latent impacts in Section 6.

Table 9 provides a summary of the identified impacts, associated level of risk (or significance rating) both pre- and post- mitigation, the identified key management and mitigation actions, and finally the identified broad closure strategy. Please refer to Appendix 3 for a full breakdown of the risk ratings according to the scoring criteria defined in Section 4.3.1.

It is important to note that the risk assessment conducted as part of the initial EIA process as well as the Cluster 2 EIA process forms the base. These risks are reviewed and supplemented in instances where additional risks or impacts are identified in subsequent updates of the FRDCP.

Table 9: Impact Assessment for Rehabilitation, Decommissioning and Closure[5].

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
Social	Potential to use local service providers and contribute directly to local economy.	+11.00	None.	+17.50	N/A
	Interruption in services.	-15.00	Notice of any service interruptions must be given at least a day before the interruption takes place – a SMS or e-mail system can be used for this purpose.	-10.00	Ongoing landowner and stakeholder engagement.
	Interference with existing land uses.	-15.00	Particulate matter (PM) emissions reduction along the unpaved roads, decommissioning areas, and within the proposed site boundary could include either watering or chemical suppressants, which can achieve up to 75% and 90% control efficiency respectively.	-11.00	On-going monitoring. Implement effective dust control measures. Revegetation of disturbed areas
	Impacts on existing services and infrastructure.	-14.00	If private roads are affected by project activities it is the responsibility of Tetra 4 to maintain these roads as long as they use it. Tetra 4 should engage with the relevant farmers about road maintenance, as some of them have preferential ways in which the roads must be maintained, for example if roads are only graded and not built up it turns into rivers when there is heavy rain. The road maintenance agreements must be formalised before construction commences to ensure all parties involved are protected and know their rights and responsibilities. It is recommended that construction[6] be	-13.00	Ongoing landowner and stakeholder engagement.

[5]The significance scores are defined as Low (<9); Medium (≥9; <17); and High (≥ 17).

[6] Where reference is made to construction activities in this risk assessment, such mitigation and management actions must be deemed to be applicable to relevant aspects of the physical decommissioning activities.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
			planned for the dry season. Tetra 4 must provide all the affected landowners with a construction schedule to ensure that they know when construction will take place on their properties. Any changes to the construction schedule must be communicated to the farmers at least a week in advance. Before the project commences Tetra 4 should compile an asset and infrastructure baseline of any landowner infrastructure that may be affected by the project. Photographs and GPS co-ordinates of the infrastructure must be included in the baseline. A copy of the baseline affecting their property should be given to each landowner, who should sign off the document to ensure that it is accurate. Tetra 4 should keep the master document. If any damage occurs it should be reinstated to its pre-project status. If the infrastructure must move, it must be done at Tetra 4's cost. Tetra 4 must ensure that the construction team has a copy of the asset and infrastructure baseline to guarantee that no infrastructure will be damaged due to ignorance during the construction phase of the project. Notice of any service interruptions must be given at least 24 hours before the interruption takes place – a SMS or e-mail system can be used for this purpose.		
	Re-instatement of access routes give access to land/infrastructure that was cut off by the project.	-13.00	It may be unavoidable to change travel patterns. It is important to inform the affected stakeholders about the possibility of this impact as soon as possible. It will allow them time to get used to the idea and plan their activities accordingly. It is also important that locally affected parties give input in potential mitigation measures. Before construction commences Tetra 4 must meet individually with each applicable landowner to discuss their movement patterns and needs. Tetra 4 must provide all the affected landowners with a construction	-9.00	Ongoing landowner and stakeholder engagement.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
			schedule to ensure that they know when construction will take place on their properties. It is recommended that construction be done outside the peak planting and harvesting seasons. Any changes to the construction schedule must be communicated to the farmers at least a week in advance. As far as possible obstruction of access routes and sensitive areas must be avoided. If it cannot be avoided both parties must agree on alternative routes, and Tetra 4 should carry the cost of implementing the alternatives. Industrial vehicles should not travel during peak traffic times. If practical and required by the landowner, access routes to land/infrastructure should be reinstated in the decommissioning phase. This must be done in conjunction with the landowners		
	Increase in social license to operate due to management of nuisance impacts.	-12.00	This is a positive impact (post mitigation) and will occur if Tetra 4 implements the suggested mitigation measures. Tetra 4 should appoint a dedicated person to communicate with the landowners. It is important for the landowners to build a relationship with this person. The person must have enough authority and access to management to ensure that he can assist with dealing with everyday issues. It is important that the landowners trust the person and have faith in their ability to address issues. In addition, Tetra 4 should establish a Community Liaison Forum that meets at least twice a year. The forum can be used to share information and give feedback on general and environmental issues. Before the project commences the construction programme must be shared with the affected parties.	+11.00	Landowner consultation.
	Impacts on safety and security of local residents due to presence of unfamiliar people in the area.	-13.00	Tetra 4 should work with the existing farmers' security groups and farmers' associations (Virginia and Theunissen) to create a farm access protocol for everybody that need to access the	-11.00	Ongoing landowner and stakeholder engagement.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
			properties, and a safety plan. Tetra 4 should also become a member of these forums. There is an existing WhatsApp group that Tetra 4 should join. Farms that are equipped with alarms are all connected to a central security point, and this is a good point of departure for Tetra 4 to consider security arrangements for their own assets and to link in and work with existing systems. Pictures, make and registration numbers of all vehicles used by Tetra 4 on site should be provided to the farmer's security group and distributed to all affected landowners to ensure that they will be able to identify these vehicles if they access their properties. In addition, for scheduled and maintenance work Tetra 4 should give a roster to the farmers stating dates and approximate times that contractors will be on the farms. Farmers emphasised that they need to know of people accessing the farm ahead of time. It is too late to inform them when entering the property. All access arrangements should be made at least 24 hours before access is required. Tetra 4 must meet with the landowners before the construction phase commence and formalise security arrangements. This should be done in writing and include the existing forums that the landowners know and trust. Vehicles should be marked as construction vehicles and should have Tetra 4's logo clearly exhibited. Entry and exit points of the site should be controlled. Areas where materials are stockpiled must be fenced. If a security company is used, their schedules should be communicated to the farmers, especially to those farmers that have Tetra 4 infrastructure that need to be guarded. It must be considered that guards changing shifts contribute to the impact of strangers accessing properties, and therefore a system that consider the safety of both the Tetra 4 infrastructure and the safety of the landowners must be implemented. The fact that it may be required that people		

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
			spend the night on the farms is a source of discomfort for many of the landowners, especially if it is people that they do not know and trust, and have no control over. Under no circumstances should anyone be allowed to erect a dwelling for security forces on any of the farms. However, the necessary sanitation facilities must be made available, and some form of shelter from the elements.		
Economic	Alternative land-use.	+8.75	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised.	+8.75	Compliance with other related National Legislative Requirements.
	Black economic transformation.	-16.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised.	-16.00	
	Country and industry competitiveness.	-18.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-18.00	
	Economic development per capita.	-13.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-13.00	

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
	Employment impacts.	-13.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-13.00	
	Fiscal income.	-23.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-23.00	
	Forex savings.	-23.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-23.00	
	GGP impact.	-13.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-13.00	
	Need and desirability.	-15.00	All the significant enhancement measures are legislated and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised	-15.00	

Air Quality	Fugitive emissions (dust) from decommissioning/ removal of all berms, trenches and other stormwater infrastructure no longer required	-11.00	The following air quality measures are recommended during construction, operational, <u>decommissioning and rehabilitation</u> and closure phases of the Project: In controlling vehicle entrained particulate matter, it is recommended that water be applied on all unpaved road sections to ensure a minimum of 50% control efficiency (CE). In addition, binding agents or chemical suppressants (such as "Dust-A-Side" or "Dustex") should be considered for application on all unpaved road sections; literature reports an emissions reduction efficiency of more than 80 % (NPI, 2011; Cecala, et al., 2012; US EPA, 2006). In order to ensure lower exhaust emissions from vehicles and machinery, equipment suppliers or contractors should be required to ensure compliance with appropriate emission standards for production fleets. Also, maintenance and repair of diesel engines should be carried out as prescribed by manufacturer in order to maximize combustion and reduce gaseous emissions. Fuel efficient driving practices on site may also help lower exhaust emissions from vehicles and machinery, such as stipulating a maximum speed on all unpaved roads and limiting unnecessary travelling of vehicles on untreated roads. In addition, other fuel efficient practices that may lower exhaust emissions include limiting idling of machinery, driving in an upper gear rather than a lower gear as much as possible, ensuring tire pressure are always adequate etc. The use of low–NOx burners in combustion systems should be considered for operation of the Helium and LNG plant. Products, liquid fuels and chemicals should be stored in areas where there are provisions for containment of spills.	-7.50	Compliance with EMPr. On-going monitoring. Implement effective dust control measures. Revegetation of disturbed areas

			The implementation of vapour recovery systems, for storage tanks and other applicable units, to control losses of VOCs and achieve over 90% recovery, should be considered. During construction and rehabilitation phases, stockpile of fine or erodible material (if applicable) should be treated regularly with water sprayers to reduce their potential for erosion. Infrastructure containing natural gas and associated GHG's and/or pollutants (including amongst others pipelines, processing plant, and storage vessels) must be cleared and captured, and not vented directly to the atmosphere.		

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
Hydrogeology	Contamination of alluvial and sand aquifers	-6.50	In most instances, the hydrogeological impacts associated with surface sources are linked to spills and leaks, which can be managed through the implementation of good housekeeping practices, regular inspections as well as sound environmental training. The regional extent of these impacts is not expected to be significant but would rather be restricted to the site. An emergency response protocol must be implemented at the operations that are aimed at early detection and swift reaction speed. In this regard, daily inspections of drilling pads, pipelines, compressors and the helium plant must be implemented. Specific emphasis must be placed on detecting leaks and spills during the inspections. An on-site communication system must be put in place to ensure that instructions are given and carried out with efficiency. In the event of a spill occurring, a method statement must be completed that describes how, where and when clean-ups will be undertaken. The on-site communication system must make provision for continual review and improvement of spill management. The necessary equipment and personal protection equipment (PPE) must be kept on site to clean spills up and leaks. Tetra4 personnel must receive adequate training on the use of the equipment and the disposal of waste material generated during a spill. All such wastes must be treated as hazardous. The waste must be placed of to a dedicated sealed container on site, which must be disposed of to a licensed facility. All on-site vehicle and equipment maintenance must be undertaken within an area of secondary containment, such as a bund or over a drip tray, to prevent accidental soil contamination. Oil and diesel stored on site must be placed	-2.30	Compliance with EMPr. Rehabilitate disturbed areas. On-going monitoring.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
			within a suitably sized bund. The dispensing of hydrocarbons must be undertaken with due care to prevent or contain spills. All waste generated must be contained and stored in suitably sealed, bunded and protected areas to avoid spills and leaks. Waste must be collected and disposed of offsite in a responsible manner so as to prevent groundwater contamination off site.		
	Stray gas migration affecting groundwater quality	-16.00	The shallow potable Karoo aquifers will be protected during gas production drilling through the insertion of several well casings and cementation. Well design will be undertaken according to designs developed by a qualified well engineer. Well design will be undertaken according to designs developed by a qualified well engineer. The upper 300 – 450m of the geological succession will be cased off using a combination of telescopic drilling, steel casing and cementation between the well annulus and the casing. This configuration is aimed at isolating the shallow Karoo potable aquifer from the deep-seated gas production zone and the saline formation water associated with the production zone. It is noted that Tetra4 does not anticipate intersecting formation water during its gas production phase. In the unlikely event that produced water has to be extracted from gas production wells, this water will be stored in sealed containers, removed from site and disposed of to a suitable licenced (where necessary) environment/waste management facility. The produced water is expected to contain elevated levels of dissolved salts, hydrocarbons and trace elements and	-9.00	Plug entire length of well and cap well. Refer to sections 4.4.6 and 6. Compliance with EMPr. Ongoing Monitoring.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk	Closure Options/Actions
			would therefore be harmful to the environment. Responsible disposal thereof is therefore important. A groundwater monitoring programme will be implemented in the gas well as well as in the monitoring and hydrocensus boreholes to detect dissolved methane and ethane gas.		

4.4 DESIGN PRINCIPLES

There are no definitive principles guiding the design or the rehabilitation, decommissioning and closure plan for onshore gas production in the South African context.

4.4.1 GENERAL SURFACE REHABILITATION

The Land Rehabilitation Society of South Africa (LARRSA) has recently published a guideline for the surface rehabilitation of coal mines (LaRSSA, 2019). There are however aspects of these guidelines which can be applied to the surface rehabilitation actions for most projects (including gas production projects) and are presented in Table 10 below.

Table 10: Key principles for surface land rehabilitation.

Component	Rehabilitation principle
Regulatory compliance	• Achieving legal compliance is a minimum for appropriate rehabilitation planning. • Rehabilitation objectives and associated actions will not conflict with local legislation and will aim to complement and possibly go beyond legal compliance, where possible.
Concurrent implementation	• Concurrent, progressive rehabilitation will be undertaken throughout the operational stage of mining[7]. • A risk-based approach will be applied to ensure concurrently implemented rehabilitation actions will achieve the desired post-mining landscape and land capability aligned with end land use targets.
Stakeholder engagement and custodianship	• Relevant mining-affected stakeholders will be identified and involved in rehabilitation planning throughout the mining lifecycle, as required. • Rehabilitation planning will leverage from local stakeholder views, experiences, cultures and/or customs, on possible uses and needs of the rehabilitated landscape, to foster a land stewardship culture from potential next land users.
Landform Management	• Rehabilitation will be undertaken and aligned to a site-specific surface landform design that will be compiled during the planning stage of an operation. • The site-specific landform design will incorporate the surface profiling needs of the target post-mining land capability and land use/s, to optimize material movement throughout the operational and decommissioning periods, and to ensure the long-term sustainability of the rehabilitated landscape. • A 'management-of-change review process' will be incorporated into the mine planning process, to ensure that changes to the mine plan do not compromise either the proposed final landform or its potential use
Land capability	• Post-mining land capability will, as far as is practically possible, be constructed to resemble the pre-mining land capability of the disturbed area. • Attention will be given to rehabilitating the site to specified land capabilities that can support a suite of mixed land uses. • Soil physical and chemical properties will be aligned to the productivity needs of the post-mining land use/s, and to support these in the long-term.
Land use	• Post-mining land use planning will consider the needs of changing regional development and planning, over time. • The site will be left in an environmentally physically safe, stable, and non-polluting condition for the defined post-mining land uses.

[7] Where reference is made to mining in these guidelines it can be extended to relevant and similar activities associated with production activities.

Component	Rehabilitation principle
	• The defined post-mining land use/s will provide socio-economic value to next land users, as agreed with these land users (once exact post-mining land uses can be defined).
Climate uncertainty	• Predictive modelling will form the basis for longer-term environmental impact identification and risk management.
Monitoring	• Monitoring will be initiated as soon as the first ground has been moved (at construction). • Monitoring will be continued progressively throughout the project lifecycle, in parallel with concurrent rehabilitation activities. • Data obtained through ongoing monitoring will be frequently assessed for trends that could demonstrate rehabilitation success, and where corrective action may be required. • The monitoring process must be linked to a corrective action process.
Adaptive land management	• An adaptive land management approach will be adopted on-site, allowing for implementation of alternative and improved rehabilitation strategies and corrective action, where required.

4.4.2 BOREHOLE PLUGGING AND ABANDONMENT

In respect of the rehabilitation plugging and abandonment reference has been made to the American Petroleum Institute (API) recommended Practice 65-3 (American Petroleum Institute, 2021). This document provides practical guidance for permanently and temporarily abandoning gas wells.

The primary goals of the practice document are protection of useable water sources, isolation of hydrocarbon bearing or water injection intervals, prevent any leakage to the surface, and prevention of unintended cross flows. Where applicable and relevant recommendations and actions defined in this practice document has been included in this FRDCP.

4.4.3 TETRA4 GAS WELL CLOSURE SEALING AND REHABILITATION GUIDELINES

Tetra4 has developed an internal guideline document addressing the planning and implementation of well abandonment, sealing and rehabilitation (Tetra4 (Pty) Ltd, 2021). These guidelines aim to provide guidance during the preparation for well closure, sealing and abandonment of a gas production/exploration well, focussing on the following aspects:

1. Determining the most suitable and appropriate closure, sealing and rehabilitation strategy with specific focus on:
    - Technical aspects pertaining to plugging mechanisms/techniques in order to ensure the most suitable and appropriate well specific closure, sealing and rehabilitation strategy is implemented - with specific focus on the plugging methods to ensure no vertical gas and/or fluid movements within the well;
    - Specifications of plugging material and equipment to ensure compliance with well abandonment standards (e.g., Best Practice Standards etc.);
    - Ensuring the landscape is safe, stable and non-polluting over the long-term, and that the post closure land use aligns with the surrounding land use and does not affect the sustained utilization thereof;
    - Mechanisms and tests that would be implemented to ensure cement bonding is structurally sound;
    - Mechanisms and tests that could be implemented for future long-term monitoring to ensure well plugging and sealing is structurally sound.

2. Preparation of a consolidated site-specific closure, sealing and rehabilitation plan and project cost-breakdown.

These guidelines have been considered and where relevant incorporated into this Final Rehabilitation, Decommissioning and Closure Plan. A copy of the latest version of the Tetra4 Guidelines in attached as Appendix 1.

4.4.4 LEGISLATIVE AND GOVERNANCE FRAMEWORK

The requirement for final rehabilitation, decommissioning, and closure stems primarily from the legislative requirements of the MPRDA and the NEMA. The relevant extracts from each of these is presented in this section.

4.4.4.1 MINERALS AND PETROLEUM RESOURCES DEVELOPMENT ACT, ACT 28 OF 2002

The following extracts relate to the principle of closure for any right issued under the MPRDA:

- Section 43(1): The holder of a prospecting right, mining right, retention permit, mining permit, or previous holder of an old order right or previous owner of works that has ceased to exist, remains responsible for any environmental liability, pollution, ecological degradation, the pumping and treatment of extraneous water, compliance to the conditions of the environmental authorisation and the management and sustainable closure thereof, until the Minister has issued a closure certificate in terms of this Act to the holder or owner concerned.

- Section 43(4): An application for a closure certificate must be made to the Regional Manager in whose region the land in question is situated within 180 days of the occurrence of the lapsing, abandonment, cancellation, cessation, relinquishment or completion contemplated in subsection (3) and must be accompanied by the required information, programmes, plans and reports prescribed in terms of this Act and the National Environmental Management Act, 1998.

- Section 43 (5): No closure certificate may be issued unless the Chief Inspector and each government department charged with the administration of any law which relates to any matter affecting the environment have confirmed in writing that the provisions pertaining to health and safety, and management pollution to water resources, the pumping and treatment of extraneous water and compliance to the conditions of the environmental authorisation have been addressed.

- Section 43 (7): The holder of a prospecting right, mining right, retention permit, mining permit, or previous holder of an old order right or previous owner of works that has ceased to exist, or the person contemplated in subsection (2), as the case may be, must plan for, manage and implement such procedures and such requirements on mine closure as may be prescribed.

- Section 43 (8): Procedures and requirements on mine closure as it relates to the compliance of the conditions of an environmental authorisation, are prescribed in terms of the National Environmental Management Act, 1998.

4.4.4.2 MINERAL AND PETROLEUM RESOURCES DEVELOPMENT REGULATIONS

The following extracts from the MPRDA Regulations are specifically applicable to the preparation of this FRDCP:

- Regulation 56: Principles for mine closure: In accordance with applicable legislative requirements for mine closure, the holder of a prospecting right, mining right, retention permit or mining permit must ensure that -

    - the closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continue throughout the life of the operation;

    - the closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continue throughout the life of the operation;

    - risks pertaining to environmental impacts must be quantified and managed pro-actively, which includes the gathering of relevant information throughout the life of a prospecting or mining

operation; in accordance with the provisions of the National Environmental Management Act, 1998, the Financial Provision Regulations, 2015 and the Environmental Impact Assessment Regulations, 2014;

- the safety and health requirements in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996) are complied with;
- residual and possible latent environmental impacts are identified and quantified; in accordance with the provisions of the National Environmental Management Act, 1998, the Financial Provision Regulations, 2015 and the Environmental Impact Assessment Regulations, 2014;
- the land is rehabilitated, as far as is practicable, to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development; in accordance with the provisions of the National Environmental Management Act, 1998, the Financial Provision Regulations, 2015 and the Environmental Impact Assessment Regulations, 2014; and
- prospecting or mining operations are closed efficiently and cost effectively.

- Regulation 61: Closure Objectives: Closure objectives form part of the environmental authorisation, as the case may be, and must-
  - identify the key objectives for mine closure to guide the project design, development and management of environmental impacts in accordance with the National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations, 2014;
  - provide broad future land use objective(s) for the site; and
  - provide proposed closure costs in accordance with the National Environmental Management Act, 1998 and the Financial Provision Regulations, 2015.
- Regulation 62: Contents of closure plan: A closure plan contemplated in section 43(3)(d) of the Act, forms part of the environmental management programme or environmental management plan, as the case may be, and must include –
  - a description of the closure objectives and how these relate to the prospecting or mine operation and its environmental and social setting;
  - a plan contemplated in regulation 2(2), showing the land or area under closure;
  - a summary of the regulatory requirements and conditions for closure negotiated and documented in the environmental authorisation, as the case may be;
  - a summary of the results of the environmental risk report and details of identified residual and latent impacts; in accordance with the National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations, 2014;
  - a summary of the results of progressive rehabilitation undertaken; in accordance with the National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations, 2014;
  - a description of the methods to decommission each prospecting or mining component and the mitigation or management strategy proposed to avoid, minimize and manage residual or latent impacts;
  - details of any long-term management and maintenance expected;

- details of a proposed closure cost and financial provision for monitoring, maintenance and post closure management; in accordance with the National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations, 2014;
- a sketch plan drawn on an appropriate scale describing the final and future land use proposal and arrangements for the site;
- a record of interested and affected persons consulted; and
- technical appendices, if any.

4.4.4.3 NATIONAL ENVIRONMENTAL MANAGEMENT ACT (ACT 107 OF 1998)

Prior to 8 December 2014, the environmental aspects of mining and production activities were regulated in terms of the MPRDA. Recent legislative amendments and the drive towards a 'one environmental system' have resulted in the inclusion of the requirement for rehabilitation, decommissioning and closure planning and associated financial provisions into the NEMA. Specific sections of the Act are extracted below:

- Section 24P: Financial provision for remediation of environmental damage:

(1) An applicant for an environmental authorisation relating to prospecting, exploration, mining, or production must, before the Minister responsible for mineral resources issues the environmental authorisation, comply with the prescribed financial provision for the rehabilitation, closure, and ongoing post decommissioning management of negative environmental impacts.

(2) If any holder or any holder of an old order right fails to rehabilitate or to manage any impact on the environment or is unable to undertake such rehabilitation or to manage such impact, the Minister responsible for mineral resources may, upon written notice to such holder, use all or part of the financial provision contemplated in subsection (1) to rehabilitate or manage the environmental impact in question.

(3) Every holder must annually-

a. assess his or her environmental liability in a prescribed manner and must increase his or her financial provision to the satisfaction of the Minister responsible for mineral resources; and

b. submit an audit report to the Minister responsible for mineral resources on the adequacy of the financial provision from an independent auditor.

(4) (a) If the Minister responsible for mineral resources is not satisfied with the assessment and financial provision contemplated in this section, the Minister responsible for mineral resources may appoint an independent assessor to conduct the assessment and determine the financial provision. (b) Any cost in respect of such assessment must be borne by the holder in question.

(5) The requirement to maintain and retain the financial provision contemplated in this section remains in force notwithstanding the issuing of a closure certificate by the Minister responsible for mineral resources in terms of the Mineral and Petroleum Resources Development Act, 2002 to the holder or owner concerned and the Minister responsible for mineral resources may retain such portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent, residual or any other environmental impacts, including the pumping of polluted or extraneous water, for a prescribed period.

(6) The Insolvency Act, 1936 (Act No. 24 of 1936), does not apply to any form of financial provision contemplated in subsection (1) and all amounts arising from that provision.

(7) The Minister, or an MEC in concurrence with the Minister, may in writing make subsections (1) to (6) with the changes required by the context applicable to any other application in terms of this Act.

- Section 24R: Mine closure on environmental authorisation:

  (1) Every holder, holder of an old order right and owner of works remain responsible for any environmental liability, pollution or ecological degradation, the pumping and treatment of polluted or extraneous water, the management and sustainable closure thereof notwithstanding the issuing of a closure certificate by the Minister responsible for mineral resources in terms of the Mineral and Petroleum Resources Development Act, 2002, to the holder or owner concerned.

  (2) When the Minister responsible for mineral resources issues a closure certificate, he or she must return such portion of the financial provision contemplated in section 24P as the Minister may deem appropriate to the holder concerned but may retain a portion of such financial provision referred to in subsection (1) for any latent, residual or any other environmental impact, including the pumping of polluted or extraneous water, for a prescribed period after issuing a closure certificate.

  (3) Every holder, holder of an old order right or owner of works must plan, manage, and implement such procedures and requirements in respect of the closure of a mine as may be prescribed.

  (4) The Minister may, in consultation with the Minister responsible for mineral resources and by notice in the Gazette, identify areas where mines are interconnected or their impacts are integrated to such an extent that the interconnection results in a cumulative impact.

  (5) The Minister may, by notice in the Gazette, publish strategies in order to facilitate mine closure where mines are interconnected, have an integrated impact, or pose a cumulative impact.

4.4.4.4 FINANCIAL PROVISIONING REGULATIONS

On 20th November 2015, the Minister promulgated the Financial Provisioning Regulations under the NEMA (GNR1147). The regulations (as amended) aim to regulate the determining and making of financial provision as contemplated in the NEMA for the costs associated with the undertaking of management, rehabilitation and remediation of environmental impacts from prospecting, exploration, mining or production operations through the lifespan of such operations and latent or residual environmental impacts that may become known in the future. These regulations provide for, inter alia:

- Determination of financial provision: An applicant or holder of a right or permit must determine and make financial provision to guarantee the availability of sufficient funds to undertake rehabilitation and remediation of the adverse environmental impacts of prospecting, exploration, mining or production operations, as contemplated in the Act and to the satisfaction of the Minister responsible for mineral resources.

- Scope of the financial provision: Rehabilitation and remediation; decommissioning and closure activities at the end of operations; and remediation and management of latent or residual impacts.

- Regulation 6: Method for determining financial provision – An applicant must determine the financial provision through a detailed itemisation of all activities and costs, calculated based on the actual costs of implementation of the measures required for:

  - Annual rehabilitation – annual rehabilitation plan;

  - Final rehabilitation, decommission and closure at end of life of operations – rehabilitation, decommissioning, and closure plan; and

  - Remediation of latent defects and residual impacts – environmental risk assessment report.

- Regulation 10: An applicant must-

  - ensure that a determination is made of the financial provision and the plans contemplated in regulation 6 are submitted as part of the information submitted for consideration by the Minister responsible for mineral resources of an application for environmental authorisation,

the associated environmental management programme and the associated right or permit in terms of the Mineral and Petroleum Resources Development Act, 2002; and

- Provide proof of payment or arrangements to provide the financial provision prior to commencing with any prospecting, exploration, mining, or production operations.

- Regulation 11: Requires annual review, assessment, and adjustment of the financial provision. The review of the adequacy of the financial provision including the proof of payment must be independently audited (annually) and included in the audit of the EMPr as required by the EIA regulations.

Appendix 4 of the Financial Provisioning Regulations provides the minimum content of a final rehabilitation, decommissioning, and closure plan. This FRDCP has been prepared to align with these requirements. Appendices 3 and 5 of the Financial Provisioning Regulations provide content requirements for the Annual Rehabilitation Plan and Environmental Risk Assessment Report, respectively. These requirements are addressed under Section 5 and 6 respectively.

4.4.5 CLOSURE VISION, OBJECTIVE AND TARGETS

The vision, and consequent objective and targets for rehabilitation, decommissioning, and closure, aim to reflect the local environmental and socio-economic context of the project, and to represent both the corporate requirements and the stakeholder expectations as well as the legislative framework and regulations.

The receiving environment within which the exploration and production activities are being undertaken include the following key land-uses:

- Agriculture- cultivated fields;
- Natural and degraded veld primarily utilised or livestock grazing;
- Mining areas; and
- Low density rural residential.

With reference to Section 4.2.13, the stakeholders consulted during the public participation process for the EIA raised concerns regarding, amongst others, the following:

- Impacts on ground water quality and availability;
- Impacts on surface water quality;
- The proposed pipeline alignment;
- Disruption of current land use and capability;
- Sense of place;
- The quantum for rehabilitation; and
- Security and access to individual farms.

With reference to both the environmental context of the project and the feedback from the consultation process the vision for closure is to:

Ensure that the landscape is safe, stable and non-polluting over the long term, and that the post closure land use aligns with the surrounding land-use and does not affect the sustained utilisation thereof.

In support of achieving this post closure vision there are certain key rehabilitation, decommissioning, and closure objectives. 'Well-conceptualised rehabilitation objectives will allow assessment of the risks associated with achieving these objectives and guide the setting of suitable rehabilitation actions to be taken to mitigate these risks at every stage of the mine's life. Rehabilitation objectives describe 'what' needs to be achieved to reach the mine's rehabilitation goal. These objectives should be aligned to site-specific characteristics that are within

the mine's control. Rehabilitation objectives should be as specific, measurable, achievable, and realistic as possible. They should also define a time period against which they can be measured' (LaRSSA, 2019). Driven by the closure vision, and with due consideration of the project context the following closure objectives and associated targets are presented in Table 11.

Table 11: Closure objectives and associated targets.

Objective	Target
Set the course for eventual ecosystem rehabilitation, including the improvement of the natural vegetation community, hydrology, and wildlife habitats for impacted areas only.	Alignment of soil condition with that required to meet the defined land capability commitments. Sustainable natural areas. Agreed upon viable land-use.
Prevent future environmental issues related to long term fluid or gas leakage or vertical movement through the well.	No migration of gas or water along the rehabilitated well bore.
Protection of water resources.	Consistent with baseline condition (specifically production indicator parameters).
Ensure that land is usable, in alignment with surrounding land uses.	Agreed upon viable land-use.

4.4.6 ALTERNATIVE CLOSURE AND POST CLOSURE OPTIONS

There are various alternative closure and post closure options available. The identification and consideration of the most suitable alternatives are driven by, inter alia the following considerations:

- The ability of the selected alternative to adequately meet the specified closure vision and objectives.
- The efficiency, viability, and practicality of the selected alternative.
- The preference, where possible, for low maintenance and sustainable options.
- The alignment with the local environmental and socio-economic context and associated opportunities and constraints.

Table 12 presents some available options and alternatives related to the rehabilitation and closure process. The options in the table below that are marked with an "✓" are considered the preferred options for the purpose of this FRDCP. It is important to note that oil and gas production closure and rehabilitation research is ongoing and consequently the available and preferred closure strategies, techniques and available technologies are developing on a continual basis which may, in the medium to long-term, lead to the identification of further closure alternatives.

Table 12: Closure alternatives

Mine feature	Aspect	Options	Advantages	Disadvantages	Comment
Exploration and production wells.	Casing	Retain casing ✓	No additional effort, time and cost to remove the casing string. The casing and associated cemented annulus may provide additional barrier and stability to the hole.	Depending on the nature of the well, corrosion of the casing over time may affect the integrity of the plug.	It is suggested that the casing is retained and that industry standard well bore plugging and abandonment be implemented.
		Remove casing	Casing is often removed in an attempt to recover and salvage the steel.	The retention of the casing is strongly dependant on the nature of the geological strata and location of groundwater aquifer and other permeable zones. The presence of these zones may also be a hindrance to the removal of a casing string. Removal of the casing may result in collapse of the hole making controlled plugging difficult.	
	Plugging extent- The primary objective of wellbore plugging is to isolate potential flow zones (including gas and water zones).	Plugging full length of well bore. ✓	Provides longer barrier distance.	Additional design and implementation costs.	As a standard the well bore will be cemented for the full length and diameter of the wellbore to surface. There may be instances where intermittent plugging options are preferrable- in such instances these deviations must be designed and
		Partial/ intermittent	Reduced design and implementation costs.	Reduced barrier length may result in opportunity for fluid or gas migration.	

Mine feature	Aspect	Options	Advantages	Disadvantages	Comment
					reviewed by a well engineer and approved by the PASA.
	Plugging Material-	There are various materials available for a barrier including (chemical, natural, and mechanical). The barrier can be a single or multi component system and should aim to have the following properties: - Inability for well fluids to pass; - No degradation of the sealing capacity over time; - Avoidance of movement; and - Appropriate of the specific environment and application.	There are different advantages and disadvantages for the different types of barrier materials. The specific environmental circumstances and the nature of the well construction will dictate which barrier is most appropriate.		The cement to be used must comply with industry best practice and the relevant API standards, or alternative standards as agreed with the PASA, and as approved by the well engineer. It is also recommended that a well bore stress model is developed and applied to the well/s to predict the long term thermal and mechanical stresses and adapt the plug material accordingly.
	Plugging techniques and barrier placement methodology.	Dump Bailer- typically used to deliver a small volume of cement.	Allows for accurate control of plug placement depth.	Out dated. This technique has the potential to allow for contamination of the well plug and therefore may affect the plug integrity. Only allows for limited cement volume per placement.	The specific type of displacement method to be utilised is depending on the well construction and alignment as well as the prevailing hydrostatic balance.

Mine feature	Aspect	Options	Advantages	Disadvantages	Comment
		Squeeze/ displacement method: This method may include: balanced plugs, pump and pull, perforation, wash and cement (PWC) , inside blowout preventer (IBOP), and sacrificial workstring release tools. ✓	The displacement method minimises the contamination of the cement by being able to displace fluid within the well. Allows for a more stable well plug.		
	Well Surface Infrastructure- this includes the well head, plinth, electrical components, and fencing (where relevant).	Complete removal ✓	Allows for complete site decommissioning and rehabilitation. Allows for future unhindered alternative land use.	Additional cost.	The surface area of a decommissioned well must be clear of obstructions and equipment. In order to allow unhindered land use of the well area, it is suggested that all surface infrastructure (up to 1m deep) be removed. In addition the well will be capped at +/-1m below ground level with the requirement for marking its' location and representing its' position on the Title/SG Diagram.
		Retain	Potential for landowner to retain for alternative uses.	Risk of future liability for rights holder. May hinder future land uses.	
Pipeline infrastructure	All pipelines	Complete removal	No remnant infrastructure on site.	Removal of the pipelines would involve significant disturbance to the land. This would undo the previous post-construction rehabilitation efforts and would likely reintroduce alien invasives and destabilise the soils (erosion).	It is proposed that the pipeline remain in the ground as removing it will re-disturb consolidated rehabilitated areas. Post closure uses may be discussed with landowners at a later stage.

Mine feature	Aspect	Options	Advantages	Disadvantages	Comment
		Retain ✓	Reduced closure phase disturbance of previously rehabilitated areas- no duplication of rehabilitation effort.	Remnant infrastructure on site. Potential for long term liability- future excavations or collapse and subsidence of overlying areas causing preferential flow paths.	
Processing facility and compressor stations infrastructure	All surface infrastructure including access roads, power and water supply.	Complete removal ✓	No remnant liability associated with surface infrastructure.	Additional cost.	Allowance is made in the current FRDCP to decommission, demolish and dispose of the processing plant infrastructure and rehabilitate the area. Although no discounting can be done in terms of GNR 1147, the possibility exists to either sell off the plant infrastructure or to treat them as assets that can be dismantled, transported and reassembled where required.
		Retain	Provides opportunity for infrastructure to be reused or repurposed either in full or partially. Allows for alternative post-closure uses.		
Access roads	Access roads	Rehabilitate ✓	No remnant liability associated with maintenance or ownership of access roads. Allows for returning the area to pre-commencement land uses.	Additional cost.	The intention is to rehabilitate the area, including the access routes, to the pre-construction condition. However, in certain instances, the landowner may request the retention of the access route. The applicability of these options will need to be addressed on a case-by-case basis prior to closure.

Mine feature	Aspect	Options	Advantages	Disadvantages	Comment
		Retain	Allows for reuse or repurposing should there be a need for such. Reduced cost.	Long term degradation of the road may result in post closure liability for holder.	

4.4.7 MOTIVATION FOR PREFERRED CLOSURE OPTIONS

With reference to Sections 4.4.5 and 4.4.6, the preferred closure option is as follows:

- Retain casing (informed by a pre-closure inspection of casing integrity) and plug using a displacement/pump/squeeze technique, the full length of the well with a suitable plugging cement, as prescribed by industry best practice, and in accordance with the applicable API guidelines and standards as signed off by a well engineer and agreed to by the PASA.
- Cut surface casing at a depth to be informed by end land-use (presumed below plough depth), remove and bury.
- Retain the pipelines in the ground to avoid the need for further ground disturbance and rehabilitation.
- Allowance is made for full decommissioning, demolition and disposal of the processing plant infrastructure after closure as well as rehabilitation of the site.
- Compressor sites will be rehabilitated and the associated infrastructure demolished and removed.
- Rehabilitate access routes or retain when requested by a landowner.

It is anticipated that the closure options presented above, together with monitoring over a 10-year post closure period, will achieve the stipulated closure objective. This closure option is in line with industry best practice and the requirements of the MPRDA Regulations.

Effective abandonment depends on knowledge of the well construction, geology, and the hydrogeology. In this regard it is recommended that prior to commencement of closure and decommissioning of any specific well the following must be undertaken:

- A detailed site-specific decommissioning plan must be prepared by an appropriately qualified specialist or specialists. This plan must take into consideration the following site-specific factors:
    - Current condition and design of the well (informed by suitable well integrity testing);
    - Records of the drilling results (geological logs), cement used and testing results for the life of each well, including the cement bond log tests immediately after grouting and prior to decommissioning as well as any periodic maintenance checks during the operational life;
    - Height of cement in annulus outside casing;
    - Considerations for the composition and placement of the plug or barriers should include:
        - Location of potential flow zones and pore pressures.
        - Location of useable water sources.
        - Formation fracture pressure of natural seals.
        - Cross flow potentials; direction and resultant equalised pressures.
        - Future field plans.
        - Compaction, subsidence, and recharged formations.
        - Corrosion risks.
        - Locations of natural faults and their ability to transmit fluids and/or pressure.
        - Ability to be able to verify the barrier.
        - Operating environment (temperature, pressures, chemical characteristics).

- Cement casing overlaps;
- The need for abandonment plugs to cover the full diameter of the hole;
- The type of fluid in annuli above cement;
- The chemical composition of the prevailing groundwater;
- The following considerations apply to determining the composition of the barrier material/s:
    - Inability for wellbore fluids to bypass in either direction.
    - No degradation of sealing capacity over time.
    - The specific host rock thermal and effective stress characteristic which may affect permanent plug integrity.
    - Avoidance of movement.
    - Appropriate for the environment (e.g. Temperature, pressure, chemical exposure) and application[8].
- Potential difficulties of injecting cement into the annulus;
- Future monitoring of the integrity of the well plug; and
- The depth below surface at which casing must be cut.

- The applicable landowner must be consulted, and input obtained regarding the current and planned land-uses applicable to the area and the need to retain surface infrastructure, well accessibility and/or access tracks.

The revised decommissioning plan and the feedback from the landowner consultation must be submitted to the PASA prior to implementation.

Table 13 provides a list of threats, opportunities and uncertainties related to the preferred closure options. Where applicable actions to address these uncertainties are presented in Section 4.10.

Table 13: Threats, opportunities, and uncertainties associated with preferred closure option.

Item:	Description:
Threats:	Insufficient financial provision to adequately implement closure plan. Insufficient management commitment to effective rehabilitation. Inadequate topsoil management during construction phases to allow for adequate topsoil cover to enable rehabilitation. Inability to identify and implement a suitable alternative land use on the defined alternative land use areas. Groundwater modelling inaccurately predicts the potential medium to long term impacts on the groundwater resources. Incorrect plug/ barrier materials used for well bore plugging could result in long term degradation of plug effectiveness.

[8] The development of an applicable well bore stress model would assist in planning the final specific barrier characteristics.

Item:	Description:
	Third party activities may affect the success of the rehabilitation and closure strategies (e.g. ongoing mining activities such as blasting, and excavations may impact on the long term integrity of well barriers and casing). Movement of faults which may intersect the zone of influence of a well may compromise the long-term stability of the barrier or casing.
Opportunities:	NEMA requires annual review of the rehabilitation and closure plans and associated financial provisions- this provides an ideal opportunity to ensure that the rehabilitation process is assessed for relevance on a continual basis.
Uncertainties:	There are certain closure actions and parameters which are uncertain prior to actual closure. These include the status of the well bores at the time of closure. The specific circumstances will need to be assessed at the time of closure by a qualified well engineer and a decommissioning plan prepared. The extent to which the infrastructure established for the production may be of value for reuse or repurposing by the landowners is uncertain at this stage and must be ascertained prior to final closure. The groundwater model should continue to be updated based on monitoring data and the predictions of impacts to water resources should be reviewed and revised. An adaptive land management approach will be adopted on-site, allowing for implementation of alternative and improved rehabilitation strategies and corrective action, where required.

4.4.8 CLOSURE PERIOD AND POST CLOSURE REQUIREMENTS

The closure period is defined as the period between the cessation of production, and the completion of active rehabilitation actions on the applicable site. It may become necessary to decommission and plug unsuccessful or dry wells during the operational phase. In these instances it is suggested that closure on these specific wells is initiated as soon as possible.

Following successful completion of the active closure actions it is suggested that a further post closure period be assigned to allow for monitoring of the success of closure. This closure and post closure monitoring will involve the following actions and durations:

- Water monitoring- as informed by the water monitoring plan for 50years after decommissioning or until a long-term trend can be determined;
- Fugitive gas emissions using either soil vapour probes, efluxes, or surface methanometers, for a period of 50 years post closure;
- Well plugging and abandonment verification to confirm that there is proper and effective vertical isolation (this could include: bond log tests, cementing tests, communication tests, hydraulic pressure tests, applied weight test); and
- Biodiversity assessments mid wet season should be undertaken by a qualified ecologist / botanist to monitor the rehabilitation progress with regards to flora for a period of 3 years after rehabilitation.

There are however certain residual and latent impacts which may manifest in the post closure phase. These relate primarily to the risk of well plug integrity and associated long-term management of vertical migration of gas and/or fluids to the shallow water resources or the surface.

The management and monitoring associated with these residual and latent risks are addressed in Section 6.

4.5 ENVIRONMENTAL INDICATORS AND MONITORING

Table 14 provides a list of the environmental impacts identified for the rehabilitation, decommissioning, and closure of the project. In addition, environmental indicators are identified for each impact, together with proposed monitoring requirements. The indicators and monitoring will aim to inform ongoing rehabilitation and remediation activities. These indicators will also inform the assessment of whether the closure objectives have been adequately met.

Table 14: Environmental Indicators and Monitoring requirements

Aspect	Impact	Monitoring Requirements	Indicators	Closure Targets
Decommissioning Phase				
Social	Potential to use local service providers and contribute directly to local economy.	None	Complaints register	No unaddressed issues.
	Interruption in services.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Complaints register	No unaddressed issues.
	Interference with existing land uses.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Complaints register	No unaddressed issues.
	Impacts on existing services and infrastructure.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Complaints register	No unaddressed issues.
	Re-instatement of access routes give access to land/infrastructure that was cut off by the project.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Complaints register	No unaddressed issues.
	Increase in social license to operate due to management of nuisance impacts.	Community Liaison Forum held twice a year during construction and operational phases. Pre- decommissioning and closure forum with relevant affected landowners.	Complaints register	No unaddressed issues.
	Impacts on safety and security of local residents due to presence of unfamiliar people in the area.	As part of the monthly ECO reports, the impact of safety and security must be assessed and reported on.	Complaints register	No unaddressed issues.
	Public perceptions about the impact of decommissioning on the sense of place.	Community Liaison Forum held twice a year during construction and operational phases. Pre- decommissioning and closure forum with relevant affected landowners. .	Complaints register	No unaddressed issues.

Aspect	Impact	Monitoring Requirements	Indicators	Closure Targets
Economic	Alternative land-use.	Refer to Environmental Risk Assessment under Section 4.3.	N/A	N/A
	Black economic transformation.		N/A	N/A
	Country and industry competitiveness.		N/A	N/A
	Economic development per capita.		N/A	N/A
	Employment impacts.		N/A	N/A
	Fiscal income.		N/A	N/A
	Forex savings.		N/A	N/A
	GGP impact.		N/A	N/A
	Need and desirability.		N/A	N/A
Air Quality	Fugitive emissions (dust) from decommissioning/ removal of all berms, trenches and other stormwater infrastructure no longer required	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust generated (complaints).	No dust nuisance complaints.
	Greenhouse gas emissions from decommissioning/ removal of stationary infrastructure	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Natural gas concentrations.	No fugitive emissions from wells.
	Fugitive emissions (dust) from decommissioning/ removal of stationary infrastructure	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust generated (complaints).	No dust nuisance complaints.

Aspect	Impact	Monitoring Requirements	Indicators	Closure Targets
	Greenhouse gas emissions from decommissioning/ removal of pipeline infrastructure	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Natural gas concentrations.	No fugitive emissions from wells.
	Fugitive emissions (dust) from decommissioning/ removal of pipeline infrastructure	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust generated (complaints).	No dust nuisance complaints.
	Greenhouse gas emissions from the removal of waste and recycling of recyclable / reclaimable waste	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Natural gas concentrations.	No fugitive emissions from wells.
	Fugitive emissions (dust) from the removal of waste and recycling of recyclable / reclaimable waste	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust generated (complaints).	No dust nuisance complaints.
Hydrogeology	Contamination of alluvial and sand aquifers	Regular monitoring and reporting (monthly ECO reports) during decommissioning. An emergency response protocol must be implemented that is aimed at early detection and swift reaction speed relating to leaks and spills.	Groundwater quality	Consistent with baseline condition (specifically production indicator parameters).
	Contamination from leakage and spillage	Monitoring should take as per the EMP requirements.	Groundwater quality	Consistent with baseline condition (specifically production indicator parameters).
	Stray gas migration affecting groundwater quality	Monitoring should take as per the EMP requirements.	Groundwater quality	Consistent with baseline condition (specifically

Aspect	Impact	Monitoring Requirements	Indicators	Closure Targets
				production indicator parameters).
	Well casing and/or cementation failure affecting groundwater quality	Monitoring should take place for 50 years after cessation of production activities or until a long term acceptable trend can be determined. A groundwater and gas monitoring programme will be implemented to serve as an early detection mechanism.	Groundwater quality and natural gas concentrations.	Consistent with baseline condition (specifically production indicator parameters) and no fugitive emissions from wells.
Economic	Alternative land-use.	Refer to Environmental Risk Assessment under Section 4.3.	N/A	N/A
	Black economic transformation.		N/A	N/A
	Country and industry competitiveness.		N/A	N/A
	Economic development per capita.		N/A	N/A
	Employment impacts.		N/A	N/A
	Fiscal income.		N/A	N/A
	Forex savings.		N/A	N/A
	GGP impact.		N/A	N/A
	Need and desirability.		N/A	N/A
Social	Potential to use local service providers and contribute directly to local economy	None.	N/A	N/A

Aspect	Impact	Monitoring Requirements	Indicators	Closure Targets
	Impacts on safety and security of local residents due to presence of unfamiliar people in the area	Appointment of a Community Liaison Officer and regular monitoring and reporting (monthly ECO reports) during closure and rehabilitation.	Complaints register	No unaddressed issues.
	Interference with existing land uses/livelihoods	Appointment of a Community Liaison Officer and regular monitoring and reporting (monthly ECO reports) during closure and rehabilitation.	Complaints register	No unaddressed issues.
	Increase in social licence to operate due to management of nuisance impacts	Appointment of a Community Liaison Officer and regular monitoring and reporting (monthly ECO reports) during closure and rehabilitation.	Complaints register	No unaddressed issues.
	Plugged wells resulting in redistribution of gas to underground workings.	Records of consultation with the affected mining entities.	Minutes of meetings	No correlated increased levels of methane on underground workings.
Biodiversity	Degradation of natural habitat- including erosion and alien invasives. Should rehabilitation not be successful then there is a potential for degradation of the rehabilitated surface and adjacent areas.	Visual inspections of rehabilitated areas.	Presence of erosion features. Presence of alien invasive species.	Alignment with adjacent reference site or pre-commencement condition.

4.6 FINAL POST CLOSURE LAND USE

The ultimate aim of most closure and land rehabilitation is to return the land to the same or similar state to what it was pre-production. In order to inform this target it is important to have a clear understanding of what the pre-production land-use and land capability was. Land-use is the way land is used by people for a defined purpose and may comprise one or more land uses. In most instances, one landscape can support numerous land-uses within the constraints of land capability, creating a multifunctional landscape.

The main economic activities within the production right area relate to farming (livestock/ game grazing and cultivated lands) and mining (primarily gold mining). The final post closure land use will depend on the specific site circumstances, in so far as it relates to the pre-production uses and also the prevailing uses, at the time of closure. It is proposed that, prior to initiating closure, a suitably qualified environmental scientist undertake an assessment and consult with the landowner and prepare a site-specific decommissioning plan for submission to PASA for review and approval. For the purposes of this FRDCP it is assumed that the post closure land use will be congruent with the agricultural and natural veld mix of land use and capability in the region.

4.7 CLOSURE ACTIONS

In order to align with the defined closure plan and final land use objectives, the Holder will need to implement a series of actions which addresses the mines infrastructure, facilities, and rights area, as well as ongoing maintenance and management thereof. These actions and obligations apply to all infrastructure, activities, and aspects both within the production right area and off the production right area which were associated with the production activities and over which the Holder has responsibility.

The anticipated closure actions can be summarised as follows:

- Phase 1: Preparation for closure.
- Phase 2: Making safe.
- Phase 3: Rehabilitation.
- Phase 4: Monitoring and maintenance.

The detailed closure actions are presented in Sections 4.7.1 to 4.7.3.

4.7.1 PHASE 1: PREPARATION FOR CLOSURE

4.7.1.1 **GENERAL PRODUCTION ACTIVITIES**

There are certain closure actions that are required to be initiated and, in some instances, concluded prior to finalising and implementing the eventual decommissioning, rehabilitation and closure of the activities. The preparatory actions include the following:

- Ensure that the FRDCP and Risk Assessment is up to date and approved (including where relevant the future updated numerical groundwater model including consideration of long-term climate change predictions and adaptation).
- Application for EA, WML and/or WUL (if applicable to implement closure plan) for decommissioning and closure activities (at least 18 months prior to scheduled closure).
- Pre-emptive planning for post closure land-use including development of surface infrastructure inventory and the identification of infrastructure which is available for reuse and repurposing post closure.
- Develop or continue with local stakeholder and public communication forum/ mechanisms to communicate rehabilitation progress and facilitate grievances.

- Engage with local stakeholders and specifically the directly affected landowner to reaffirm the final closure strategy- for instance there may be instances where a landowner may wish to retain or repurpose certain infrastructure.
- Update material and topsoil balances to confirm availability of suitable material for rehabilitation.
- The need for, and extent of, and active revegetation will be determined during the initial site assessment as well as the pre-closure site assessment.
- Ensure that a comprehensive alien vegetation eradication, control and management plan is in place.
- Ensure that applicable sensitive areas and stockpiles are suitably identified and demarcated and the water and waste management plans are up to date (including inventories of waste sources, storage and eventual disposal options).

These actions apply primarily to the surface infrastructure not directly associated with the wells (Section 4.7.1.2 addressed the actions specific to the wells) including the processing plant, and gas gathering infrastructure.

4.7.1.2 PREPARATION FOR WELL DECOMMISIONING AND CLOSURE

A well that is no longer active or producing, or for which an approved suspension period has passed, must be plugged and decommissioned in accordance with an approved decommissioning plan. The following tasks will be undertaken prior to decommissioning:

- Site inspection and assessment by a suitably qualified environmental professional with the aim to:
    - Confirm pre-closure site conditions.
    - Undertake a site-specific closure risk assessment.
    - Consult with the affected landowner to confirm closure land use.
- Site inspection by a suitably qualified specialist/s to:
    - Assess the conditions of the specific well in respect of inter alia:
        - Current condition and design of the well; and
        - The integrity of the casing and grouting;
    - Determine the most suitable and appropriate decommissioning strategy with specific focus on the plugging method (including plug dimensions and plugging materials to be used) to ensure no vertical gas and/or fluid movements within the well[9].
    - Prepare a technical decommissioning plan addressing the factors listed in Section 4.4.7.
- Preparation of a consolidated site-specific closure and decommissioning plan.

The site-specific closure and decommissioning plan will be submitted to the PASA for review and approval prior to initiating closure.

4.7.2 PHASE2 2: CLOSURE AND REHABILITATION

Cluster 2 closure actions will be informed, and guided, by the approved closure and decommissioning plan prepared in Cluster 1. Table 15 provides an indication of typical closure and rehabilitation actions that would be followed.

[9] Internationally accepted best practice should be applied and reference should be made to the relevant British Oil and Gas (OPp71), and/or the API guidelines and standards.

Table 15: Summary of typical closure actions.

Component	Closure Action
Dismantling and removal of any on site infrastructure (including processing plant and compressor stations).	• Pre-emptive planning for post closure land-use including development of surface infrastructure inventory and the identification of infrastructure which is available for reuse and repurposing post closure. • Removal of all services, structures, machinery, and infrastructure unless these are specifically required for post-production land-use, post-production projects or have been requested by the landowner. • Establish formal agreements for any infrastructure handed over for third party use, and management. • All identified infrastructure should be broken down to natural ground level. All waste materials to be disposed of at suitably licenced disposal facilities. • Remove all power lines. • Dismantle and dispose of all fences that do not form part of post-closure property boundaries. • Areas where infrastructure was demolished should be assessed through a risk-based system to determine if there is any residual contamination or risk and appropriate remediation measures implemented. Where contaminated material is detected, this should be removed and disposed of. • Profile the area to be free draining. • Remove and rehabilitate all Stormwater management infrastructure not required in the final closure plan. • Assess available topsoil stockpiles in respect of quantity and quality- the topsoil's to be placed for rehabilitation must be suitable for revegetation. • Revegetate disturbed areas with suitable local grass mix in areas where natural regrowth is not successful of anticipated. • A waste and infrastructure hierarchical principal should be applied to all decommissioned infrastructure or wastes, as follows: Reduce, re-use, recycle, dispose. • Monitor and manage dust generated from decommissioning activities to relevant standards. • Removal and safe disposal of any remnant processing waste deposits, including evaporation ponds/ dams. • Pump and treat or dispose (at licenced facility) remnant polluted water from evaporation ponds/ dams. • Remove liners and residue and dispose at suitably licenced facility. • Ongoing monitoring to ensure no erosion, ponding and adequate revegetation.
Rehabilitation of access roads	• Develop rehabilitation phase traffic/ transport layout plan to utilise existing access routes where possible and minimise unnecessary access roads. • Restrict vehicular movements to designated access and routes to avoid unnecessary soil compaction. • Conclude final closure layout plan defining access roads required for ongoing monitoring, management, and maintenance. • Remove access roads with no beneficial re-use potential by deep ripping, shaping and levelling after the removal and disposal of any culverts, drains, ditches and/or other infrastructure. Natural drainage patterns are to be reinstated.

Component	Closure Action
	• Retained access roads to be designed in accordance with relevant engineering standards and specifications- including specific management of stormwater. • Closure, decommissioning, and rehabilitation of all access roads (incl associated structures, signage, culverts, etc) unless these are specifically required for post-closure land-use, post-closure projects, or have been requested by the landowner. • Remove any contaminated soil from roads, dispose at suitably licenced facilities. • Deep rip all compacted areas prior to rehabilitation. • Topsoil rehabilitation and amelioration as is necessary. • Revegetation. • Apply dust suppression (e.g. water sprays) where necessary.
Well site	• The borehole must be cleared of obstructions prior to abandonment. This includes associated surface infrastructure. • Remove any waste materials from the well sites and dispose at a suitably licenced waste disposal facility. • Prior to placing plugs- the state and effectiveness of the applicable annular barrier must be evaluated and verified (method may include cement bond logs, calliper logging, or communication tests). Where necessary this may require remediation of this annular barrier prior to plugging. • Suitably qualified specialist or specialists to design the most suitable and appropriate closure strategy to ensure no vertical gas or fluid movements and that all potential hydrocarbon / water bearing formations by utilizing placed cement plugs. This must include determination of plug length/ location and plug material specifications. • The cement plugs are stacked along the entire length of the wellbore (both in the open hole as well as the upper casing) to ensure efficient redundancy. The extent of plugging to be confirmed during the Preparation phase. • All plugs are tagged to ensure successful placement. • Cementation technique to follow the squeeze displacement technique (or alternative as directed by the well engineer). Wiper plugs must be utilised where applicable. • Conduct cement top-ups along the annulus, and existing cemented sections showing “no bond” or “poor bond” from logging results. • The integrity and effectiveness of the plug must be evaluated and verified once completed. There are many evaluation and verification methods which can be used subject to a specific well circumstance (e.g. physical or mechanical tests, or hydraulic/ pressure tests). The most suitable verification method to be determined by a suitably qualified well engineer. • A surface / shallow cement plug (+/-50m below ground Level) is set, and the well is cut and capped +/-1m below ground level to remove the wellhead and all casing above this point. • The cellar is then collapsed and the surface reinstated and the site rehabilitated. • Rehabilitation must reflect the local environment -ecosystem rehabilitation of impacted areas, including natural fauna and flora, hydrology and hydrogeology

Component	Closure Action
	• Ensure that than the final landscape is safe, stable and non-polluting over the long term, and that post closure land-use does not affect the sustained utilization. • Placement of a "surface tag" in order to ensure monitoring can continue once the casing is cut and the area revegetated.
General Surface Rehabilitation	• Develop and implement an alien vegetation eradication control and management plan (AVECMP). • The removal and/or disturbance of previously unaffected topsoil's must be avoided as far as possible and limited to the existing areas of disturbance. • Develop and implement a revegetation plan. Seeding and planting to be done at, or immediately after, the first rains in spring, and into freshly prepared, fine-tilled seedbeds (where soils are not prone to crusting). • Annual monitoring of the status of rehabilitation and revegetation. • No driving will be permissible on any rehabilitated areas- only on pre-defined designated routes for monitoring. • Implement soil amelioration as is necessary. • Any contamination of the topsoil on surrounding areas must be avoided by ensuring machinery is well maintained and leak free. If contamination has occurred, the area must be remediated and ameliorated immediately. • Monitoring, including review and assessment of soil balances, soil surveys (stripped, stockpiles, and placed). • Implement defoliation on established grasses and vegetation under direction of rehabilitation specialist- to allow for reintroduction of organic matter. • Ongoing rehabilitation monitoring (including soil surveys) and maintenance until relinquishment. • Ongoing rehabilitation of eroded areas through a root cause investigation and rectification approach. • Shape all channels and drains (where applicable) to smooth slopes and integrate into the natural drainage pattern. • Construct contour banks and energy dissipating structures as necessary to protect disturbed areas from erosion prior to stabilisation. • Implement controlled livestock grazing once vegetation is established. Restrict access of livestock newly rehabilitated unless specifically required for defoliation as instructed by a suitably qualified rehabilitation specialist. • Ongoing rehabilitation monitoring and maintenance until relinquishment. Including but not limited to: Alien invasive monitoring and management, erosion control and remediation, vegetation growth and supplementation).
Social and economic change management.	• Public review and comment on rehabilitation, decommissioning, and closure planning. • Regular consultation with I&APs on closure planning and rehabilitation progress, and any intrusive activities. • Develop final land management and maintenance plan with relevant landowners. • Implement land management and maintenance plan.

In accordance with Regulation 132(3) of the MPRDA regulations: The surface area of the decommissioning well must be clear of obstructions and equipment and the well bore must be cemented for the full length and diameter of the wellbore to surface.

Landform, erosion control and re-vegetation is an important part of the rehabilitation process. Landform and land use are closely interrelated, and the landform should be returned as closely as possible to the original landform. Community expectations, compatibility with local land use practices and regional infrastructure, or the need to replace natural ecosystems and faunal habitats all support returning the land as closely as possible to its original appearance and productive capacity.

4.7.3 PHASE 3: MONITORING, MAINTENANCE AND RELINQUISHMENT

The purpose of monitoring is to ensure that the objectives of the rehabilitation and closure plan are met. In this regard the following actions, to be adjusted based on the completion of the pre-closure site assessment, are proposed:

- **Groundwater monitoring (production and exploration wells):** The post-closure monitoring should take place for 50 years or until a long-term acceptable trend can be determined. The extent of the monitoring is to be determined in the site-specific closure and decommission plan (provision has been made for annual monitoring). The aim of this monitoring is to confirm that abandoned wells are safe and are not resulting in a pollution hazard.
- **Flora (all areas):** Biodiversity assessments mid wet season should be undertaken by a qualified ecologist / botanist to monitor the rehabilitation progress with regards to flora. Confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. 'Acceptable cover' means re-establishment of pioneer grass communities over the disturbed areas at a density similar to surrounding undisturbed areas, non-eroding and free of invasive alien plants.
- **Gas emissions (production and exploration wells):** The well site must be monitored for the release of gas from the decommissioned well site. This can be undertaken through appropriate sampling techniques, either soil vapour probes, efluxes, or surface methanometers.

Annual (or as agreed with PASA) environmental reports will be submitted to the PASA and other relevant stakeholders for at least 1 year post-decommissioning (phase 3). The monitoring reports shall include a list of any remedial action necessary to ensure that infrastructure that has not been removed remains safe and pollution free and that rehabilitation of project sites are in a stable, weed and free condition. Electronic/digital photographs will be taken before and after rehabilitation. Please refer to Section 4.13 for further detail on the required auditing and monitoring requirements.

4.8 FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE SCHEDULE

This section presents a high-level list of rehabilitation and closure components and the key actions related to the final rehabilitation, decommissioning, and closure. The key schedule drivers for each activity are presented in Table 16. It is important to note that there are potentially permits and licences which may be required prior to initiating closure activities these may include water use licences and/or environmental authorisations. These should be initiated as soon as practically possible as the timeframes for these processes can be extensive.

Table 16: Closure schedule drivers

Activity	Closure schedule driver
Ongoing activities	Ongoing progressive rehabilitation as production progresses (specifically post-construction rehabilitation of pipeline routes and well site laydown areas).

Activity	Closure schedule driver
	Ongoing decommissioning and closure of abandoned exploration and production wells. The timing of this will depend on when a decision is made to abandon a specific well.
Planning and preparation for Closure	Updated FRDCP and compliance with the Financial Provision Regulations. Obtain relevant closure related environmental authorisations, licences, and permissions (if applicable).
Dismantling and removal of any on site infrastructure	Progressively as infrastructure is no longer required. Final dismantling of all infrastructure not to be retained at cessation of production activities.
Rehabilitation of access roads	Cessation of production activities and where relevant rehabilitation activities- if possible rehabilitation of access roads should be done progressively as these roads are no longer required.
Decommissioning and closure of well sites	Well decommissioning and plugging will be initiated once a well site is no longer yielding viable gas volumes or lapsing of the approved suspension period. The closure will commence on completion and approval of the site-specific decommissioning plan.
Removal and safe disposal of processing waste deposits, including PCD's and evaporation ponds/ dams.	Evaporation ponds/dams to be decommissioned once dirty water areas and need for evaporation ponds/dams ends (i.e. once pollution source terms are removed)- most likely at the end of decommissioning and rehabilitation.
General surface rehabilitation (including backfilled open cast areas and voids, stockpile areas, compacted areas, etc).	Completion of decommissioning. Seeding and planting is most successful when done at or immediately after the first rains in spring, and into freshly prepared, fine-tilled seedbeds (where soils are not prone to crusting).
Rehabilitation Monitoring	Ongoing throughout rehabilitation activities and into the closure and post closure periods.
Social and economic change management	Ongoing throughout rehabilitation activities and into the closure period.

4.9 ORGANISATIONAL CAPACITY

It is critical that roles and responsibilities for the effective planning, implementation, monitoring and revision of the closure process are clearly defined and provided for. The Holder of the Production Right is ultimately responsible for ensuring compliance with all the provisions of the Right and associated plans, as well as other relevant legal requirements. The Holder must ensure knowledge and understanding of the applicable legislation, guidelines, and industry best practices.

Capacity in the following key roles and responsibilities must be provided for:

- Internal Closure champion: a suitably qualified person(s) who will be accountable for the following:
    - Driving the ongoing development, refinement and implementation of the closure plan;
    - Resourcing and implementing the plan;

    - Ongoing management and monitoring requirements to support the closure plan;
    - To ensure the integration of the rehabilitation and closure activities with general operational activities; and
    - Ensure legal compliance and deliver on commitments.
- Internal Social champion: a suitably qualified person(s) who will be accountable for the following:
    - Develop and implement training strategies for internal training;
    - Develop and implement effective communication with all stakeholders;
    - Develop and implement a stakeholder forum to promote information and idea sharing regarding closure related aspects and/or ensuring meaningful contributions to existing forums; and
    - Continually develop the relationship with I&APs, to promote the social licence to operate and close and decommission.
- Independent Environmental Assessment Practitioner: This individual will be appointed to ensure compliance with the requirements of the FRDCP and specifically to undertake the following tasks:
    - Undertake the required pre-closure environmental site assessment, risk assessment, and if required landowner consultations.
    - Prepare a site-specific final closure and decommissioning plan.
    - Undertake the required periodic compliance monitoring and reporting during the closure period.
- Well Engineer and or suitably qualified specialist/s: This individual must be a suitably qualified professional who must have relevant experience in petroleum exploration and production. Key attributes must include experience and qualifications related to the technologies applicable to production well closure and abandonment, as well as a thorough understanding of internationally accepted well closure and abandonment standard and guidelines. This specialist will be responsible for ensuring that the closure plan is implemented to ensure that the risks to the environment and surrounding communities are prevented or limited.

Further education, training and capacity building is critical to ensure that the production activities align with evolving internally accepted best practice and research. In this regard the Holder must ensure that regular review of international best practice is undertaken and where applicable implemented throughout the project programme. It needs to be recognised that closure planning needs to start early within the project lifecycle and continued as an integral component of the operations.

4.10 IDENTIFICATION OF CLOSURE PLAN GAPS

The key gaps applicable to this closure plan are as follows:

- The specific locations of the future production wells and associated pipeline infrastructure is unknown. These can only be defined once successful drilling has been undertaken and decision is taken to integrate the respective wells into the production network. Consequently the scope and content of the closure plan is largely dependent on the specific environmental context associated with the activities. The closure liability estimate will need to be updated (and where necessary the closure plan amended) once the exact locations are formally determined;
- The exact geological stratigraphy and nature of the well profiles is unknown. The specific geological stratigraphy will be a determining factor in both the well designs and the planning for closure and decommissioning;

The following actions have been proposed to address these gaps:

- Complete the further exploration to determine the exact locations of the proposed new wells.
- A detailed drilling log will be prepared and maintained for each of the wells to ensure that the specific geological stratigraphy and sub-surface conditions are considering and inform the final site-specific closure and decommissioning plan;
- Annual updates to the hydrogeological model must continue; and
- Ensure continual review and assessment of the closure and decommissioning actions in relation to international best practice- considering ingoing research and development.

Further the financial provisioning regulations requires that the FRDCP be revisited, assessed, and revised on an annual basis. This annual review must continue to aim to ensure that the gaps identified above are addressed, as applicable, and the relevant financial provisioning updated.

4.11 RELINQUISHMENT CRITERIA

Relinquishment can be defined as the formal approval by the relevant regulating authority indicating that the completion criteria for the production activity have been met to the satisfaction of the authority. In this regard the relinquishment criteria are driven by the objectives of closure and consequently the indicators applicable to each impact associated with the closure and decommissioning. Reference is made to Table 14 which presents each identified environmental impact, the associated indicators and proposed closure targets. In summary the proposed relinquishment criteria include:

- Groundwater: the quality and quantity of the groundwater levels must be consistent with the pre-production condition- or adjusted depending on external inputs and drivers.
- Air quality: Evidence must be provided that there are no gas emissions from the well sites.
- Biodiversity: The vegetation cover of the affected areas must be consistent with surrounding vegetative cover. There must be ecosystem functionality which is consistent with the surroundings.
- Social: There must be no unattended complaints. Where possible written confirmation from the affected landowner must be solicited confirming that outstanding issues have been addressed and closed out.
- Waste: There must be no waste materials remaining on site.
- Land-use: The area must be available for ongoing land uses. The location of all historic production/exploration wells must be demarcated and where appropriate reflected on the relevant property title information.

4.12 CLOSURE COST AND FINANCIAL PROVISION- FRDCP

The closure cost estimation was determined by Minelock Consulting Engineers and was based on the requirements of GNR1147. The GNR1147 quantum is expected to represent a realistic estimation of the required cost for effective decommissioning, rehabilitation, closure, and management of ongoing residual, and potential future latent, impacts.

4.12.1 APPROACH TO FINAL CLOSURE COST DETERMINATION

Funds must be available at any time, equal to the sum of the actual costs of implementing the plans and reports for a period of 10 years (as per Section 7, Chapter 2 of the Financial Provisions Regulations). Tetra4's production right was issued in 2010, with a remainder of 19 years[10]. Therefore, NEMA Financial Regulations specify an

[10] Tetra4 will need to apply for an extension of the Production Right validity period closer to the expiry of the 20 years.

accuracy level of 70% for operations 30 years or less (but more than 10 years). The remainder of this section provides details on the proposed closure cost. The assumptions and limitations stated in Section 4.12.2 also underpin the basis of this closure cost determination.

The closure cost has been calculated through the following steps:

- Review of available information to inform the closure battery limits for the Tetra4 operation;
- Verify unit rates for infrastructure dismantling and demolition as well as associated rehabilitation of disturbed areas, taking into account the latest demolition equipment available;
- Develop layout plans indicating existing and proposed infrastructure to be included in the rehabilitation and closure cost estimation;
- Unit rates were sourced from available precedents, inputs from specialists in the field, and experience;
- Rates are based on third-party contractor rates and not mining rates; and
- Apply the verified unit rates and associated quantities measured from the layout plans in spreadsheets to determine the closure costs.

The battery limits for this closure provision assessment are limited to:

- Access roads;
- Sub-surface pipelines;
- Pigging stations and low drains;
- Coalescer filter or knockout drum at each booster station;
- Pipe markers;
- Well heads;
- Production and exploration wells;
- Inline booster compressor or infield reciprocating compressor;
- Gas driers;
- Fencing;
- Combined LNG and Helium Plant;
- Helium storage and dispenser units;
- LNG gas storage and dispenser units;
- Chemical storage area;
- Temporary Hazardous waste storage;
- Temporary General waste storage;
- Mobile offices and ablution facilities; and
- Compressor Stations 1, 2 and 3.

4.12.2 COST ASSUMPTIONS AND QUALIFICATIONS

Closure cost estimations were determined using the following general and site-specific assumptions and qualifications:

- General:
    - Only decommissioning and rehabilitation costs equating to an outside contractor establishing on-site and conducting decommissioning and rehabilitation-related work. Based on the above, dedicated contractors would be commissioned to conduct the demolition and work over the plant site. This would require establishment costs for the demolition and rehabilitation contractors and hence, the allowance of preliminary and general (P&Gs) in the cost estimate. Allowance has also been made for third party contractors and consultants to conduct post closure care and maintenance work, as well as compliance monitoring.
    - Costs pertaining to workforce management, re-training/re-skilling are outside the scope of this costing.
    - Concrete footings and bases would be demolished to a maximum of 1 000 mm below the final surface topography.
    - All infrastructure, other than the pipelines which will remain will be completely dismantled, regardless of whether it is foreseen that certain components would be sold off/transferred to third parties post closure. Hence, no allowance was made for the beneficial re use of any of the infrastructure. Until such agreements have been put in place, the assumption remains that total demolition would be required.
    - Movable assets will be removed from site for sale and/or re used by the owners of Tetra4, and the cost associated with dismantling and transport of these items are not included in the cost determination.
    - Fixed ratios for P&Gs, contingencies and socio-economic mitigation measures have been applied.
    - Income from the sale of salvage steel does not offset closure cost allowances.
    - Closure costs have been determined for the scheduled and unscheduled closure scenario only. Scheduled closure takes place at a planned date and/or time horizon in accordance with overall mine planning and unscheduled takes place should the mine close with the infrastructure as is at present.
    - The costs have been reported in present day costs. Closure cost estimations were determined using the following general and site-specific assumptions and qualifications:
    - It is assumed that the management and mitigation measures suggested in the EIA Report relating to ongoing environmental management are complied with. This includes post production clean-up and rehabilitation.
- Site Specific
    - It was assumed that the existing, planned gas production wells and eleven existing exploration wells will be sealed off by pumping grout/cement in to the well as part of the closure and rehabilitation phase. The pressure grouting/cementing of the wells will be undertaken from near the base of the well to surface, commonly known as the Halliburton Method. In addition, it is assumed that all drilling, including casing and grouting, is carried out in accordance with industry best practice and the applicable guidelines and that permeable zones are adequately isolated (including the usable ground water aquifers) as part of the well closure.
    - It is assumed that the loggers will provide a statement, based on the well bond log tests to be carried out, to inform the closure methodology of each well during the construction phase. In the event of unplanned closure, the latest statement will be used to inform the decommissioning plan.

- General waste generated during the demolition and remediation phase will be disposed of at Welkom general landfill site.
- Hazardous waste generated during demolition will be disposed of at a registered hazardous landfill site.
- A dedicated salvage yard and de-contamination bay will be established to de-contaminate demolition waste and screen recyclables.
- The above ground sections, of the pipeline will be dismantled and sealed off.
- No allowance was made for the rehabilitation of unsuccessful exploration wells. It was assumed that these wells will be rehabilitated during operation.
- It was assumed that the pipe markers will remain intact for future reference post closure.
- No allowance was made for post closure water treatment after rehabilitation has been completed.
- It was assumed that constructed power lines (if any) will be transferred to post-closure landowner.
- No allowance was made for bulk water supply during closure phase.
- Additional studies: nominal allowances for technical and specialist studies required to adequately plan for and implement closure activities.
- Preliminaries and general: allowance of 10% of sub-total A (rehabilitation and closure actions).
- Contingencies: Allowance of 10% allowance of 10% of sub-total A (rehabilitation and closure actions).

4.12.3 DESCRIPTION OF UNIT RATES

Unit rates that were applied during the closure determination were obtained from MineLock's existing database. The database is updated in consultation with demolition practitioners and/or civil contractors. The post-closure unit rates that are included in the applied rates are summarised in the subsections below.

4.12.3.1 **GENERAL SURFACE REHABILITATION**

4.12.3.1.1 GENERAL SURFACE SHAPING

It was assumed that general surface shaping would be required over most of the areas where surface infrastructure has been removed, as part of the overall surface rehabilitation. This includes the stockpiling of building/demolition rubble to be removed for disposal, as well as the subsequent shaping and profiling of these surfaces. It has been assumed that shaping and profiling would involve the dozing of material at a 500 mm average thickness. With an adopted dozing rate of R 22/m3, this equates to about R 110 001.06 /ha.

4.12.3.1.2 GRAVEL ROADS

It was assumed that the gravel access roads are approximately 6m wide. Gravel roads will be ripped at a rate of R 1/m^2 and vegetated at a rate of R 7.00/m^2. Gravel roads amount to R 8.00/m^2.

4.12.3.1.3 RIPPING

About compaction alleviation, allowance has been made for a mid-sized dozer equipped with 3 ripper tines, ripping to a depth of approximately 500 mm for compaction alleviation. An average unit rate of R 5 862.86/ha was estimated based on a wet rate of R 1 284.50h at a rate 60m^2/minute.

4.12.3.1.4 VEGETATION

In terms of vegetation establishment, if vegetation must be established on uncompact growth medium/topsoil, soil amelioration will most likely be required. This will depend on the nature of the soil. To determine a unit rate

for re-vegetation, allowance has been made to apply 0.5 ton/ha fertiliser, 5 ton/ha lime and 15 ton/ha organic material such as well-cured cattle manure. If cultivation and seeding are also included, but ripping to alleviate compaction excluded, this rate equates to R 60 161.84/ha.

4.12.3.1.5 SURFACE WATER MONITORING

Allowance has been made to conduct the surface water monitoring at 3 monitoring points. If assumed that it would take at least one man-day of an independent specialist (including the preparation of the sampling equipment) to conduct the sampling at these points, this would equate to about R14 702.00 per sampling event for professional fees and associated disbursements. If an additional allowance is made for sample analysis of R 1 300.00 per sample, this equates to an additional amount of R 3 900.00, totalling to R 17 600.00 per event. It has been assumed that surface water monitoring should continue 5 years' post-closure at a bi-annual frequency (R37 202.00/year).

4.12.3.1.6 GROUNDWATER MONITORING

It has been assumed that 10 groundwater monitoring boreholes would be required to reflect post closure groundwater quality. If it is assumed that two man-days would be required to conduct a monitoring event (including preparation, purging ex.) this would equate to about R 25 202.00 per sampling event for professional fees and associated disbursements. Allowance has also been made to conduct chemical sample analysis at R 3 500.00/sample. Hence, these costs amount to about R 60 202.00 per event. It has been assumed that groundwater monitoring should continue for 50 years post-closure at an annual frequency.

4.12.3.1.7 REHABILITATION MONITORING

Biodiversity and soils (Landscape Function analysis) assessments (including mid-wet season) should be undertaken by a suitably qualified ecologist / botanist / soil scientist to monitor the rehabilitation progress. The monitoring should take place for bi-annually, 3 years after rehabilitation. There should be confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. 'Acceptable cover' means re-establishment of pioneer grass communities over the disturbed areas at a density similar to the surrounding undisturbed areas, non-eroding and free of invasive alien plants.

It was assumed that one man-day would be required to conduct the rehabilitation monitoring over the disturbed area. Assuming a consultant rate of R600.00/hr, this would equate to R 9 000.00 per event for professional fees and associated disbursements. Hence, these costs amount to about R 9 101.00 per event. It has been assumed that rehabilitation monitoring should continue for 50 years post-closure at a bi-annual frequency (R18 202.00/year).

4.12.3.1.8 REHABILITATION CARE AND MAINTENANCE

It is assumed that this would require 1 weeks per year of a team of 5 workers and 1 TLB as supporting equipment to conduct the corrective measures over 5 ha. It is assumed that the hourly rate of the workers is R 38hr and the equipment R 3 000.00/d (per machine). Care and maintenance should continue for 50 years post-closure. The overall rate is R 24 500.00/year. It has been assumed that the workers and equipment could be sourced locally.

4.12.3.2 **SITE SPECIFIC**

Site specific unit rates were calculated based on experience and rates obtained from contractors. The site-specific unit rate includes the following:

4.12.3.2.1 DOWN HOLE SURVEYS

Allowance was made to survey the existing and proposed wells to determine the pre-decommissioning conditions (e.g. blockages to ensure the wells are plugged/rehabilitated to the ultimate depth).

Unit rate composition:

- Personnel – supervisor (1) 33days @ R6 300.00/day;
- Personnel – skilled (2) 30days @ R2 630.00/day;

- Survey equipment – wire line winch & dummies, generator, dip meters, hand tools, shovels & picks required for 21 wells total cost @ R7 570.00 and
- Survey 4x4 LDV allowance made for 4500km @ R7.81.

Total cost for conducting pre-closure down hole survey per hole is R24 318.96.

4.12.3.2.2 BOND LOG TESTING

Allowance was made to test the integrity of the grouting in the wells to ensure there are no poor grouting bonds or inconsistent densities. All gas well locations will require CBL test work to be done prior to final closure. Based on the geographical location of each well, three wells can be tested per day at a daily cost of R9 140. Future associated costs include:

- Logging unit preparation and mobilization/demobilization, @ R7 646.00;
- Logging caliper/gamma ray sonde per m, @ R11.35;
- Logging CBL sonde per m, @ R23.90;
- Log processing, analysis and formal reporting per m, @ R39.29.

Total cost per well amounts to R58 782.47.

4.12.3.2.3 UNBLOCKED COLLAPSED WELLS

Allowance was made for the unblocking of collapsed wells to ensure isolation/sealing to depth. This is key in preventing future preferential pathways for potential groundwater contamination.

Unit rate composition:

- Drill, Compressor, Labour & Equipment per hole @ R158 641.00.

4.12.3.2.4 BOREHOLE GROUTING

Allowance was made for the grouting/cementing of the wells to a depth of 750 m. An additional 20% grouting volume was allowed.

Unit rate composition:

- Personnel – supervisor (1) 66 days @ R4 720.00/day;
- Personnel – skilled (4) 66 days @ R2 968.00/day;
- Personnel – unskilled (3) 66 days @ R1 882.00/day;
- Grouting 4x4 D/C LDV allowance made for 11 000km @ R6,75;
- Drill/Work Over Rig, trimming installation allowance made for 30 hours @ R3 000.00/hour;
- Tremmi Installation & Removal @ 39 967.00/well;
- Grout Pumped into Wells 190 m3 required @ R6 000.00/m3;
- Excess Mixed Grout – waste allowance 38 m3 @ R6 000.00/m3;
- Grouting Trailer, Horse – mixer, pumps, hoses, flow meters @ R28 437.00/well;
- Trimming string -5" steel schedule 80 @ R53 766.00/well;
- Tremmi string 5" steel schedule 80 for 19 wells @ R53 766.00/ well;
- John Deere 4x4 tractor & trailer – water @ R4 272.00/well; and

- Ancillary equipment -Subbie pump, water pump, hand tools, generator/welder, measurement wheel, 5000 L water tank @ R8 185.00/well.

4.12.3.2.5 GAS TRANSPORTATION PIPELINE

All above ground pipeline infrastructure will be dismantled/demolished and sealed off. The in-situ gas transportation pipeline will remain as is.

4.12.4 FINAL REHABILITATION DECOMMISSIONING AND CLOSURE COST ESTIMATE

The closure cost for the proposed Cluster 2 production activities is estimated to be R284 106 332.54 (excluding VAT) at the end of the project life cycle (Table 1). This is based on the assumption that the construction of the gas gathering network and plant will commence in ~March to May 2023 and the planned additional drilling to be undertaken in the forthcoming 12 months following construction commencing. This closure cost is based on 2022 values and will require annual reassessment, revision and escalation. Table 17 provides a summary of the determined closure cost estimate. Please refer Appendix 2 for the detailed breakdown of the items, quantities and costs.

Table 17: Scheduled and unscheduled closure liability assessment for Tetra4.

	Scheduled 2022	Unscheduled 2022
Decommissioning and Closure		
Infrastructural Areas	R 54 152 271.61	R 18 050 576.70
Wells	R 170 235 343.60	R 56 744 547.08
General Surface Rehabilitation	R 2 312 197.39	R 770 724.76
Closure phase monitoring	R 1 323 315.19	R 1 323 315.19
P&Gs and Contingencies	R 50 165 088.12	R 16 915 616.02
Total Final Rehabilitation, Decommissioning and Closure Costs (Excl VAT)	**R 278 188 215.92**	**R 93 804 779.75**

4.13 MONITORING, AUDITING AND REPORTING

The requirement for monitoring and auditing should be carried through all phases of the project lifecycle. The financial provision regulations require that monitoring, auditing and reporting which relate to the risk assessment (see section 4.3), legal requirements (see section 4.4.2) and knowledge gaps (see section 4.10) as a minimum and must include-

(i) a schedule outlining internal, external, and legislated audits of the plan for the year, including-

   a. the person responsible for undertaking the audit(s);

   b. the planned date of audit and frequency of audit;

   c. an explanation of the approach that will be taken to address and close out audit results and schedule;

(ii) a schedule of reporting requirements providing an outline of internal and external reporting, including disclosure of updates of the plan to stakeholders;

(iii) a monitoring plan which outlines-

   a. parameters to be monitored, frequency of monitoring and period of monitoring; and

   b. an explanation of the approach that will be taken to analyse monitoring results and how these results will be used to inform adaptive or corrective management and/or risk reduction activities.

This section aims to present the monitoring plan which will need to be implemented in the rehabilitation and decommissioning, and closure phases. For detail on the monitoring requirements during the production and progressive rehabilitation phase, and the post-closure phase, please refer to Sections 5 and 6 respectively.

For the purposes of this closure plan the monitoring and auditing is separated into two distinct categories namely, compliance monitoring and environmental monitoring. The compliance monitoring will typically align with, and be a continuation of, the requirements of compliance monitoring and reporting as specified in the EMPr. Table 18 and Table 19 provide the compliance monitoring and reporting plan and the environmental monitoring and reporting plan respectively, applicable to the decommissioning, rehabilitation, and closure phase.

In accordance with Regulation 11 of the NEMA Financial Provisioning Regulations the Holder must ensure annual review of the annual rehabilitation plan, the final rehabilitation decommissioning and closure plan, as well as the environmental risk assessment. This annual review must be audited by an independent auditor.

All monitoring and auditing must be accompanied by applicable records and evidence (e.g. delivery slips, photographic records, etc). All reports must be retained and made available for inspection by the ECO, the Holder and /or the Relevant Competent Authorities. Copies of all documentation, permits, licences, and authorisations (incl. copy of EA and relevant amendments to the EMPr and EA, waste disposal certificates, disposal licences, water use licences, etc.) must be obtained and kept in a site environmental file.

An environmental compliance register must be prepared and maintained throughout construction, operation and decommissioning in order to monitor environmental concerns, incidents, and non-conformances. This register should be utilised to measure overall environmental performance.

The applicant must use the audit report findings to continually ensure that environmental protection measures are working effectively on site through a system of self-checking. The EMPr should be viewed as a dynamic document aimed at continual environmental performance improvement. In this regard the provisions of Regulation 34-37 of GNR 982 apply to the process of amending the EMPr

Table 18: Compliance monitoring and reporting plan.

Type	Functional Requirement	Responsibility	Frequency	Reporting Mechanism
Daily site inspections	- Undertake site inspections. - Photographic record of site activities. - Data capturing for record and compliance verification purposes. - Daily site inspection diary.	Environmental Officer (EO)	Daily	No routine reporting. Ad hoc as necessary.
Monthly Compliance Report	- Monitor and report on compliance with the requirements of the EA, EMPr, and closure plan and general environmental performance. - Include the results of all relevant environmental monitoring. - Include status of rehabilitation activities. - Include records of: o Waste manifests. o Incident registers. o Complaints registers. o Relevant corrective action reports.	Environmental Manager/ EO	Monthly	Monthly compliance report
Monthly ECO Audits (Decommissioning Phase)	- Site inspection and photographic record. - Audit and report on compliance with EA, EMPr and FRDCP. - Monitoring compliance with Annual rehabilitation Plan. - Alignment with requirements of Appendix 7 of GNR982 (as amended), NEMA.	Independent ECO/Environmental Auditor	Monthly	Monthly Audit Report

Type	Functional Requirement	Responsibility	Frequency	Reporting Mechanism
Annual Independent Audit	- Site inspection and photographic record. - Audit and report on compliance with EA, EMPr and FRDCP. - Monitoring compliance with Annual rehabilitation Plan - Alignment with requirements of Appendix 7 of GNR982 (as amended), NEMA.	Independent ECO/Environmental Auditor	Annual	Annual Environmental Compliance Audit Report
Annual review of financial provisioning reports in accordance with the requirements of Regulation 11 of the Financial Provision Regulations.	- Review, assess and adjust: o Annual Rehabilitation Plan; o FRDCP; and o Environmental Risk Assessment. - Ensure on-going compliance with the requirements of the Annual Rehabilitation Plan and the FRDCP.	Independent Specialist.	Annual	Annual Financial Provision Assessment and update.

Table 19: Monitoring plan- FRDCP

Aspect	Applicable phase	Functional Requirement	Performance indicator/ target	Frequency	Reporting Mechanism
Surface Water	- Decommissioning. - Closure. - Post-closure (5 years post closure)	Standards: - Aquatic Water Quality Standards as published in the Department of Environmental Affairs (DEA) (2014): Framework for the Management of Contaminated Land; - South African National Standards (SANS) 241 1:2011 drinking water standards (SABS, 2015) which sets numerical limits for specific determinants to provide the minimum assurance necessary that the drinking water is deemed to present an acceptable health risk for lifetime consumption. Locations: Downstream of proposed pipeline river crossings (Doring River, Sand River, Bosluisspruit) Bosluisspruit). Parameters: Full monitoring set[11].	Target: < 10% variation in upstream and downstream if exceeded then review and institute additional monitoring and investigation.	- Bi-annual when active construction/ decommissioning activities within applicable catchment.	- Monitoring report. - Annual Environmental Audit Reports

[11] pH, Electrical conductivity (EC), Total Hardness, Total Dissolved Solids (TDS), Alkalinity, Ammonia (NH3), Bromide (Br), Ni trite (NO2), Total Nitrogen, Bicarbonate (HCO3), Fluoride, Chloride, Nitrate (NO3), Sulphate (SO4), Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), Silver (Ag), Aluminium (Al), Arsenic (As)Boron (B), Barium (Ba), Beryllium (Be), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Lithium (Li), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Silicon (Si), Strontium (Sr), Thalium (Tl), Titanium (Ti), Vanadium (V), Zinc (Zn), MTBE, Benzene, TAME, Toluene, Ethyl Benzene, m+p Xylene, o Xylene, 1, 3, 5 Trimethyl benzene, 1, 2, 4 Trimethyl benzene, Naphthalene, TPH GRO C6 C10, TPH GRO C10 C40, Polycyclic aromatic compounds, Total oil and grease.

Aspect	Applicable phase	Functional Requirement	Performance indicator/ target	Frequency	Reporting Mechanism
Groundwater	- Decommissioning. - Closure. - Post-closure (50 years post closure)	Standards: as per the prevailing routine monitoring requirements or alternatively: - Guidance on Sampling Techniques (SABS ISO 5667:2:1991), Guidance on Sampling of Groundwater (SABS ISO 5667:11:2009) and Guidance on the Preservation and Handling of Samples (SABS ISO 566 7:3:1994). Laboratory analysis undertaken at a SANAS Accredited Laboratory. Locations: Existing Tetra4 routine monitoring points as well as additional 2 monitoring points near the plant. Monitoring parameters (minimum): - Full monitoring set. - Physical parameters: Groundwater levels.	- Alignment with background and baseline values. - An increase in any of the indicator elements by more than 25% from baseline conditions will trigger a response from Tetra4. - The lowering in groundwater level by more than 10m will trigger a response from Tetra4. - No water supply (quality and quantity) complaints.	- Decommissioning and Closure: Bi-monthly as per the production/ operational phase monitoring requirements. - Post-closure: Annually	- Annual Monitoring Report. - Annual Environmental Audit Reports
Biodiversity	- Decommissioning. - Rehabilitation. - Closure.	Standards: - Conservation of Agricultural Resources Act, Act No. 43 of 1983 ; National Environmental Management: Biodiversity Act, Act No. 10 of 2004 alien and invasive species list (2014).	- Target: Confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. “Acceptable cover” means re-establishment of pioneer grass communities over the	- Biodiversity assessments mid wet season should be undertaken by a qualified ecologist / botanist to monitor the rehabilitation progress. Bi-annual survey for a	- Annual Monitoring Report. - Annual Environmental Audit Reports

Aspect	Applicable phase	Functional Requirement	Performance indicator/ target	Frequency	Reporting Mechanism
		- Timed random meander method. Parameters: - Flora and Fauna Surveys: Plant community composition. Alien and invasive plant abundance (numbers, density, cover, frequency); Condition measures of vigour, performance, fecundity); Structure size or age class information). Locations: All production areas and adjacent area (~20m). Random meanders within all defined rehabilitated natural areas.	disturbed areas at a density similar to surrounding undisturbed areas, non-eroding and free of invasive alien plants. - Indicators : New species appearing on site, alien species list (including density information), change in composition/ structure of native plant communities, extent of invasive species populations, record of clearing activities, decline in abundance of alien plant species over time.	period of 3 years after rehabilitation.	
Wells	- Decommissioning. - Rehabilitation. - Closure. Post-closure.	Standards: - Plug / barrier evaluation and verification: Well plugging and abandonment verification to confirm that there is proper and effective vertical isolation (this could include: bond log tests, cementing tests, communication tests, hydraulic pressure tests, applied weight test). This should be informed by a well engineer and the applicable API standards.	- Pass barrier evaluation and verification test. - No stray gas or fluid migration. - VOCs GLCs should comply with the TCEQ guideline. - Soil gas measurements should not exceed relevant reference site values. No temporal increase in the soil gas	- Plug evaluation/ verification: Once off post plugging. - Soil and surface gas levels monitoring every 5 years for 50 years.	- Annual Monitoring Report. - Annual Environmental Audit Reports

Aspect	Applicable phase	Functional Requirement	Performance indicator/ target	Frequency	Reporting Mechanism
		- Gas emissions: Passive diffusive sampling, National Ambient Air Quality Standards (GN1210/2009). The well site must be monitored for the release of gas from the decommissioned well site. This may be done by soil vapour testing or elfluxes and/or surface methanometer or alternative method approved by a qualified well Engineer or Independent Environmental Specialist. Locations: At all closed/ abandoned wells.			

5 ANNUAL REHABILITATION PLAN

The annual rehabilitation plan (ARP) aims to:

- Review concurrent rehabilitation and remediation activities already implemented;
- Establish rehabilitation and remediation goals and outcomes for the forthcoming 12 months, which contribute to the gradual achievement of the post-production land use, closure vision and objectives identified in the holder's final rehabilitation, decommissioning, and mine closure plan;
- Establish a plan, schedule, and budget for rehabilitation for the forthcoming 12 months;
- Identify and address shortcomings experienced in the preceding 12 months of rehabilitation; and
- Evaluate and update the cost of rehabilitation for the 12-month period and for closure, for purposes of supplementing the financial provision guarantee or other financial provision instrument.

The purpose of an ARP report is to provide a record containing the relevant information regarding concurrent rehabilitation and remediation activities for the site for the forthcoming 12 months and how these relate to the operation's closure vision, as detailed in the final rehabilitation, decommissioning and mine/production closure plan. The ARP also indicates what closure objectives and criteria are being achieved through the implementation of the plan.

5.1 STATUS OF ENVIRONMENTAL MONITORING

This section presents the key findings of the environmental monitoring carried out on the site. The monitoring is done in accordance with the current obligations and requirements as specified in the EMPr. Table 20 presents the summary of the most recent monitoring reports. Detailed description of monitoring undertaken, and consequent findings are available in the associated source monitoring reports.

Tetra4 has other monitoring obligations which relate to the construction or operational phase specifically. These include dust, air quality, and localised surface waters. The findings for these studies are not presented herein as they do not have a bearing on the identified rehabilitation, decommissioning, and closure risks.

Table 20: Status of environmental monitoring.

Report	Key findings	Relevant Rehabilitation, Decommissioning and Closure Considerations
Regional routine groundwater and surface water monitoring	Tetra4 has been conducting bi-monthly groundwater and surface water monitoring around the existing HDR1 production facility since mid-2017. The following conclusions are presented in the latest monitoring report: "The chemical character of groundwater can be altered due to a variety of influences. These can be natural: minerals and gases reacting with the water in its relatively slow natural passage through sediments and rocks and the interaction of lower lying and deeper aquifers, or anthropogenic causes. The possibility of surface (rivers and streams) and groundwater interactions in lower lying areas also exist. Pollution from these surface water sources could potentially pollute groundwater. The time-series chemistry data indicate that variations in the chemical character of the groundwater in the area exist over time and space, although no evidence exist that these changes fall outside of the naturally occurring variations. There seems to be little evidence of a definite trend of chemical change at the current monitoring sites as the R^2 values are mostly low and account for very little of the variance. Further statistical analysis, using annual data sets, is needed to confidently determine whether any meaningful trends exist. Some bi-monthly parameters did exceed the standard deviation from the mean baseline concentrations as well as the 25 % limit from the mean for this monitoring event at certain sites. These parameters were: Ammonia, Barium, Boron, Bromide, Calcium, Chloride, Conductivity, Dissolved Inorganic Carbon, Dissolved Methane, Lithium, Magnesium, Manganese, Nitrate, Potassium, Sodium, Strontium, Sulphate, TDS, Total Alkalinity as CaCO3 and TSS. High standard deviation values of the mean baseline for some of these parameters mean that there is high variability (low central tendency) of the data points around the mean for the parameters at each respective site. High standard deviation could possibly be attributed to the limited baseline data taken over a short period, leading to lowered reliability of the baseline mean. The high standard deviation could also hint on the natural volatility of these chemical parameters as the variation is high over a short sampling period for the baseline study. The recent increases in Bromide concentrations need to be investigated. The water in the area is naturally saline – previous studies showed that Sodium/ Chloride dominated water types have a strong correlation with elevated methane concentrations. Alvarez et al. (2016) further highlights the above by identifying that low Nitrate and Sulphate in Sodium rich water are strong predictors in the natural occurrence of high Methane concentrations. It is difficult to determine the exact reason for any changes that may occur in groundwater chemistry and whether, if any are present, these changes are significant without any statistical analysis.	Monitoring to continue to ensure reliable data for trend analysis leading towards closure. Monitoring network should be expanded to include the expanding production well network.

Report	Key findings	Relevant Rehabilitation, Decommissioning and Closure Considerations
	Health concerns associated with chemical determinants of drinking water, differs from that of microbial contamination, as chemical determinants can cause adverse health effects after prolonged periods of exposure. None of the sites included in this monitoring programme have water suitable for drinking (either chronic health or aesthetic effects exist). The standard microbial, physical, aesthetic and chemical determinant thresholds as presented in SANS 241-1:2015 provides a numerical limit for certain parameters, which if met, could prevent the health of consumers from deteriorating over prolonged exposure. These standards are set to be protective of the general population over a lifetime of consumption and to ensure that water quality is preserved for future generations. Parameters that exceeded either SANS 241-1:2015 limits and/or DWAF water quality guidelines at certain sites for this monitoring event include: Chloride, Conductivity, Manganese, Sodium, TDS and TSS".	

5.2 SHORTCOMINGS IDENTIFIED DURING THE PRECEDING PERIOD

This report is limited to the proposed Cluster 2 gas production project which has yet to commence and therefore no shortcomings during the preceding period are relevant to Cluster 2 project at this time.

5.3 PLANNED REHABILITATION AND REMEDIATION

Planned rehabilitation is divided into two main categories, namely: Addressing accumulated rehabilitation backlog or identified shortcomings from previous periods; and progressive rehabilitation associated with ongoing operations. Similar to the shortcomings described in Section 5.2, the proposed Cluster 2 development has not yet commenced and therefore no planned rehabilitation and remediation measures are relevant at this time.

5.4 ANNUAL REHABILITATION COSTING

No annual rehabilitation costs are applicable at this time. Once the proposed Cluster 2 project commences, any annual rehabilitation costs will be determined during subsequent annual cost updates.

6 ENVIRONMENTAL RISK ASSESSMENT – LATENT AND RESIDUAL ENVIRONMENTAL IMPACTS

According to the Financial Provisioning Regulations (2015) the objective of the environmental risk assessment report that relates to latent and residual impacts is to:

- ensure timeous risk reduction through appropriate interventions;
- identify and quantify the potential latent environmental risks related to post closure;
- detail the approach to managing the risks;
- quantify the potential liabilities associated with the management of the risks; and
- outline monitoring, auditing, and reporting requirements.

This section of the report aims to address these objectives separately. In certain cases, these objectives have been discussed and presented in the preceding sections of this report.

6.1 THE ASSESSMENT PROCESS USED AND DESCRIPTION OF LATENT ENVIRONMENTAL RISK

Section 4.3 of this report provides a detailed description of the environmental impact/risk identification and assessment (including the methodology and findings) undertaken. Section 4.3 also includes identified mitigation measures which, once implemented successfully, will result in the avoidance or acceptable reduction of the associated impact. The primary latent and residual risks identified to potentially occur are listed below:

- Well casing and/or cementation failure affecting groundwater quality as a result of vertical migration of fluid and/or gas.

The measures considered to ensure that the risk of vertical zonal interaction (groundwater interplay between aquifers, and/or hydrocarbon movements) is mitigated, is the plugging of the entire well, as previously required under Regulation 132 of the MPRDA Regulations and industry best practice. In order to ensure that the closure vision, objectives and targets are met, the possibility that the integrity of the well plug may deteriorate over very long periods of time has been considered in the ERA under Section 4.3.

The drivers that could result in the manifestation of the latent risk are largely defined by the specifics of the site location and the geological profile surrounding each specific well. However in general the drivers for this impact are summarised in the Hydrogeological study included in the original EIA report, which states the following:

"The steel casing and cement seals in the gas wells may undergo mechanical and/or chemical failure in the long-term. The failure could result from poor well completion practices, corrosion of steel casing and/or the deterioration of cement during and after gas production. In the event that the casing and/or cementation in a well fail, the well can become a high-permeability conduit for saline water and stray gas from deep-seated formations to the overlying shallow Karoo aquifers. Vertical pressure gradients in the subsurface can drive the movement of saline water and stray gas along the well in this instance."

"A well's susceptibility to functional failure relates to the experience level, standards, regulations and oversight used to design, build, operate and plug the well (http://oilprice.com/Energy/Energy-General). Literature suggests that the percentage of wells that have some form of casing and/or seal failure is highly variable, varying between 2 – 75% per project (Davies, et al, 2015).

Saline water and/or stray gas can migrate from a failed well through a number of subsurface pathways (Davies, et al, 2015). These include the development of channels in the cement, poor removal of the mud cake that forms during drilling, shrinkage of cement, the potential for high cement permeability due to poor installation methods and geological features such as bedding planes, contact zones, fault and shear zones that can act as preferential flow paths.

A leak can be catastrophic and result in well blowout, but it can also take place at very low rates that are barely detectable. If a well isn't sealed efficiently, methane and ethane gas can migrate up it and accumulate in confined spaces, including private boreholes.

For this reason, the oil and gas industry has developed proven casing, cementing, drilling, completion and plugging requirements and regulations."

Table 21, presents the identified latent and residual risks; the assessment of the impacts; the recommended management and mitigation measures; the impact drivers, timeframes, and triggers; as well as the suggested closure options and actions.

Table 21: Latent and residual risks.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk (post-mitigation)	Impact Drivers	Impact Timeframes	Impact Triggers	Closure Options/Actions
Groundwater	Well casing and/or cementation failure affecting groundwater quality as a result of vertical migration of fluid and/or gas.	-16 (medium)	Well abandonment and plugging to comply with the requirements of the Petroleum Regulations and accepted best practice. Tetra4 will implement well-specific plugging requirements protect the shallow potable Karoo aquifers at closure. Well design will be done by a qualified well engineer or other suitably qualified specialist/s who will take corrosion, pressures, temperatures, exposure times, production life and well rehabilitation into consideration. The cement seals will be pumped as a water-cement slurry down the casing to the bottom of the well, leaving a sheath of cement to set and harden. The integrity of the seals should, where applicable, be pressure	-9 (medium)	- Geological profile of closed well bore. - Well casing integrity. - Suitability and quality of the annulus barrier. - Suitability and quality of final well bore plug (mechanical factors as well as plug material factors). - Nature of the intersected flow (gas/ water) zones.	Unknown. Depending in the nature of the well and formations the impact may occur at any time in the future.	Elevations in dissolved gas and deep aquifer indicators in shallow groundwater. Gas emissions on surface.	Well closure and abandonment according to regulations and applicable international best practice.

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk (post-mitigation)	Impact Drivers	Impact Timeframes	Impact Triggers	Closure Options/Actions
			tested before the next phase of drilling commences. If the well fails the pressure test, the casing will be re-cemented before drilling continues. Testing will be implemented to ensure that the plug is placed at the proper level and provides adequate protection of permeable zones, for example the fracture zones from which gas was produced and the overlying Karoo aquifers. These tests should include tagging the top of the plug. Pressure testing should be undertaken on the seal but care should be taken not to damage the seal during pressure testing. Swabbing can be undertaken to remove fluids from the well. Upon completion of the rehabilitation of the well, a surface casing vent flow					

Aspect	Impact	Pre-mitigation risk	Suggested Mitigation Measures	Post-mitigation risk (post-mitigation)	Impact Drivers	Impact Timeframes	Impact Triggers	Closure Options/Actions
			test should be considered to determine whether gas or liquid or a combination thereof is escaping from the casing. If gas is detected during this test, additional seals should be designed and implemented. A groundwater and gas monitoring programme will be implemented at each well to serve as an early detection mechanism. Tetra4 has also prepared a Gas Well, Closure, Abandonment and Rehabilitation Guideline document which will be complied with.					

6.2 MANAGEMENT ACTIVITIES, COSTING AND MONITORING REQUIREMENTS

Prevention through accuracy of implementation is the key to addressing and reducing possible latent and residual impacts. This section aims to define the actions required during the post closure phase to manage, address, and monitor residual and latent risks.

6.2.1 MONITORING REQUIREMENTS AND CORRECTIVE MANAGEMENT

Section 4.13 provides a breakdown of the monitoring and auditing requirements for the operation, rehabilitation and decommissioning, closure, as well as post-closure phases. The post closure phase monitoring will aim primarily to monitor key drivers and parameters which causally relate to the predicted latent and residual impacts, and where applicable to trigger management and mitigation activities associated with these. The specific monitoring aspects identified include the following (refer to Table 19 for more detail):

- Surface water monitoring: 5 years post closure.
- Groundwater monitoring: 50 years post closure (annually)
- Surface gas: 50 years (5-year intervals)

Testing of grouting and barriers will be essential for this project and should be implemented for each well, immediately after grouting. Effective records of the drilling results, cement used, and testing results must be kept for the life of each well. A final test should be carried out during the closure phase and is to be informed by a qualified well engineer. The results and the life of well records must be made available to the well engineer, to inform the plug design.

6.2.2 MANAGEMENT AND MITIGATION ACTIVITIES

The monitoring plan described above will provide invaluable insight into the likelihood that the risk will materialise and the expected timeframes and durations of the impacts. On the basis of the current risk assessment and predictive methods, it is expected that certain post closure management activities and mitigation measures will be required. Table 22 presents the impacts and associated mitigation measures identified once the impact is manifest. The alternatives considered and the motivation for the proposed alternatives are also presented. Please refer to Table 12 for a more detailed explanation of each alternative and the associated advantages and disadvantages.

Table 22: Post closure management activities and mitigation measures.

Impact	Alternative	Selected Alternative
Well casing and/or cementation failure affecting groundwater quality as a result of vertical migration of fluid and/or gas.	Identify the specific sources of the fluid /or gas and remove pathway. This could include redrilling and plugging affected well sites.	Tetra4 should make provision for re-plugging/topping up a reasonable percentage of wells.
	Identify affected receptors and provide alternative resources (e.g. alternative water supply options).	
	Interception of contaminated water, treatment and discharge.	
	Restrict future development on affected high risk areas.	

6.2.3 COSTING ESTIMATION FOR RESIDUAL AND LATENT IMPACTS

The monitoring plan described above will provide invaluable insight into the likelihood that the risk will materialise and the expected timeframes and durations of the impacts. However it is considered prudent that some form of financial provision is made for well integrity failure post closure at this early stage.

Patroni (2007) completed a study on the lifespan of wells-based corrosion and casing thickness and found that the lifespan of the casing tested is 75 – 110 years. In addition, the hydrogeological specialist study compiled as part of the EIA considers the post-mitigation risk as relatively low (-9). Furthermore, various studies carried out in Pennsylvania, USA between 2008 and 2013 have found gas well failures resulting in gas leaks to be as low as 2,5% to 3,4% (Vidic et al, 2013).

Based on this variable information the following is proposed:

- Surface Methane Monitoring: The surface methane gas monitoring period is to be increased to 50 years at a frequency of 5 years for each well. It has been assumed that 300 locations will require monitoring post closure for a period of 50 years. This can be undertaken through appropriate sampling techniques, either soil vapour probes, efluxes, or surface methanometers. If it is assumed that 5 man-days would be required to conduct a monitoring event (including preparation, site establishment, equipment hire ex.) this would equate to R 113 270.32 per event.
- Re-drilling and Re-plugging of Wells: An allowance to re-drill and cement three of the wells during the 50 year period has been proposed. The following costs are associated with this activity:
    - Excavation of material to access plug, @ R 13 061.14
    - Removal of plug and re-drill, @ R 247 190.25
    - Plug of well, @ R 260 965.60
    - Surface Capping of Well, @ R 8 022.29
    - Backfill excavated area, @ R 528.51

    Therefore the total cost to re-drill/plug one well amounts to R 529 767.81.
- Groundwater Monitoring: It is suggested that groundwater monitoring at each well site should continue for 50 years post closure. Monitoring is to be performed once per year during April, the month when aquifers are at their fullest. If it is assumed that two man-days would be required to conduct a monitoring event (including preparation, purging ex.) this would equate to about R 25 202.00 per sampling event for professional fees and associated disbursements. Allowance has also been made to conduct chemical sample analysis at R 3500/sample. Hence, these costs amount to about R 60 202.00 per event.

Table 23 provides a summary of the determined costs for the management of the identified residual and latent impacts. Please refer Appendix 2 for the detailed breakdown of the items, quantities and costs.

Table 23: Latent and Residual Cost Estimation.

	Scheduled 2021	Unscheduled 2021
Post Closure Phase		
Monitoring	R 4 328 813.20	R 4 328 813.20
Latent and residual risk provision (Redrill and plugging of borehole)	R 1 589 303.42	R 529 767.81
Total Latent and Residual Cost (excl VAT)	**R 5 918 116.62**	**R 4 858 581.01**

The site-specific environmental assessments performed once the exact drill sites are known, as well as geological data gathered during the drilling process, will allow for a more detailed understanding of the risks related to this

specific impact. This information, along with new international best practice guidelines that may be developed in the future (Section 4.4.6), will be considered in all annual updates of the financial provisions and changes to the risk assessment will be reported on. In addition, monitoring results and auditing reports, as described under Section 4.13, for up to 10 years after decommissioning will inform the revised risk assessment further.

Appendix 1: Tetra4 Gas Well Closure, Abandonment and Rehabilitation Guidelines

Appendix 2: Cost Quantum Determination detail and supporting documentation

Appendix 3: Environmental Risk/ Impact Assessment Detail

VIRGINIA PRODUCTION RIGHT

PASA REF#: 12/4/1/07/2/2 PR

GAS WELL CLOSURE, ABANDONMENT AND REHABILITATION GUIDELINES

2021

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1. PURPOSE OF THIS DOCUMENT

This document aims to provide guidance during the preparation for well closure, sealing and abandonment of a gas production/exploration well, focussing on the following aspects:

1. Determining the most suitable and appropriate closure, sealing and rehabilitation strategy with specific focus on:
    - Technical aspects pertaining to plugging mechanisms/techniques in order to ensure the most suitable and appropriate well specific closure, sealing and rehabilitation strategy is implemented - with specific focus on the plugging methods to ensure no vertical gas and/or fluid movements within the well;
    - Specifications of plugging material and equipment to ensure compliance with well abandonment standards (e.g., Best Practice Standards etc.);
    - Ensuring the landscape is safe, stable and non-polluting over the long-term, and that the post closure land use aligns with the surrounding land use and does not affect the sustained utilization thereof;
    - Mechanisms and tests that would be implemented to ensure cement bonding is structurally sound;
    - Mechanisms and tests that could be implemented for *future long-term monitoring* to ensure well plugging and sealing is structurally sound
2. Preparation of a consolidated site-specific closure, sealing and rehabilitation plan and project cost-breakdown.

2. WELL CLOSURE AND ABANDONMENT REQUIREMENTS AS PER THE EMPR

2.1 Well Objectives

Driven by the closure targets, the following well closure and rehabilitation objectives applies:

1. Well closure must represent legislative frameworks and requirements as stipulated by:
    - Industry Best Practice standards and guidelines; and
2. The gas well sealing, and closure plan must be aimed at preventing groundwater and natural gas reservoir fluids from migrating within or laterally through a well over time, by isolating all porous formations and freshwater aquifers.
3. Reflect the local environment - ecosystem rehabilitation of impacted areas, including natural fauna and flora, hydrology and hydrogeology;
4. Ensure than the final landscape is safe, stable and non-polluting over the long term, and that post closure land-use does not affect the sustained utilization thereof.

2.2 Closure Objectives

The surface area of the well to be abandoned and sealed, must be clear of obstructions and equipment and the well must be cemented for the full length and diameter of the well to surface.

Landform, erosion control and re-vegetation is an important part of the rehabilitation process. Landform and land use are closely interrelated, and the landform should be returned as closely as possible to the original landform. This requires the following:

- Remove any discard or waste materials from the well sites and dispose at a suitably licenced waste disposal facility;
- Shape, level and de-compact the final landscape after removing all of the project infrastructure, where necessary dress with topsoil and, where necessary, vegetate with indigenous species.

As is the nature of natural gas exploration, wells not yielding viable gas will be plugged and rehabilitated. The basic aim is to render wells permanently safe and remove all surface signs of exploration activity. All efforts should be taken to ensure the surface area is returned as close as possible to its pre-exploration condition.

The following factors must be taken into account when designing the well closure strategy:

- Final condition and design of the well;
- Height of the cement in the annulus outside the casing;
- Any permeable formations outside the casing that must be covered in cement;
- Any cemented casing overlaps;
- The need for abandonment plugs to cover the full diameter of the wellbore;
- The type of fluid in the annuli above the cement;
- Consideration of the difficulties of injecting cement into the annulus;
- Future monitoring of the well plug integrity;
- The depth below surface at which casings must be cut; and
- Any related seismic activity risks.

There are various alternative closure and post closure options available. The identification and consideration of the most suitable alternatives are driven by, inter alia the following considerations:

- The ability of the selected alternative to adequately meet the specified closure vision and objectives;
- The efficiency, viability, and practicality of the selected alternative; and
- The alignment with the local environmental and socio-economic context and associated opportunities and constraints.

The table below presents options and alternatives referenced in the EMP related to the process of abandoning and closure of a well site. The preferred options mentioned in the table below, are subject to input from the Contractor and Well Specialist who are required to advise on suitable options related to well-specific conditions.

Table 1: Recommended well closure techniques

Exploration activity	Aspect	Options	Comment
Exploration wells	Casing	Retain	Subject to pre-closure inspection of casing integrity by well engineer. The retention of well casings is strongly dependent on the nature of the geological strata and location of aquifers and other porous/permeable zones. The presence of these zones may also be a hindrance to the removal of a casing string.
	Plugging extent	Entire well length	Best Practice Guidelines requires well to be cemented for the full length and diameter of the wellbore to surface.
	Plugging material	API Standard	The cement to be used must comply with the requirements of the relevant API standards and Best Practice Guidelines, or alternative standards as agreed with the PASA and as approved by a well engineer.
	Plugging technique	Squeeze	The displacement method minimizes the contamination of the cement by being able to displace fluid within the well – thus allowing for a more stable well plug.
	Well surface infrastructure	Complete removal	Best Practice Guidelines requires that the surface areas of a decommissioning well must be clear of obstructions and equipment. In order to allow hindered land use of the well area, it is suggested that all surface infrastructures be removed. In addition, the well be capped at +- 1m below the ground level with the requirement for marking its location and representing its position on the Title/SG diagram.

It is anticipated that the closure options listed in the table above is in line with industry Best Practice Guidelines.

3. WELL CLOSURE, SEALING AND REHABILITATION ACTIONS

The anticipated closure actions can be summarised as follows:

1. Phase 1: Preparation for closure
2. Phase 2: Well Closure and Sealing
3. Phase 3: Earth Works and Surface Rehabilitation
4. Phase 4: Reporting

The tables below provide a summary of the closure actions/requirements for each phase.

PHASE 1: PREPARATION FOR CLOSURE

A licence holder may only suspend a production well on obtaining the approval of the designated agency (PASA). In this regard, a well that is no longer active or producing, or for which the approved suspension period has passed, must be plugged/sealed and rehabilitated in accordance with a PASA approved closure, sealing and rehabilitation plan.

The following tasks should be undertaken prior to well closure and rehabilitation:

Table 2: Summary of tasks to be undertaken prior to well closure and rehabilitation

Actions	Requirements
1. The well must be cleared of obstructions prior to abandonment	• Removal of surface infrastructure ○ Tetra4 will advise on storage facilities to store removed infrastructure

2. Assess well condition through downhole logging	• Conduct **Calliper logging** to identify and investigate potential blockages/cavities within well.
	  ○ This information is crucial for the planning of cementation and volumetric requirements
	• **Cement Bond Logging** to investigate the current integrity of the casing and cementation
	  ○ Determine whether top-up cementation work will be required (specifically across sections with “no cement bond” or “poor cement bond” results are noted).

3. Preparation of a site-specific closure, sealing and rehabilitation plan	• Contractor to determine the most suitable and appropriate closure, sealing and rehabilitation strategy with specific focus on the plugging method to ensure no vertical gas and/or fluid movements within the well.
	• Contractor to prepare a consolidated site-specifi closre/sealing plan – to be submitted to Tetra4 for approval.
	• The identification and consideration of the most suitable alternatives must be driven by the following considerations:
	  ○ The ability of the selected alternative to adequately meet the specified closure vision and objectives;
	  ○ The efficiency, viability, and practicality of the selected alternativs; and

	○ The alignment with the local environmental and socio-economic context and associated opportunities and constraints

PHASE 2: WELL CLOSURE AND SEALING

The table below provides a summary of tasks to be undertaken during well closure and sealing.

Table 3: Tasks should be undertaken during well closure and sealing

Actions	Requirements
4. Isolate all potential hydrocarbon/water bearing formations through the placement of cement plugs	• Develop cement formulation for cementing the entire well annulus. • Develop cement formulation to top-up "no bond" or "poor bond" cemented sections between casing and formation walls – ensure cement seals and does not disperse into porous formations. • Cement formulations and volumetric calculations to be approved by well engineer/cement specialist
5. Well Cementation	• Contractor must ensure cement mixture seals the entire well length along the well annulus. Cement plugs must be stacked along the full length and diameter of the well to surface (open hole section above the packer as well as the upper casing) to ensure efficient redundancy. • All plugs must be tagged to ensure successful placement. • Cementation extent: ○ From end of hole (bottom of well) to surface. • Cementation technique: ○ **Squeeze technique** - this displacement method minimizes the contamination of the cement by being able to displace fluid within the well, thus allowing for a more stable well plug. Contractor must also make use of wiper plugs for cement displacement. • Contractor to conduct cement top-ups along the annulus and existing cemented sections showing "no bond" or "poor bond" from logging results. • A surface / shallow cement plug (+/ 50m below ground Level) must be set, and the well casing must be cut and capped 1 m below ground level to remove the wellhead and all casing above this point
6. Cementation integrity testing	• Integrity of the plugs must be confirmed by setting weight down on the upper most plug (using the drill string) as well as a differential pressure test for 4 hours at determined pressure with less than 10% bleed over the period. Pressure test data to be captured in 15-minute intervals for the entire 4-hour testing period.

PHASE 3: EARTH WORKS AND SURFACE REHABILITATION

The table below provides a summary of tasks to be undertaken during earth works and surface rehabilitation

Table 4: Tasks should be undertaken earth works and surface rehabilitation

Actions	Requirements
7. Earth Works and Surface Rehabilitation	• The well casing must be cut and capped 1 m below ground level to remove the wellhead and all casing above this point; • Placement of a "surface tag" in order to ensure monitoring can continue once the casing is cut and the area revegetated. • Surface area to be rehabilitated is ±40 m^2 (well dependant – Tetra4 to confirm rehabilitation size) • Earth works and surface rehabilitation must include: o Earthworks to shape and profile the area in order to conform to the surrounding area; o Re-instate natural drainage lines; o Re-vegetate surface areas with an *Eragrostis teff* or local pioneer specie seed mix • Rehabilitation must reflect the local environment - ecosystem rehabilitation of impacted areas, including natural fauna and flora, hydrology and hydrogeology • Contractor must ensure that than the final landscape is safe, stable and non-polluting over the long term, and that post closure land-use does not affect the sustained utilization

PHASE 4: REPORTING

The table below provides a summary of reporting requirements after well closure, sealing and rehabilitation.

Table 5: Summary of reporting requirements

Actions	Requirements
9.	• Contractor to prepare a comprehensive project report containing the following: o Calliper and CBL logging results; o Cement formulations and Material Safety Datahseets of all additives; o Cementation methodology and photographs; o Recorded pressure test data; o Well tagging photographs and coordinates; o Surface rehabilitation photographs.

REPORT NO:
P114 TETRA4 Cluster 2
Closure Cost

MineLock
Environmental Engineers

Scheduled and Unscheduled Closure Costs for TETRA4 Cluster 2: Near Virginia in the Free State Province, using Contractors

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List of terms and abbreviations used

Rehabilitation	The re-instatement of a disturbed area into a usable state (not necessarily its pre-mining state) as defined by broad land use and related performance objectives
Remediation	To assist in the rehabilitation process by enhancing the quality of an area through specific actions to improve especially bio-physical site conditions
Scheduled closure	Closure that happens at the planned date and/or time horizon
Unscheduled closure	Immediate closure of a site, representing decommissioning and rehabilitation of the site in its present state
Decommissioning	This involves the deconstruction/removal and/or transfer of surface infrastructure after cessation of operations and the initiation of general site rehabilitation
Care and maintenance	This involve the maintaining and corrective action as requires as well as conducting the required inspection and monitoring to demonstrate achievement of success of the implemented measures
Closure	This involves the application for a closure certificate and initiation of the transfer of on-going care and maintenance to third parties
Site relinquishment	Receipt of a closure certificate and handover to third parties for on-going care and maintenance, if required
Post-closure	The period of on-going care and maintenance, as per arrangement with third parties
Preliminary and Generals (P&Gs)	This is a key cost item which is directly related to whether third party contractors are applied for site rehabilitation. This cost item comprises both fixed and time-related charges. The former makes allowance for establishment (and de-establishment) of contractors on site, as well as covering their operational requirements for their offices (electricity/water/communications), latrines, etc. Time-related items make allowance for the running costs of the fixed charged items for the contract period
Contingencies	This allows for making reasonable Provision for possible oversights/omissions and possible work not foreseen at the time of compilation of the closure costs. Allowance of between 10 percent and 20 percent would usually be made based on the accuracy of the estimations. The South African Department of Mineral Resources Guideline (January 2005) requires an allowance of 10 percent

1. INTRODUCTION

MineLock Environmental Engineers (Pty) Ltd (MineLock) was commissioned by Environmental Impact Management Services (Pty) Ltd (EIMS) to assist with the compilation of the Cluster 2 Financial Provisioning and Closure Costing Report.

This report reflects the scheduled and unscheduled closure costs for Tetra4 Cluster 2 based on third party/contractors' rates as of October 2022. It is noted that the long running costs such as care and maintenance were not discounted and are reflected as accumulated present-day costs. The costs are also VAT exclusive. It is noted the closure costs reflected in this report only relate to the activities of Tetra4 for cluster 2.

2. APPROACH TO COST DETERMINATION

Funds must be available at any time, equal to the sum of the actual costs of implementing the plans and reports for a period of 10 years (as per Section 7, Chapter 2 of the Financial Provisions Regulations). Tetra4's production right was issued in 2010, with a remainder of 19 years. Therefore, NEMA Financial Regulations specify an accuracy level of 70% for operations 30 years or less (but more than 10 years). The remainder of this section provides details on the proposed closure cost. The assumptions and limitations stated in Section 4 also underpin the basis of this closure cost determination.

The closure cost has been calculated through the following steps:

- Review of available information to inform the closure battery limits for the Tetra4 operation;
- Verify unit rates for infrastructure dismantling and demolition as well as associated rehabilitation of disturbed areas, taking into account the latest demolition equipment available;
- Develop layout plans indicating existing and proposed infrastructure to be included in the rehabilitation and closure cost estimation;
- Unit rates were sourced from available precedents, inputs from specialists in the field, and experience;
- Rates are based on third-party contractor rates and are different to the gas production internal rates; and
- Apply the verified unit rates and associated quantities measured from the layout plans in spreadsheets to determine the closure costs.

The battery limits for this closure provision assessment are limited to:

- Access roads;
- Above surface pipelines;
- Pigging stations (14 allowed);
- Low point drains (240 allowed);
- Coalescer filter/ knockout drum at booster stations;
- Compressor stations;
- Booster stations;
- Pipe markers (assumed to be 100 m apart with 480 km of pipeline);
- Well heads;
- 300 production and 400 exploration wells (assumed 33% at unscheduled closure);

- Fencing;
- Temporary Hazardous waste storage;
- Temporary General waste storage;
- Utility area;
- Admin building, Central control building and the Laboratory;
- Workshops, Warehouse, and Fire patrol building;
- External area with cranage;
- LIR, Substation and Transformers;
- Truck loading operator shelter;
- LNG area;
- LNG storage area;
- Helium storage area;
- Pre-treatment and Helium separation unit;
- Fuel gas and Flare system;
- Evaporation pond;
- Warm and cold flare packages;
- Storage tanks;
- Switch Yard for cluster 2;
- Pig trap area;
- 2 x LNG Weigh Bridges;
- Pipe racks;
- All access roads;
- Truck and car parking areas;
- Liquid helium truck loading system.
-

3. GAS PRODUCTION LOCATION AND EXTENT

The proposed Cluster 2 production area is located approximately Cluster 2 application area is 5km south west of the town of Virginia, 9km south the town of Welkom and 16km north of the town of Theunissen, within the Matjhabeng and Masilonyana Local Municipalities, in the Free State Province, over an area of approximately 27 500 hectares (ha).

4. ASSUMPTIONS AND QUALIFICATIONS

Closure cost estimations were determined using the following general and site-specific assumptions and qualifications:

- Only decommissioning and rehabilitation costs equating to an outside contractor establishing on-site and conducting decommissioning and rehabilitation-related work. Based on the above, dedicated contractors would be commissioned to conduct the demolition and work over the plant site. This would require establishment costs for the demolition and rehabilitation contractors and hence, the allowance of preliminary and general (P&Gs) in the cost estimate. Allowance has also been made for third party contractors and consultants to conduct post closure care and maintenance work, as well as compliance monitoring.

- Costs pertaining to workforce management, re-training/re-skilling are outside the scope of this costing.
- Concrete footings and bases would be demolished to a maximum of 1 000 mm below the final surface topography.
- All infrastructure, other than the pipelines which will remain in the ground will be completely dismantled, regardless of whether it is foreseen that certain components would be sold off/transferred to third parties post closure. Hence, no allowance was made for the beneficial re use of any of the infrastructure. Until such agreements have been put in place, the assumption remains that total demolition would be required.
- Movable assets will be removed from site for sale and/or re used by the owners of Tetra 4, and the cost associated with dismantling and transport of these items are not included in the cost determination.
- Fixed ratios for P&Gs, contingencies and socio-economic mitigation measures have been applied.
- Income from the sale of salvage steel does not offset closure cost allowances.
- Closure costs have been determined for the scheduled and unscheduled closure scenario only. Scheduled closure takes place at a planned date and/or time horizon in accordance with overall life of mine (LOM) planning and unscheduled closure takes place should the mine close with the infrastructure as is at present.
- The costs have been reported in present day costs.
- It is assumed that the management and mitigation measures suggested in the EIA Report relating to ongoing environmental management are complied with. This includes post production clean-up and rehabilitation.

Site Specific

- It was assumed that Cluster 2 project entails a total of 300 production wells (400 exploration wells) and will be sealed off by pumping grout/cement in to the well as part of the closure and rehabilitation phase. The pressure grouting/cementing of the wells will be undertaken from near the base of the well to surface, commonly known as the Halliburton Method. In addition, it is assumed that all drilling, including casing and grouting, is carried out in accordance with industry best practice and the applicable guidelines and that permeable zones are adequately isolated (including the usable ground water aquifers) as part of the well closure.
- It is assumed that the well engineer will provide a statement, based on the well bond log tests to be carried out every 5 years during the operational phase, to inform the closure methodology of each well during the construction phase. In the event of unplanned closure, the latest statement will be used to inform the decommissioning plan.
- An allowance was made to re-drill and cement 3 (1%) of the wells during the 50 year period of maintenance and monitoring.
- General waste generated during the demolition and remediation phase will be disposed of at Welkom general landfill site.
- Hazardous waste generated during demolition will be disposed of at a registered hazardous landfill site.
- A dedicated salvage yard and de-contamination bay will be established to de-contaminate demolition waste and screen recyclables.
- The above ground sections, of the pipeline will be dismantled and sealed off.

- No allowance was made for post closure water treatment after rehabilitation has been completed.
- It was assumed that constructed power lines (if any) will be transferred to post-closure landowner.
- It was assumed that water required for demolition and remediation purposes will be municipal water. No allowance was made for bulk water supply during closure phase.
- No allowance was made for additional specialist studies required to adequately plan for and implement closure activities.
- Preliminaries and general: allowance of 12% of sub-total A (rehabilitation and closure actions); and
- Contingencies: Allowance of 10% allowance of 10% of sub-total A (rehabilitation and closure actions).

5. UNIT RATES

Unit rates that were applied during the closure determination were obtained from MineLock's existing database. The database is updated in consultation with demolition practitioners and/or civil contractors. The post-closure unit rates that are included in the applied rates are summarised below.

5.1 GENERAL SURFACE SHAPING

It was assumed that general surface shaping would be required over most of the areas where surface infrastructure has been removed, as part of the overall surface rehabilitation. This includes the stockpiling of building/demolition rubble to be removed for disposal, as well as the subsequent shaping and profiling of these surfaces. It has been assumed that shaping and profiling would involve the dozing of material at a 500 mm average thickness. With an adopted dozing rate of R 22/m^3, this equates to about R 110 001.06 /ha.

5.2 GRAVEL ROADS

It was assumed that the gravel access roads are approximately 6m wide. Gravel roads will be ripped at a rate of R 1/m^2 and vegetated at a rate of R 7.00/m^2. Gravel roads amount to R 8.00/m^2.

5.3 RIPPING

About compaction alleviation, allowance has been made for a mid-sized dozer equipped with 3 ripper tines, ripping to a depth of approximately 500 mm for compaction alleviation. An average unit rate of R 5 862.86/ha was estimated based on a wet rate of R 1 284.50h at a rate 60m^2/minute.

5.4 VEGETATION

In terms of vegetation establishment, if vegetation must be established on uncompact growth medium/topsoil, soil amelioration will most likely be required. This will depend on the nature of the soil. To determine a unit rate for re-vegetation, allowance has been made to apply 0.5 ton/ha fertiliser, 5 ton/ha lime and 15 ton/ha organic material such as well-cured cattle manure. If cultivation and seeding are also included, but ripping to alleviate compaction excluded, this rate equates to R 60 161.84/ha.

5.5 SURFACE WATER MONITORING

Allowance has been made to conduct the surface water monitoring at 3 monitoring points. If assumed that it would take at least one man-day of an independent specialist (including the preparation of the sampling equipment) to conduct the sampling at these points, this would equate to about R14 702.00 per sampling event for professional fees and associated disbursements. If an additional allowance is made for sample analysis of R 1 300.00 per sample, this equates to an additional amount of R 3 900.00, totalling to R 17 600.00 per event. It has been assumed that surface water monitoring should continue 5 years' post-closure at a **bi-annual frequency** (R37 202.00/year).

5.6 GROUNDWATER MONITORING

It has been assumed that 10 groundwater monitoring boreholes would be required to reflect post closure groundwater quality.

If it is assumed that two man-days would be required to conduct a monitoring event (including preparation, purging ex.) this would equate to about R 25 202.00 per sampling event for professional fees and associated disbursements. Allowance has also been made to conduct chemical sample analysis at R 3 500.00/sample. Hence, these costs amount to about R 60 202.00 per event. It has been assumed that groundwater monitoring should continue for 50 years post-closure at an annual frequency.

5.7 REHABILITATION MONITORING

Biodiversity and soils (Landscape Function analysis) assessments (including mid-wet season) should be undertaken by a suitably qualified ecologist / botanist / soil scientist to monitor the rehabilitation progress. The monitoring should take place for bi-annually, 3 years after rehabilitation. There should be confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. 'Acceptable cover' means re-establishment of pioneer grass communities over the disturbed areas at a density similar to the surrounding undisturbed areas, non-eroding and free of invasive alien plants.

It was assumed that one man-day would be required to conduct the rehabilitation monitoring over the disturbed area. Assuming a consultant rate of R600.00/hr, this would equate to R 9 000.00 per event for professional fees and associated disbursements. Hence, these costs amount to about R 9 101.00 per event. It has been assumed that rehabilitation monitoring should continue for 50 years post-closure at a bi-annual frequency (R18 202.00/year).

5.8 REHABILITATION CARE AND MAINTENANCE

It is assumed that this would require 1 weeks per year of a team of 5 workers and 1 TLB as supporting equipment to conduct the corrective measures over 5 ha. It is assumed that the hourly rate of the workers is R 38hr and the equipment R 3 000.00/d (per machine). Care and maintenance should continue for 50 years post-closure. The overall rate is R 24 500.00/year.

It has been assumed that the workers and equipment could be sourced locally

Site Specific

Site specific unit rates were calculated based on experience and rates obtained from contractors. The site-specific unit rate includes the following:

5.9 DOWN HOLE SURVEYS

Allowance was made to survey the proposed wells for blockages to ensure the wells are plugged/rehabilitated to the ultimate depth.

Unit rate composition:

- Personnel – supervisor (1) 33days @ R6300.00/day.
- Personnel – skilled (2) 30days @ R2 630.00/day.
- Survey equipment – wire line winch & dummies, generator, dip meters, hand tools, shovels & picks required for 21 wells total cost @ R7 570.00.
- Survey 4x4 LDV allowance made for 4500km @ R7.81.

Total cost for conducting pre-closure down hole survey per hole is R24 318.96

5.10 BOND TESTING

Allowance was made to test the integrity of the grouting in the wells to ensure there are no poor grouting bonds or inconsistent densities. All gas well locations will require CBL test work to be done prior to final closure. Based on the geographical location of each well, three wells can be tested per day at a daily cost of R 9140. Future associated costs include:

- Logging unit preparation and mobilization/demobilization, @ R 7 646.00.
- Logging caliper/gamma ray sonde per m, @ R 11.35.
- Logging CBL sonde per m, @ R 23.90.
- Log processing, analysis, and formal reporting per m, @ R 39.29.

Total cost per well amounts to R 58 782.47

5.11 UNBLOCKED COLLAPSED WELLS

Allowance was made for the unblocking of 10 collapsed wells to ensure isolation/sealing to depth. This is key in preventing future preferential pathways for potential groundwater contamination.

Unit rate composition:

- Drill, Compressor, Labour & Equipment per hole @ R158 641.00

5.12 BOREHOLE GROUTING

Allowance was made for the grouting/cementing of the wells to a depth of 750 m. An additional 20% grouting volume was allowed.

Unit rate composition:

- Personnel – supervisor (1) 66 days @ R4 720.00/day.
- Personnel – skilled (4) 66 days @ R2 968.00/day.
- Personnel – unskilled (3) 66 days @ R1 882.00/day.
- Grouting 4x4 D/C LDV allowance made for 11 000km @ R6,75.
- Drill/Work Over Rig, trimming installation allowance made for 30 hours @ R3 000.00/hour.
- Tremmi Installation & Removal @ 39 967.00/well.

- Grout Pumped into Wells 190 m^3 required @ R6 000.00/m^3.
- Excess Mixed Grout – waste allowance 38 m^3 @ R6 000.00/m^3.
- Grouting Trailer, Horse – mixer, pumps, hoses, flow meters @ R28 437.00/well.
- Trimming string -5" steel schedule 80 @ R53 766.00/well.
- Tremmi string 5" steel schedule 80 for 19 wells @ R53 766.00/ well.
- John Deere 4x4 tractor & trailer – water @ R4 272.00/well.
- Ancillary equipment -Subbie pump, water pump, hand tools, generator/welder, measurement wheel, 5000 L water tank @ R8 185.00/well.

5.13 GAS TRANSPORTATION PIPELINE

All above ground pipeline infrastructure will be dismantled/demolished and sealed off. The in-situ gas transportation pipeline will remain as is.

6. LATENT AND RESIDUAL COSTING

The monitoring plan described above will provide invaluable insight into the likelihood that the risk will materialise and the expected timeframes and durations of the impacts. However, it is considered prudent that some form of financial provision is made for well integrity failure post closure at this early stage.

Patroni (2007) completed a study on the lifespan of wells-based corrosion and casing thickness and found that the lifespan of the casing tested is 75 – 110 years. In addition, the hydrogeological specialist study compiled as part of the EIA considers the post-mitigation risk as relatively low (-7.5). Furthermore, various studies carried out in Pennsylvania, USA between 2008 and 2013 have found gas well failures resulting in gas leaks to be as low as 2,5% to 3,4% (Vidic et al, 2013).

Based on this variable information the following is proposed:

- Surface Methane Monitoring: The surface methane gas monitoring period is to be increased to 50 years at a frequency of 5 years for each well. It has been assumed that 300 locations will require monitoring post closure for a period of 50 years. This can be undertaken through appropriate sampling techniques, either soil vapour probes or surface methanometers. If it is assumed that 5 man-days would be required to conduct a monitoring event (including preparation, site establishment, equipment hire ex.) this would equate to R 113 270.32 per event.
- Re-drilling and Re-plugging of Wells: An allowance to re-drill and cement 3 of the wells during the 50-year period has been proposed. The following costs are associated with this activity:
  - Excavation of material to access plug, @ R 13 061.14.
  - Removal of plug and re-drill, @ R 247 190.25.
  - Plug of well, @ R 260 965.60.
  - Surface Capping of Well, @ R 8 022.29.
  - Backfill excavated area, @ R 528.51.

Therefore, the total cost to re-drill/plug one well amounts to R 529 767.81.

Groundwater Monitoring: It is suggested that groundwater monitoring at each well site should continue for 50 years post closure. Monitoring is to be performed once per year during April, the month when aquifers are at their fullest.

If it is assumed that two man-days would be required to conduct a monitoring event (including preparation, purging ex.) this would equate to about R 25 202.00 per sampling event for professional fees and associated disbursements. Allowance has also been made to conduct chemical sample analysis at R 3500/sample. Hence, these costs amount to about R 60 202.00 per event.

Table 1 provides a summary of the determined costs for the management of the identified residual and latent impacts. Please refer Appendix A for the detailed breakdown of the items, quantities and costs.

Table 1: Latent and Residual Cost Estimation

	Scheduled 2022	Unscheduled 2022
Post Closure Phase		
Monitoring	R 4 328 813.20	R 4 328 813.20
Latent and residual risk provision (Redrill and plugging of borehole)	R 1 589 303.42	R 529 767.81
Total Latent and Residual Cost (excl VAT)	**R 5 918 116.62**	**R 4 858 581.01**

7. CLOSURE COST DETERMINATION

The closure cost for the proposed production activities is estimated to be **R 284 106 332.54** at the end of the project life cycle. This closure cost is based on 2022 values and will require annual reassessment, revision, and escalation. This value includes R 5 918 116.62 which is allocated to provide for the latent and residual impacts as detailed under Section 6. The remainder of the total value amounts to R 278 188 215.92 and this is provided for decommissioning, closure and rehabilitation.

8. STATEMENTS OF INDEPENDENCE AND COMPETENCE

8.1. STATEMENTS OF INDEPENDENCE

MineLock is an independent international consultancy. Neither MineLock nor its staff, have or have had, any interest in this project capable of affecting their ability to give an objective and unbiased opinion, and have and/or will not receive any pecuniary or other benefits in connection with the project, other than normal consulting fees.

8.2. STATEMENTS OF COMPETENCE

MineLock is based in Pretoria. This division is responsible for closure planning as well as the determination of decommissioning, rehabilitation and closure costs and liabilities for both mining and manufacturing-related industries.

The division has been involved with closure planning and costing projects for key clients throughout South Africa, utilising the South African Department of Mineral Resources' financial provision guideline (January 2005), the NEMA GNR 1147 regulations as well as international good practice to ensure closure costs are country- and site-specific, market-related and appropriate for the site conditions.

All costing and liability estimations are guided and reviewed by Douglas Richards (senior environmental engineer), Director of MineLock Environmental Engineers (Pty) Ltd.

9. SUMMARY OF CLOSURE LIABILITY

Table 2: Scheduled and unscheduled closure liability assessment for Tetra4

	Scheduled 2022		Unscheduled 2022	
TETRA 4 Cluster 2				
Infrastructural Areas	R	54 152 271.61	R	18 050 576.70
Wells	R	170 235 343.60	R	18 050 576.70
General Surface Rehabilitation	R	2 312 197.39	R	770 724.76
Closure phase monitoring	R	1 323 315.19	R	1 323 315.19
P&Gs and Contingencies	R	50 165 088.12	R	16 915 616.02
Annual Rehabilitation	R	-	R	-
Post Closure Phase	R	5 918 116.62	R	4 858 581.01
TOTAL	**R**	**284 106 332.54**	**R**	**98 663 360.76**

10. CONCLUSION AND RECOMMENDATIONS

The financial provision for rehabilitation and closure for Tetra4 Cluster 2 is documented in this report. Information was provided by Tetra4. Estimates / assumptions were made based on experience. The unit rates used in the closure costing were obtained from MineLock's database of recent third-party rates. The unit rates were adapted to reflect site specific conditions. It is recommended that a workshop is conducted with the drilling contractor to refine the plugging rates based on on-site conditions.

11. REFERENCES

Department of Mineral Resources, 2005. *Guideline Document For The Evaluation Of The Quantum Of Closure-Related Financial Provision Provided By A Mine;*

Guidelines for Surface Coal Mines. 2019. *Compiled by R. Hattingh. Published by the Coaltech Research Association,* the Minerals Council of South Africa and the Land Rehabilitation Society of Southern Africa;

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Douglas Richards
Director

APPENDIX A

MineLock Environmental Engineers

114 TETRA4 - Cluster 2

Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
	1	**Decomissioning and Closure**						**R 94 201 778.49**
Assume 33% will be implemented within the 1st year	**1.1**	**Infrastructural Areas**						**R 18 378 802.74**
		Admin Building - Phase 2						
Assume single storey brick building, Area 547 m^2		Normal one storey brick buildings	Yes	E1,1	/m²	547.00	R 442.12	R 241 842.06
Concrete base assumed to be light concrete (200 mm)		Concrete Base (Light concrete)	Yes	B1,1	/m³	109.40	R 552.38	R 60 430.81
		External Area with Cranage						
Concrete base assumed to be medium concrete (200 mm), Area 302 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	60.40	R 869.58	R 52 522.87
		Workshop- Warehouse and Fire Patrol Building						
Assume concrete thickness of 200 mm, Area 1550 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	310.00	R 869.58	R 269 571.04
Assume single storey brick building		Normal one storey brick buildings	Yes	E1,1	/m²	1550.00	R 442.12	R 685 292.85
Assume medium plant over 50 % of surface area		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	775.00	R 1 397.55	R 1 083 098.34
		Utility Area						
Utility area 5620 m^2, Assume concrete base thickness of 250 mm for a total area of 662,8 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	165.70	R 869.58	R 144 090.07
2 Canopies with areas 38 & 58 m^2		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	96.00	R 93.35	R 8 961.98
Assume light plant over 20 % of the surface area with total area of 5620 m^2		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	1124.00	R 350.18	R 393 607.45
Assume medium plant over 70 % of the concrete surface areas 662,8 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	463.96	R 1 397.55	R 648 405.55
		Pig Trap Area						
Concrete base assumed to be light concrete (250 mm) with area 586 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	146.50	R 552.38	R 80 924.26
		Central Control Building and Laboratory						
Assume concrete thickness of 250 mm,Area 2192 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	548.00	R 869.58	R 476 532.03
Assume single storey brick building		Normal one storey brick buildings	Yes	E1,1	/m²	2192.00	R 442.12	R 969 136.73
Assume medium plant over 30 % of surface area		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	657.60	R 1 397.55	R 919 026.41
		LNG Storage Area						
Concrete base assumed to be light concrete (500 mm), Area of 3702 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	1851.00	R 552.38	R 1 022 462.78
Assume concrete footings with thickness of 500 mm and each steel tank standing on two concrete blocks of 1,5m x 0.5m x 2m (11 Steel tanks)		Concrete Footings (heavy concrete)	Yes	B1,4	/m³	33.00	R 1 466.70	R 48 401.23
11 steel tank used (steel tanks 300 m^3)		Steel tanks	Yes	C1,3	/tank	11.00	R 7 427.04	R 81 697.49
		Truck Loading Operation Shelter						
Building at truck loading area for operator, Area 245 m^2		Prefabricated building	Yes	E1,3	/m²	245.00	R 111.33	R 27 276.36
		LNG Area						
Concrete base assumed to be light concrete (500 mm), over 50% of the area of 1708 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	427.00	R 552.38	R 235 867.97
Building with no cladding assumed to be a canopy 15 m x 40 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	600.00	R 93.35	R 56 012.40

MineLock Environmental Engineers

114 TETRA4 - Cluster 2

Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Assume medium plant over 70 % of surface area of 1708 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	1195.60	R 1 397.55	R 1 670 906.28
		Pre-treatment & Helium Seperation Unit						
Concrete base assumed to be light concrete (500 mm), areas 364, 26, 26, 68, 242.2, 142 and 53 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	460.60	R 552.38	R 254 428.07
Canopy areas: 16 m x 21 m, 11 m x 6,5 m, 18 m x 4 m, 6 m x 4,5 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	506.50	R 93.35	R 47 283.80
Assume light plant over 20 % of the surface area with total area of 2363 m^2		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	472.60	R 350.18	R 165 497.22
Assume medium plant over 70 % of areas 364, 26, 26, 68, 242.2, 142 and 53 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	644.84	R 1 397.55	R 901 193.72
		Helium Area						
Concrete base assumed to be light concrete (500 mm), assume over areas: 508, 508, 186, 236, 307, 180, 48, 97.4 & 34.3 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	1052.35	R 552.38	R 581 301.30
Canopy areas: 2 times 15 m x 30 m, 15 m x 14 m, 18 m x 15 m, 15 m x 16 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	1620.00	R 93.35	R 151 233.48
Assume light plant over 10 % of the surface area with total area of 2928 m^2		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	292.80	R 350.18	R 102 534.04
Assume medium plant over 70 % of areas 508, 508, 186, 236, 307, 180, 48, 97.4 & 34.3 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	1473.29	R 1 397.55	R 2 058 990.90
Assume concrete footings with thickness of 500 mm and each steel tank standing on two concrete blocks of 1,5m x 0.5m x 2m (2 Steel tanks)		Concrete Footings (heavy concrete)	Yes	B1,4	/m³	6.00	R 1 466.70	R 8 800.22
2 steel tank used (steel tanks 100 m^3)		Steel tanks	Yes	C1,3	/tank	2.00	R 7 427.04	R 14 854.09
		All Pipe Racks						
Steel frame used for the pipe racks with total length of 1004 m		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	1004.00	R 1 397.55	R 1 403 136.42
		Warm and Cold Flare Packages						
Concrete base assumed to be light concrete (250 mm) with area 11739 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	2934.75	R 552.38	R 1 621 108.94
		Fuel Gas & Flare System						
Area of 260 m^2 , assume concrete base of 300 mm thick		Concrete Base (Medium concrete)	Yes	B1,2	/m³	78.00	R 869.58	R 67 827.55
Assume Canopy over area		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	260.00	R 93.35	R 24 272.04
Assume light concrete wall with thickness 0.25 m and height 1 m around canopy area (65 m)		Concrete Base (Light concrete)	Yes	B1,1	/m³	16.25	R 552.38	R 8 976.24
Assume one steel tank used		Steel tanks	Yes	C1,3	/tank	1.00	R 7 427.04	R 7 427.04
		Switch Yard Phase 2						
Concrete base assumed to be light concrete (250 mm thick), area of 616 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	154.00	R 552.38	R 85 067.14
		LIR, Substation & Transformers						
Assume Canopy over Substation area 3656 m^2		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	3656.00	R 93.35	R 341 302.22
Assume concrete thickness of 500 mm over plant area 1528 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	764.00	R 869.58	R 664 362.18
Assume concrete thickness of 200 mm over surface area 3656 - 1528 = 2128 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	425.60	R 869.58	R 370 094.95
Assume medium plant over 30% of plant area 1528 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	458.40	R 1 397.55	R 640 635.20
Assume medium plant over 30 % of surface area 2128 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	638.40	R 1 397.55	R 892 193.52
		Evaporation Pond Phase 2						
Dam size 103 x 67 x 1.4 m (say water level is at 1 m)		Pump Water Out of Dam	Yes	L1,2	/m³	6901.00	R 4.06	R 28 045.66

MineLock Environmental Engineers

114 TETRA4 - Cluster 2

Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Assume single HDPE liner used		Remove Liner	Yes	L1,3	/m²	6901.00	R 5.83	R 40 260.43
		Excavation - Remove all Material 500 mm below	Yes	G1,6	/m³	3450.50	R 51.06	R 176 196.33
Assume 1 m over area		Levelling and shaping of area	Yes	G1,3	/m³	6901.00	R 23.00	R 158 723.00
		Storage Tanks						
Concrete footings assumed to be medium concrete (300 mm) with area 485 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	145.50	R 869.58	R 126 524.47
Assume medium plant over plant area 69 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	69.00	R 1 397.55	R 96 430.69
2 steel tanks		Steel tanks	Yes	C1,3	/tank	2.00	R 7 427.04	R 14 854.09
		Remaining Infrastructure to be removed						
14 Pigging stations for phase 2		**Pigging Stations (Quantity 14)**				**14.00**		
Light plant to be removed with area 4 m x 5,355 m		Dismantle of wellhead and HDPE connections	Yes	A1,3	/m²	299.88	R 728.40	R 218 432.14
Assume 300 mm concrete base		Concrete Base (Medium concrete)	Yes	B1,2	/m³	89.96	R 869.58	R 78 231.25
Excavation of a 0,5 m x 0,5 m area around pigging station to a depth of 0,5 meters.		Excavation of material and demolition hammer and casing	Yes	A1,4	/m³	1.75	R 13 061.15	R 22 857.01
Thickness of 115 mm, hight of 1,2 m and width of 1 m given (precast pit A)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	1.93	R 869.58	R 1 680.04
Thickness of 200 mm, hight of 0.65 m and width of 1.2 m given (concrete pit B)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	2.18	R 869.58	R 1 899.17
Fencing 500 mm from concrete base with area 6 m x 8 m		Dismantle fencing	Yes	D1,1	/m	420.00	R 48.86	R 20 519.52
Assume 6 m x 8 m area to be dozed 0.5 m depth		Levelling and shaping of area	Yes	G1,3	/m³	336.00	R 23.00	R 7 728.00
Assume 6 m x 8 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.07	R 60 161.84	R 4 042.88
Assume light plant over 50% of the plant area		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	149.94	R 350.18	R 52 506.67
240 low point drains for phase 2		**Low Point Drains (Quantity 240)**				**240.00**		
Assume 1m x 1m concrete box with thickness 200 mm		Concrete Base (Light concrete)	Yes	B1,1	/m³	48.00	R 552.38	R 26 514.43
Excavation of a 0,5 m x 0,5 m area around drian to a depth of 0,5 meters.		Excavation of material and demolition hammer and casing	Yes	A1,4	/m³	30.00	R 13 061.15	R 391 834.44
		Rip footprint area	Yes	G1,2	/ha	0.12	R 5 862.86	R 703.54
Assume 1,5 m x 1,5 m area to be dozed 0.5 m depth		Levelling and shaping of area	Yes	G1,3	/m³	270.00	R 23.00	R 6 210.00
Assume 1,5 m x 1,5 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.05	R 60 161.84	R 3 248.74
Assumed pipe markers placed every 100 m of 480 km of pipeline		**Pipe Markers (Quantity 4800)**				**4800.00**		
Concrete pipe marker with base 0,5 m x 0,4 m x 0,4 m, pole 1,35 m x 0,15 m x 0,15 m, aerial marker 0,33 m x 0,8 m x 0,8 m, Assume pipe markers every 100 m of pipeline, with total length of 480 km giving 4800 markers		Concrete Base (Medium concrete)	Yes	B1,2	/m³	1543.56	R 869.58	R 1 342 255.08
		Rehabilitation of roads and paved surfaces						
Provision was made for the rehabilitation of access roads that can not be practically transferred to post-closure land owners. A allowance of 250 m per well (400 exploration wells), approx 100km may be required.		Rehabilitation of roads and paved surfaces, Access road (two track road)	Yes	F1,1	/m	100000.00	R 8.00	R 800 000.00
Additional roads at plant 2275.6 m		Rehabilitation of roads and paved surfaces, Access road (two track road)	Yes	F1,1	/m	2275.60	R 8.00	R 18 204.80
Truck parking area 1620 m^2		Truck Parking Area	Yes	F1,2	/m²	1620.00	R 25.46	R 41 248.14
Parking areas, 455 m^2 , 223 m^2 , 480 m^3		Truck Parking Area	Yes	F1,2	/m²	1158.00	R 25.46	R 29 484.78
2 X LNG Weighbridge area 90 m^2, 250 mm thick		Concrete Base (Medium concrete)	Yes	B1,2	/m³	45.00	R 869.58	R 39 131.28
Assume medium plant over plant area (LNG Weighbridge area 2 x 90 m^2)		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	180.00	R 1 397.55	R 251 558.32
Assume 1.8 m high razor wire mesh with total length of 1391 m (fencing around site)		Dismantle fencing	Yes	D1,1	/m	1391.00	R 48.86	R 67 958.70

MineLock Environmental Engineers

114 TETRA4 - Cluster 2

Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
same as phase 1 compressor station. A surface area of 30 X 45 m used for the compressor station. The compressor stations include CS1, CS2 and CS3.		**Compressor Stations**				**3.00**		
Surface area will have medium concrete 150 mm thick (area of 49 m x 35 m)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	771.75	R 869.58	R 671 101.45
Surface area will have medium concrete 250 mm thick (area of 13 m x 5 m)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	48.75	R 869.58	R 42 392.22
Surface area will have medium concrete 300 mm thick (area of 22 m x 5 m)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	99.00	R 869.58	R 86 088.82
Assume office area 5 m x 8 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	120.00	R 93.35	R 11 202.48
Two HDPE to carbon steel pits with area 3,82 m x 0,92 m x 0,9 m		Remove concrete pit including piping and plant	Yes	B1,5	/m³	18.98	R 728.40	R 13 823.37
Assume light plant over 10%		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	2.11	R 350.18	R 738.41
2 m wide and 166 m long fire break to be demolished, assume 150 mm thick		Remove fire break (rock finish), Load and haul within the free haul distance	Yes	G1,1	/m³	149.40	R 17.06	R 2 549.36
Electric fence 150 m		Dismantle electric fencing	Yes	D1,2	/m	450.00	R 56.06	R 25 228.80
Outer perimeter fence 166 m		Dismantle fencing	Yes	D1,1	/m	498.00	R 48.86	R 24 330.29
Assume light plant over plant area		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	525.00	R 350.18	R 183 846.89
28 Booster stations will be built: The area of the booster station is 14 m x 10 m		**Booster Stations**				**28.00**		
Surface area will have medium concrete with assumed thickness of 250 mm		Concrete Base (Medium concrete)	Yes	B1,2	/m³	980.00	R 869.58	R 852 192.32
Assume medium plant over 80% of the area		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	3136.00	R 1 397.55	R 4 382 705.01
Fencing assumed to be 50 m long		Dismantle fencing	Yes	D1,1	/m	1400.00	R 48.86	R 68 398.40
Assume 14 m x 6 m area to be dozed 0.5 m depth		Levelling and shaping of area	Yes	G1,3	/m³	1960.00	R 23.00	R 45 080.00
Assume 14 m x 10 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.39	R 60 161.84	R 23 583.44
		Disposal of demolition waste						
		Concrete demolition waste						
All concrete excluding pipe markers and wells		Crushing of concrete demolition waste	Yes	H1,1	/m²	41312.95	R 82.64	R 3 414 306.44
Load and Haul of demolition waste to Welkom General landfill site		Transport of concrete demolition waste	Yes	H1,2	/m³	41312.95	R 391.76	R 16 184 910.02
		Steel demolition waste						R -
		Transport of steel demolition waste	Yes	H1,3	/m³	6858.50	R 391.76	R 2 686 910.65
		General demolition waste						R -
		Transport of waste to dedicated demolition waste disposal site	Yes	H1,4	/m³	4630.00	R 391.76	R 1 813 865.47
		Disposal of demolition waste	Yes	H1,5	/m³	4630.00	R 131.63	R 609 454.97
		Hazardous waste						R -
Load and Haul of Hazardous waste generated during demolition for disposal at Holfontein. (350km)		Transport of demolition hazardous waste	Yes	H1,6	/m³	80.00	R 2 742.08	R 219 366.29
Disposal cost		Disposal of demolition hazardous waste	Yes	H1,7	/m³	80.00	R 1 487.67	R 119 013.60
Assume 33% will be implemented within the 1st year	**1.2**	**Wells**						**R 56 741 729.84**
Wells to be surveyed to determine depth as well as any blockages, that may prevent rehabilitation of wells.		Down Hole survey	Yes	A1,1	/well/m	400.00	R 24 318.96	R 9 727 585.60
Provision was made for opening of 10 collapsed wells if encountered to ensure proper rehabilitation. Assumed depth of 750m		Un-block of collapsed boreholes	Yes	A1,2	/well	10.00	R 158 641.00	R 1 586 410.00
300 Production wells are planned in total for phase 2		**Planned Production Wells (Quantity 300)**				**300.00**		
Light plant to be removed (0.2 x 1m)		Dismantle of wellhead and HDPE connections	Yes	A1,3	/m²	60.00	R 728.40	R 43 703.91

MineLock Environmental Engineers

114 TETRA4 - Cluster 2

Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Areas of 1.3 m x 1.1 m concrete footing, manhole squers and monholle cover, assume light concrete		Concrete Base (Light concrete)	Yes	B1,1	/m³	180.84	R 552.38	R 99 893.12
Excavation of a 0,5 m x 0,5 m area around well to a depth of 0,5 meters.		Excavation of material and demolition hammer and casing	Yes	A1,4	/m³	37.50	R 13 061.15	R 489 793.05
Infill well with Bentonite Grout assume 750m depth and diameter 100 mm		Plug of well	Yes	A1,5	/well/m	225000.00	R 445.74	R 100 291 674.00
Assume concrete capping 1 m x 1 m x 0,3 m		Surface Capping of Well	Yes	A1,6	/m³	90.00	R 8 022.29	R 722 006.47
No fencing around the wells		Dismantle fencing	No	D1,1	/m	12000.00	R 48.86	R -
No fencing around the wells		Dismantle electric fencing	No	D1,2	/m	9120.00	R 56.06	R -
No fire breaks around the wells		Remove fire break (rock finish), Load and haul within the free haul distance	No	G1,1	/m³	144.00	R 17.06	R -
Backfilling of manhole		Backfill excavated area	Yes	G1,5	/m³	552.30	R 66.06	R 36 487.15
3 m x 3 m area		Rip footprint area	Yes	G1,2	/ha	0.27	R 5 862.86	R 1 582.97
3 m x 3 m area to be dozed 0.1 m depth		Levelling and shaping of area	Yes	G1,3	/m³	270.00	R 23.00	R 6 210.00
3 m x 3 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.27	R 60 161.84	R 16 243.70
400 Exploration wells are planned for phase 2		**Planned Exploration Wells (Quantity 400 of which 300 will be production wells)**				**100.00**		
Assume no concrete around the well		Concrete Base (Light concrete)	No	B1,1	/m³	2500.00	R 552.38	R -
Infill wells with Grout/cement Assume depth of well to be plugged are 650 m		Plug of well	Yes	A1,5	/well/m	75000.00	R 445.74	R 33 430 558.00
Assume concrete capping 1 m x 1 m x 0,3 m		Surface Capping of Well	Yes	A1,6	/m³	30.00	R 8 022.29	R 240 668.82
Backfilling of manhole		Backfill excavated area	Yes	G1,5	/m³	184.10	R 66.06	R 12 162.38
3 m x 3 m area		Levelling and shaping of area	Yes	G1,3	/m³	129.60	R 23.00	R 2 980.80
3 m x 3 m area to be dozed 0.1 m depth		Rip footprint area	Yes	G1,2	/ha	0.09	R 5 862.86	R 527.66
3 m x 3 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.09	R 60 161.84	R 5 414.57
		Concrete Bond Log testing						
Provision was made for CBL testing after wells are plugged		CBL Testing	Yes	A1,7	No.	400.00	R 58 782.47	R 23 512 989.60
Based on the 33% of the infrastructure	**1.3**	**General Surface Rehabilitation**						**R 770 724.76**
		Rip footprint area	Yes	G1,2	/ha	3.92	R 5 862.86	R 22 971.70
		General levelling and shaping	Yes	I1,6	/ha	3.92	R 110 001.06	R 431 002.87
		Import of topsoil (assume Topsoil will be available within 50km at R5.50/km)	Yes	G1,7	/m³	5877.26	R 276.06	R 1 622 498.52
		Establish vegetation	Yes	I1,7	/ha	3.92	R 60 161.84	R 235 724.30
Monitoring commitments will be the same as at scheduled closure	**1.4**	**Closure phase monitoring**						**R 1 323 315.19**
Bi-annually monitoring for 50 years		Rehabilitation monitoring of rehabilitated areas	Yes	K1,5	/yr	3.00	R 18 202.00	R 54 606.00
5 days per year for 50 years		Care and maintenance of rehabilitated areas	Yes	K1,6	/yr	3.00	R 24 500.00	R 73 500.00
Every second month for 3 years		Bi-monthly groundwater quality monitoring (Decommisionoing and closure phase)	Yes	K1,2	/yr	3.00	R 361 201.06	R 1 083 603.19
Biannually for 3 years		Surface water quality monitoring	Yes	K1,1	/yr	3.00	R 37 202.00	R 111 606.00
	1.5	**P&Gs and Contingencies**						**R 16 987 205.96**
Assume 12% of sub-total		Preliminaries and general	Yes	J1,1	%	R 77 214 572.53	12%	R 9 265 748.70
Assume 10% of sub-total		Contingencies	Yes	J1,2	%	R 77 214 572.53	10%	R 7 721 457.25
No wells to be rehabilitated for phase 2	**2**	**Annual Rehabilitation Costing**						**R -**
	3	**Post Closure Phase**						**R 4 858 581.01**
Monitoring commitments will be the same as at scheduled closure	**3.1**	**Monitoring**						**R 4 328 813.20**
Bi-annual monitoring for 5 years		Surface water quality monitoring	Yes	K1,1	/yr	5.00	R 37 202.00	R 186 010.00

MineLock Environmental Engineers

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Annually for 50 years		Annual groundwater quality monitoring (post-closure phase)	Yes	K1,3	/yr	50.00	R 60 202.00	R 3 010 100.00
Gas leakage monitoring every 5 years for 50 years		Gas leakage Monitoring	Yes	K1,4	/5yr	10.00	R 113 270.32	R 1 132 703.20
Assume only 1 well will be redrilled and pluged in the first year of implementation	**3.2**	**Latent and residual risk provision (Redrill and plugging of borehole)**						**R 529 767.81**
Excavation of a 2m x 2m area around well to a depth of 2meters.		Excavation of material to access plug	Yes	A1,8	/well	1.00	R 13 061.14	R 13 061.14
		Removal of plug and redrill	Yes	A1,9	/well	1.00	R 247 190.25	R 247 190.25
Infill well with Bentonite Grout assume 750m depth.		Plug of well	Yes	A1,10	/well	1.00	R 260 965.60	R 260 965.60
		Surface Capping of Well	Yes	A1,11	sum	1.00	R 8 022.29	R 8 022.29
		Backfill excavated area	Yes	G1,5	/m³	8.00	R 66.06	R 528.51
TOTAL								**R 99 060 359.49**

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
	1	**Decomissioning and Closure**						**R 278 188 215.92**
	1.1	**Infrastructural Areas**						**R 54 152 271.61**
		Admin Building - Phase 2						
Assume single storey brick building, Area 547 m^2		Normal one storey brick buildings	Yes	E1,1	/m²	547.00	R 442.12	R 241 842.06
Concrete base assumed to be light concrete (200 mm)		Concrete Base (Light concrete)	Yes	B1,1	/m³	109.40	R 552.38	R 60 430.81
		External Area with Cranage						
Concrete base assumed to be medium concrete (200 mm), Area 302 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	60.40	R 869.58	R 52 522.87
		Workshop- Warehouse and Fire Patrol Building						
Assume concrete thickness of 200 mm, Area 1550 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	310.00	R 869.58	R 269 571.04
Assume single storey brick building		Normal one storey brick buildings	Yes	E1,1	/m²	1550.00	R 442.12	R 685 292.85
Assume medium plant over 50 % of surface area		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	775.00	R 1 397.55	R 1 083 098.34
		Utility Area						
Utility area 5620 m^2, Assume concrete base thickness of 250 mm for a total area of 662,8 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	165.70	R 869.58	R 144 090.07
2 Canopies with areas 38 & 58 m^2		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	96.00	R 93.35	R 8 961.98
Assume light plant over 20 % of the surface area with total area of 5620 m^2		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	1124.00	R 350.18	R 393 607.45
Assume medium plant over 70 % of the concrete surface areas 662,8 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	463.96	R 1 397.55	R 648 405.55
		Pig Trap Area						
Concrete base assumed to be light concrete (250 mm) with area 586 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	146.50	R 552.38	R 80 924.26
		Central Control Building and Laboratory						
Assume concrete thickness of 250 mm,Area 2192 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	548.00	R 869.58	R 476 532.03
Assume single storey brick building		Normal one storey brick buildings	Yes	E1,1	/m²	2192.00	R 442.12	R 969 136.73
Assume medium plant over 30 % of surface area		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	657.60	R 1 397.55	R 919 026.41
		LNG Storage Area						
Concrete base assumed to be light concrete (500 mm), Area of 3702 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	1851.00	R 552.38	R 1 022 462.78
Assume concrete footings with thickness of 500 mm and each steel tank standing on two concrete blocks of 1,5m x 0.5m x 2m (11 Steel tanks)		Concrete Footings (heavy concrete)	Yes	B1,4	/m³	33.00	R 1 466.70	R 48 401.23
11 steel tank used (steel tanks 300 m^3)		Steel tanks	Yes	C1,3	/tank	11.00	R 7 427.04	R 81 697.49
		Truck Loading Operation Shelter						
Building at truck loading area for operator, Area 245 m^2		Prefabricated building	Yes	E1,3	/m²	245.00	R 111.33	R 27 276.36
		LNG Area						
Concrete base assumed to be light concrete (500 mm), over 50% of the area of 1708 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	427.00	R 552.38	R 235 867.97
Building with no cladding assumed to be a canopy 15 m x 40 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	600.00	R 93.35	R 56 012.40

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Assume medium plant over 70 % of surface area of 1708 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	1195.60	R 1 397.55	R 1 670 906.28
		Pre-treatment & Helium Seperation Unit						
Concrete base assumed to be light concrete (500 mm), areas 364, 26, 26, 68, 242.2, 142 and 53 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	460.60	R 552.38	R 254 428.07
Canopy areas: 16 m x 21 m, 11 m x 6,5 m, 18 m x 4 m, 6 m x 4,5 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	506.50	R 93.35	R 47 283.80
Assume light plant over 20 % of the surface area with total area of 2363 m^2		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	472.60	R 350.18	R 165 497.22
Assume medium plant over 70 % of areas 364, 26, 26, 68, 242.2, 142 and 53 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	644.84	R 1 397.55	R 901 193.72
		Helium Area						
Concrete base assumed to be light concrete (500 mm), assume over areas: 508, 508, 186, 236, 307, 180, 48, 97.4 & 34.3 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	1052.35	R 552.38	R 581 301.30
Canopy areas: 2 times 15 m x 30 m, 15 m x 14 m, 18 m x 15 m, 15 m x 16 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	1620.00	R 93.35	R 151 233.48
Assume light plant over 10 % of the surface area with total area of 2928 m^2		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	292.80	R 350.18	R 102 534.04
Assume medium plant over 70 % of areas 508, 508, 186, 236, 307, 180, 48, 97.4 & 34.3 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	1473.29	R 1 397.55	R 2 058 990.90
Assume concrete footings with thickness of 500 mm and each steel tank standing on two concrete blocks of 1,5m x 0.5m x 2m (2 Steel tanks)		Concrete Footings (heavy concrete)	Yes	B1,4	/m³	6.00	R 1 466.70	R 8 800.22
2 steel tank used (steel tanks 100 m^3)		Steel tanks	Yes	C1,3	/tank	2.00	R 7 427.04	R 14 854.09
		All Pipe Racks						
Steel frame used for the pipe racks with total length of 1004 m		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	1004.00	R 1 397.55	R 1 403 136.42
		Warm and Cold Flare Packages						
Concrete base assumed to be light concrete (250 mm) with area 11739 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	2934.75	R 552.38	R 1 621 108.94
		Fuel Gas & Flare System						
Area of 260 m^2 , assume concrete base of 300 mm thick		Concrete Base (Medium concrete)	Yes	B1,2	/m³	78.00	R 869.58	R 67 827.55
Assume Canopy over area		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	260.00	R 93.35	R 24 272.04
Assume light concrete wall with thickness 0.25 m and height 1 m around canopy area (65 m)		Concrete Base (Light concrete)	Yes	B1,1	/m³	16.25	R 552.38	R 8 976.24
Assume one steel tank used		Steel tanks	Yes	C1,3	/tank	1.00	R 7 427.04	R 7 427.04
		Switch Yard Phase 2						
Concrete base assumed to be light concrete (250 mm thick), area of 616 m^2		Concrete Base (Light concrete)	Yes	B1,1	/m³	154.00	R 552.38	R 85 067.14
		LIR, Substation & Transformers						
Assume Canopy over Substation area 3656 m^2		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	3656.00	R 93.35	R 341 302.22
Assume concrete thickness of 500 mm over plant area 1528 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	764.00	R 869.58	R 664 362.18
Assume concrete thickness of 200 mm over surface area 3656 - 1528 = 2128 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	425.60	R 869.58	R 370 094.95
Assume medium plant over 30% of plant area 1528 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	458.40	R 1 397.55	R 640 635.20
Assume medium plant over 30 % of surface area 2128 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	638.40	R 1 397.55	R 892 193.52
		Evaporation Pond Phase 2						
Dam size 103 x 67 x 1.4 m (say water level is at 1 m)		Pump Water Out of Dam	Yes	L1,2	/m³	6901.00	R 4.06	R 28 045.66

MineLock Environmental Engineers

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Assume single HDPE liner used		Remove Liner	Yes	L1,3	/m²	6901.00	R 5.83	R 40 260.43
		Excavation - Remove all Material 500 mm below	Yes	G1,6	/m³	3450.50	R 51.06	R 176 196.33
Assume 1 m over area		Levelling and shaping of area	Yes	G1,3	/m³	6901.00	R 23.00	R 158 723.00
		Storage Tanks						
Concrete footings assumed to be medium concrete (300 mm) with area 485 m^2		Concrete Base (Medium concrete)	Yes	B1,2	/m³	145.50	R 869.58	R 126 524.47
Assume medium plant over plant area 69 m^2		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	69.00	R 1 397.55	R 96 430.69
2 steel tanks		Steel tanks	Yes	C1,3	/tank	2.00	R 7 427.04	R 14 854.09
		Remaining Infrastructure to be removed						
14 Pigging stations for phase 2		**Pigging Stations (Quantity 14)**				**14.00**		
Light plant to be removed with area 4 m x 5,355 m		Dismantle of wellhead and HDPE connections	Yes	A1,3	/m²	299.88	R 728.40	R 218 432.14
Assume 300 mm concrete base		Concrete Base (Medium concrete)	Yes	B1,2	/m³	89.96	R 869.58	R 78 231.25
Excavation of a 0,5 m x 0,5 m area around pigging station to a depth of 0,5 meters.		Excavation of material and demolition hammer and casing	Yes	A1,4	/m³	1.75	R 13 061.15	R 22 857.01
Thickness of 115 mm, hight of 1,2 m and width of 1 m given (precast pit A)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	1.93	R 869.58	R 1 680.04
Thickness of 200 mm, hight of 0.65 m and width of 1.2 m given (concrete pit B)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	2.18	R 869.58	R 1 899.17
Fencing 500 mm from concrete base with area 6 m x 8 m		Dismantle fencing	Yes	D1,1	/m	420.00	R 48.86	R 20 519.52
Assume 6 m x 8 m area to be dozed 0.5 m depth		Levelling and shaping of area	Yes	G1,3	/m³	336.00	R 23.00	R 7 728.00
Assume 6 m x 8 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.07	R 60 161.84	R 4 042.88
Assume light plant over 50% of the plant area		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	149.94	R 350.18	R 52 506.67
240 low point drains for phase 2		**Low Point Drains (Quantity 240)**				**240.00**		
Assume 1m x 1m concrete box with thickness 200 mm		Concrete Base (Light concrete)	Yes	B1,1	/m³	48.00	R 552.38	R 26 514.43
Excavation of a 0,5 m x 0,5 m area around drian to a depth of 0,5 meters.		Excavation of material and demolition hammer and casing	Yes	A1,4	/m³	30.00	R 13 061.15	R 391 834.44
		Rip footprint area	Yes	G1,2	/ha	0.12	R 5 862.86	R 703.54
Assume 1,5 m x 1,5 m area to be dozed 0.5 m depth		Levelling and shaping of area	Yes	G1,3	/m³	270.00	R 23.00	R 6 210.00
Assume 1,5 m x 1,5 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.05	R 60 161.84	R 3 248.74
Assumed pipe markers placed every 100 m of 480 km of pipeline		**Pipe Markers (Quantity 4800)**				**4800.00**		
Concrete pipe marker with base 0,5 m x 0,4 m x 0,4 m, pole 1,35 m x 0,15 m x 0,15 m. Assume pipe markers every 100 m of pipeline, with total length of 480 km giving 4800 markers		Concrete Base (Medium concrete)	Yes	B1,2	/m³	384.00	R 869.58	R 333 920.26
		Rehabilitation of roads and paved surfaces						
Provision was made for the rehabilitation of access roads that can not be practically transferred to post-closure land owners. A allowance of 250 m per well (400 exploration wells), approx 100km may be required.		Rehabilitation of roads and paved surfaces, Access road (two track road)	Yes	F1,1	/m	100000.00	R 8.00	R 800 000.00
Additional roads at plant 2275.6 m		Rehabilitation of roads and paved surfaces, Access road (two track road)	Yes	F1,1	/m	2275.60	R 8.00	R 18 204.80
Truck parking area 1620 m^2		Truck Parking Area	Yes	F1,2	/m²	1620.00	R 25.46	R 41 248.14
Parking areas, 455 m^2 , 223 m^2 , 480 m^3		Truck Parking Area	Yes	F1,2	/m²	1158.00	R 25.46	R 29 484.78
2 X LNG Weighbridge area 90 m^2, 250 mm thick		Concrete Base (Medium concrete)	Yes	B1,2	/m³	45.00	R 869.58	R 39 131.28
Assume medium plant over plant area (LNG Weighbridge area 2 x 90 m^2)		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	180.00	R 1 397.55	R 251 558.32

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Assume 1.8 m high razor wire mesh with total length of 1391 m (fencing around site)		Dismantle fencing	Yes	D1,1	/m	1391.00	R 48.86	R 67 958.70
same as phase 1 compressor station. A surface area of 30 X 45 m used for the compressor station. The compressor stations include CS1, CS2 and CS3.		**Compressor Stations**				**3.00**		
Surface area will have medium concrete 150 mm thick (area of 49 m x 35 m)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	771.75	R 869.58	R 671 101.45
Surface area will have medium concrete 250 mm thick (area of 13 m x 5 m)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	48.75	R 869.58	R 42 392.22
Surface area will have medium concrete 300 mm thick (area of 22 m x 5 m)		Concrete Base (Medium concrete)	Yes	B1,2	/m³	99.00	R 869.58	R 86 088.82
Assume office area 5 m x 8 m		Remove Canopies/light steel structures (80 kg per square meter)	Yes	C1,5	/m²	120.00	R 93.35	R 11 202.48
Two HDPE to carbon steel pits with area 3,82 m x 0,92 m x 0,9 m		Remove concrete pit including piping and plant	Yes	B1,5	/m³	18.98	R 728.40	R 13 823.37
Assume light plant over 10%		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	2.11	R 350.18	R 738.41
2 m wide and 166 m long fire break to be demolished, assume 150 mm thick		Remove fire break (rock finish), Load and haul within the free haul distance	Yes	G1,1	/m³	149.40	R 17.06	R 2 549.36
Electric fence 150 m		Dismantle electric fencing	Yes	D1,2	/m	450.00	R 56.06	R 25 228.80
Outer perimeter fence 166 m		Dismantle fencing	Yes	D1,1	/m	498.00	R 48.86	R 24 330.29
Assume light plant over plant area		Light plant or structures (300kg per square meter)	Yes	C1,1	/m²	525.00	R 350.18	R 183 846.89
		Levelling and shaping of area	Yes	G1,3	/m³	675.00	R 23.00	R 15 525.00
		Establish vegetation	Yes	G1,4	/ha	0.14	R 60 161.84	R 8 121.85
28 Booster stations will be built: The area of the booster station is 14 m x 10 m		**Booster Stations**				**28.00**		
Surface area will have medium concrete with assumed thickness of 250 mm		Concrete Base (Medium concrete)	Yes	B1,2	/m³	980.00	R 869.58	R 852 192.32
Assume medium plant over 80% of the area		Medium plant or structures (800 kg per square meter)	Yes	C1,2	/m²	3136.00	R 1 397.55	R 4 382 705.01
Fencing assumed to be 50 m long		Dismantle fencing	Yes	D1,1	/m	1400.00	R 48.86	R 68 398.40
Assume 14 m x 6 m area to be dozed 0.5 m depth		Levelling and shaping of area	Yes	G1,3	/m³	1960.00	R 23.00	R 45 080.00
Assume 14 m x 10 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.39	R 60 161.84	R 23 583.44
		Disposal of demolition waste						
		Concrete demolition waste						
All concrete excluding pipe markers and wells		Crushing of concrete demolition waste	Yes	H1,1	/m²	41312.95	R 82.64	R 3 414 306.44
Load and Haul of demolition waste to Welkom General landfill site		Transport of concrete demolition waste	Yes	H1,2	/m³	41312.95	R 391.76	R 16 184 910.02
		Steel demolition waste						R -
		Transport of steel demolition waste	Yes	H1,3	/m³	6858.50	R 391.76	R 2 686 910.65
		General demolition waste						R -
		Transport of waste to dedicated demolition waste disposal site	Yes	H1,4	/m³	4630.00	R 391.76	R 1 813 865.47
		Disposal of demolition waste	Yes	H1,5	/m³	4630.00	R 131.63	R 609 454.97
		Hazardous waste						R -
Load and Haul of Hazardous waste generated during demolition for disposal at Holfontein. (350km)		Transport of demolition hazardous waste	Yes	H1,6	/m³	80.00	R 2 742.08	R 219 366.29
Disposal cost		Disposal of demolition hazardous waste	Yes	H1,7	/m³	80.00	R 1 487.67	R 119 013.60
	1.2	**Wells**						**R 170 235 343.60**
Wells to be surveyed to determine depth as well as any blockages, that may prevent rehabilitation of wells.		Down Hole survey	Yes	A1,1	/well/m	400.00	R 24 318.96	R 9 727 585.60

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Provision was made for opening of 10 collapsed wells if encountered to ensure proper rehabilitation. Assumed depth of 750m		Un-block of collapsed boreholes	Yes	A1,2	/well	10.00	R 158 641.00	R 1 586 410.00
300 Production wells are planned in total for phase 2		**Planned Production Wells (Quantity 300)**				**300.00**		
Light plant to be removed (0.2 x 1m)		Dismantle of wellhead and HDPE connections	Yes	A1,3	/m²	60.00	R 728.40	R 43 703.91
Areas of 1.3 m x 1.1 m concrete footing, manhole squers and monholle cover, assume light concrete		Concrete Base (Light concrete)	Yes	B1,1	/m³	180.84	R 552.38	R 99 893.12
Excavation of a 0,5 m x 0,5 m area around well to a depth of 0,5 meters.		Excavation of material and demolition hammer and casing	Yes	A1,4	/m³	37.50	R 13 061.15	R 489 793.05
Infill well with Bentonite Grout assume 750m depth and diameter 100 mm		Plug of well	Yes	A1,5	/well/m	225000.00	R 445.74	R 100 291 674.00
Assume concrete capping 1 m x 1 m x 0,3 m		Surface Capping of Well	Yes	A1,6	/m³	90.00	R 8 022.29	R 722 006.47
No fencing around the wells		Dismantle fencing	No	D1,1	/m	12000.00	R 48.86	R -
No fencing around the wells		Dismantle electric fencing	No	D1,2	/m	9120.00	R 56.06	R -
No fire breaks around the wells		Remove fire break (rock finish), Load and haul within the free haul distance	No	G1,1	/m³	144.00	R 17.06	R -
Backfilling of manhole		Backfill excavated area	Yes	G1,5	/m³	552.30	R 66.06	R 36 487.15
3 m x 3 m area		Rip footprint area	Yes	G1,2	/ha	0.27	R 5 862.86	R 1 582.97
3 m x 3 m area to be dozed 0.1 m depth		Levelling and shaping of area	Yes	G1,3	/m³	270.00	R 23.00	R 6 210.00
3 m x 3 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.27	R 60 161.84	R 16 243.70
400 Exploration wells are planned for phase 2		**Planned Exploration Wells (Quantity 400 of which 300 will be production wells)**				**100.00**		
Assume no concrete around the well		Concrete Base (Light concrete)	No	B1,1	/m³	2500.00	R 552.38	R -
Infill wells with Grout/cement Assume depth of well to be plugged are 650 m		Plug of well	Yes	A1,5	/well/m	75000.00	R 445.74	R 33 430 558.00
Assume concrete capping 1 m x 1 m x 0,3 m		Surface Capping of Well	Yes	A1,6	/m³	30.00	R 8 022.29	R 240 668.82
Backfilling of manhole		Backfill excavated area	Yes	G1,5	/m³	184.10	R 66.06	R 12 162.38
3 m x 3 m area		Levelling and shaping of area	Yes	G1,3	/m³	497.07	R 23.00	R 11 432.61
3 m x 3 m area to be dozed 0.1 m depth		Rip footprint area	Yes	G1,2	/ha	0.09	R 5 862.86	R 527.66
3 m x 3 m area will require vegetation		Establish vegetation	Yes	G1,4	/ha	0.09	R 60 161.84	R 5 414.57
		Concrete Bond Log testing						
Provision was made for CBL testing after wells are plugged		CBL Testing	Yes	A1,7	No.	400.00	R 58 782.47	R 23 512 989.60
	1.3	**General Surface Rehabilitation**						**R 2 312 197.39**
		Rip footprint area	Yes	G1,2	/ha	3.92	R 5 862.86	R 22 971.70
		General levelling and shaping	Yes	I1,6	/ha	3.92	R 110 001.06	R 431 002.87
		Import of topsoil (assume Topsoil will be available within 50km at R5.50/km)	Yes	G1,7	/m³	5877.26	R 276.06	R 1 622 498.52
		Establish vegetation	Yes	I1,7	/ha	3.92	R 60 161.84	R 235 724.30
	1.4	**Closure phase monitoring**						**R 1 323 315.19**
Bi-annually monitoring for 3 years		Rehabilitation monitoring of rehabilitated areas	Yes	K1,5	/yr	3.00	R 18 202.00	R 54 606.00
5 days per year for 3 years		Care and maintenance of rehabilitated areas	Yes	K1,6	/yr	3.00	R 24 500.00	R 73 500.00
Every second month for 3 years		Bi-monthly groundwater quality monitoring (Decommisionoing and closure phase)	Yes	K1,2	/yr	3.00	R 361 201.06	R 1 083 603.19
Biannually for 3 years		Surface water quality monitoring	Yes	K1,1	/yr	3.00	R 37 202.00	R 111 606.00
	1.5	**P&Gs and Contingencies**						**R 50 165 088.12**
Assume 12% of sub-total		Preliminaries and general	Yes	J1,1	%	R 228 023 127.80	12%	R 27 362 775.34

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Tetra4 PROJECT

SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost
Assume 10% of sub-total		Contingencies	Yes	J1,2	%	R 228 023 127.80	10%	R 22 802 312.78
No wells to be rehabilitated for phase 2	**2**	**Annual Rehabilitation Costing**						**R -**
	3	**Post Closure Phase**						**R 5 918 116.62**
	3.1	**Monitoring**						**R 4 328 813.20**
Bi-annual monitoring for 5 years		Surface water quality monitoring	Yes	K1,1	/yr	5.00	R 37 202.00	R 186 010.00
Annually for 50 years		Annual groundwater quality monitoring (post-closure phase)	Yes	K1,3	/yr	50.00	R 60 202.00	R 3 010 100.00
Gas leakage monitoring every 5 years for 50 years		Gas leakage Monitoring	Yes	K1,4	/5yr	10.00	R 113 270.32	R 1 132 703.20
Assume 3 wells will be redrilled and pluged at scheduled closure	**3.2**	**Latent and residual risk provision (Redrill and plugging of borehole)**						**R 1 589 303.42**
Excavation of a 2m x 2m area around well to a depth of 2meters.		Excavation of material to access plug	Yes	A1,8	/well	3.00	R 13 061.14	R 39 183.43
		Removal of plug and redrill	Yes	A1,9	/well	3.00	R 247 190.25	R 741 570.76
Infill well with Bentonite Grout assume 750m depth.		Plug of well	Yes	A1,10	/well	3.00	R 260 965.60	R 782 896.81
		Surface Capping of Well	Yes	A1,11	sum	3.00	R 8 022.29	R 24 066.88
		Backfill excavated area	Yes	G1,5	/m³	24.00	R 66.06	R 1 585.54
TOTAL								**R 284 106 332.54**

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SCEDULED Closure Costing

Comments/Assumptions	No.	Rehabilitation / Closure Action	Applicable	Unit Rate Code	Units	Quantity	Rate	Activity Cost

IMPACT DESCRIPTION					Pre-Mitigation							Post Mitigation								Priority Factor Criteria			
Identifier	Discipline	Impact	Alternative	Phase	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Pre-mitigation ER	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score
7	Air Quality	Air Quality - Increase in air quality impacts due to decommissioning and closure	Alternative 1	Decommissioning	-1	3	2	4	2	4	-11	-1	3	2	3	2	3	-7.5	Medium	1	1	1.00	-8
15	Noise	Noise - Increase in noise levels	Alternative 1	Decommissioning	-1	3	2	4	2	4	-11	-1	3	2	3	2	3	-7.5	Medium	1	1	1.00	-8
27	Geohydrology	Migration of saline groundwater from the deep, fractured aquifer to the overlying, potable aquifer(s) during the borehole closure and decommissioning phase.	Alternative 1	Decommissioning	-1	3	3	5	5	4	-16	-1	2	2	4	4	3	-9	Medium	2	2	1.25	-11
28	Geohydrology	Migration of stray gas from the deep, fractured aquifer to the overlying, potable aquifer(s) borehole closure and decommissioning phase.	Alternative 1	Decommissioning	-1	3	3	5	5	4	-16	-1	2	2	4	4	3	-9	Medium	2	2	1.25	-11
29	Geohydrology	Groundwater pollution as a result of wastewater spills and seepage from the evaporation dams.	Alternative 1	Decommissioning	-1	3	3	3	4	2	-6.5	-1	2	2	2	3	1	-2.3	Medium	1	2	1.13	-3
30	Geohydrology	Poor quality leachate may emanate from the plant footprint area which may have a negative impact on groundwater quality.	Alternative 1	Decommissioning	-1	3	3	3	4	2	-6.5	-1	2	2	2	3	1	-2.3	Medium	1	2	1.13	-3
31	Geohydrology	De-mobilisation of heavy vehicle and machinery as part of the decommissioning phase on-site may cause hydrocarbon contamination of groundwater resources.	Alternative 1	Decommissioning	-1	3	3	3	4	2	-6.5	-1	2	2	2	3	1	-2.3	Medium	1	2	1.13	-3
40	Hydrology	Erosion	Alternative 1	Decommissioning	-1	2	3	3	2	2	-5	-1	2	3	3	2	1	-2.5	Low	2	2	1.25	-3
41	Hydrology	Stromwater contamination	Alternative 1	Decommissioning	-1	3	3	3	3	3	-9	-1	2	2	1	2	2	-3.5	Medium	2	2	1.25	-4
42	Hydrology	Alien and/or Invasive Vegetation	Alternative 1	Decommissioning	-1	3	4	3	3	2	-6.5	-1	2	2	1	2	1	-1.8	Low	2	1	1.13	-2
71	Visual	Impact on Existing Agricultural Landscape Character	Alternative 1	Decommissioning	-1	2	4	2	2	4	-10	-1	1	1	1	1	1	-1	Medium	2	1	1.13	-1
74	Visual	Impact on Existing Natural Landscape Character	Alternative 1	Decommissioning	-1	2	1	2	2	3	-5.3	-1	1	1	1	1	2	-2	Medium	1	1	1.00	-2
77	Visual	The visual impact on views from local roads	Alternative 1	Decommissioning	-1	2	3	3	2	4	-10	-1	1	1	1	1	1	-1	Medium	1	1	1.00	-1
80	Visual	Change of Natural of Views from Homesteads	Alternative 1	Decommissioning	-1	2	3	3	2	4	-10	-1	1	1	1	1	1	-1	Medium	1	1	1.00	-1
83	Visual	The visual impact on views from local homesteads due to Lighting	Alternative 1	Decommissioning	-1	2	1	4	1	4	-8	-1	1	1	1	1	1	-1	Medium	1	1	1.00	-1
94	Terrestrial	Continued encroachment of vegetation community by alien invasive plant species as well as erosion due to disturbed soils	Alternative 1	Decommissioning	-1	2	2	3	3	3	-7.5	-1	2	3	2	2	2	-4.5	High	1	1	1.00	-5
95	Terrestrial	Continued displacement and fragmentation of the faunal community (including potential threatened or protected species) due to ongoing habitat degradation/loss (infringement, litter, road mortalities and/or poaching).	Alternative 1	Decommissioning	-1	2	2	3	3	3	-7.5	-1	2	3	2	2	2	-4.5	High	1	1	1.00	-5
100	Pedology	Decommissioning of Compressors and Wells		Decommissioning	-1	2	2	2	2	3	-6	-1	2	2	2	2	3	-6	Medium	2	1	1.13	-7
101	Pedology	Decommissioning of pipelines and transmission loop		Decommissioning	-1	2	2	2	2	2	-4	-1	2	2	2	2	2	-4	Medium	2	1	1.13	-5
159	Wetlands	Pipelines and Transmission loop - Habitat	Alternative 1	Decommissioning	-1	3	2	3	2	3	-7.5	-1	2	2	2	2	2	-4	Medium	2	1	1.13	-5
160	Wetlands	Pipelines and Transmission loop - Water Quality	Alternative 1	Decommissioning	-1	2	2	2	1	2	-3.5	-1	2	2	2	1	2	-3.5	Medium	1	1	1.00	-4
161	Wetlands	Pipelines and Transmission loop - Flow	Alternative 1	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
162	Wetlands	Compressors Station CS1 - Habitat	Alternative 1	Decommissioning	-1	3	2	3	3	3	-8.3	-1	2	3	2	3	2	-5	Medium	2	1	1.13	-6
163	Wetlands	Compressors Station CS1 - Water Quality	Alternative 1	Decommissioning	-1	2	2	2	1	2	-3.5	-1	2	2	2	1	2	-3.5	Medium	1	1	1.00	-4
164	Wetlands	Compressors Station CS1 - Flow	Alternative 1	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
165	Wetlands	Compressors Station CS1 - Habitat	Alternative 2	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
166	Wetlands	Compressors Station CS1 - Water Quality	Alternative 2	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
167	Wetlands	Compressors Station CS1 - Flow	Alternative 2	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	1	2	2	-2.5	Medium	1	1	1.00	-3
168	Wetlands	Compressors CS2 - Habitat	Alternative 1	Decommissioning	-1	2	2	2	2	2	-4	-1	2	2	2	2	2	-4	Medium	2	1	1.13	-5
169	Wetlands	Compressors CS2 - Water Quality	Alternative 1	Decommissioning	-1	2	2	2	1	2	-3.5	-1	2	2	2	1	2	-3.5	Medium	1	1	1.00	-4
170	Wetlands	Compressors CS2 - Flow	Alternative 1	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
171	Wetlands	Compressors CS3 - Habitat	Alternative 1	Decommissioning	-1	1	2	1	1	3	-3.8	-1	1	1	2	2	2	-3	Medium	2	1	1.13	-3
172	Wetlands	Compressors CS3 - Water Quality	Alternative 1	Decommissioning	-1	2	2	2	1	2	-3.5	-1	2	2	2	1	2	-3.5	Medium	1	1	1.00	-4
173	Wetlands	Compressors CS3 - Flow	Alternative 1	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
174	Wetlands	Compressors CS3 - Habitat	Alternative 2	Decommissioning	-1	2	2	2	2	2	-4	-1	2	2	2	2	2	-4	Medium	2	1	1.13	-5
175	Wetlands	Compressors CS3 - Water Quality	Alternative 2	Decommissioning	-1	2	2	2	1	2	-3.5	-1	2	2	2	1	2	-3.5	Medium	1	1	1.00	-4
176	Wetlands	Compressors CS3 - Flow	Alternative 2	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
177	Wetlands	Powerlines - Habitat	Alternative 1	Decommissioning	-1	3	2	3	2	2	-5	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
178	Wetlands	Powerlines - Water Quality	Alternative 1	Decommissioning	-1	1	1	1	1	2	-2	-1	1	1	2	1	1	-1.3	Medium	1	1	1.00	-1
179	Wetlands	Powerlines - Flow	Alternative 1	Decommissioning	-1	1	1	1	2	2	-2.5	-1	1	1	2	1	1	-1.3	Medium	1	1	1.00	-1
180	Wetlands	Access Roads - Habitat	Alternative 1	Decommissioning	-1	2	2	3	2	2	-4.5	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3
181	Wetlands	Access Roads - Water Quality	Alternative 1	Decommissioning	-1	2	2	2	2	3	-6	-1	2	2	2	2	2	-4	Medium	1	1	1.00	-4
182	Wetlands	Access Roads - Flow	Alternative 1	Decommissioning	-1	2	1	2	2	2	-3.5	-1	1	1	1	1	2	-2	Medium	1	1	1.00	-2
183	Wetlands	LNG/LHe Plant - Habitat	Alternative 1	Decommissioning	-1	2	2	2	2	2	-4	-1	1	1	2	2	2	-3	Medium	1	1	1.00	-3

184	Wetlands	LNG/LHe Plant - Water Quality	Alternative 1	Decommissioning	-1	2	1	2	2	2	-3.5	-1	1	1	1	2	2	-2.5	Medium	1	1	1.00	-3
185	Wetlands	LNG/LHe Plant - Flow	Alternative 1	Decommissioning	-1	1	1	2	2	2	-3	-1	1	1	1	2	2	-2.5	Medium	1	1	1.00	-3
206	Economic	GGP Impact	Alternative 1	Decommissioning	-1	4	2	4	3	4	-13	-1	4	2	4	3	4	-13	High	1	1	1.00	-13
207	Economic	Employment Impacts	Alternative 1	Decommissioning	-1	4	2	4	3	4	-13	-1	4	2	4	3	4	-13	High	1	1	1.00	-13
208	Economic	Forex savings	Alternative 1	Decommissioning	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
209	Economic	Fiscal Income	Alternative 1	Decommissioning	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
210	Economic	Economic development per capita	Alternative 1	Decommissioning	-1	4	2	4	3	4	-13	-1	4	2	4	3	4	-13	High	1	1	1.00	-13
211	Economic	Country and Industry Competitiveness	Alternative 1	Decommissioning	-1	5	5	3	5	4	-18	-1	5	5	3	5	4	-18	Medium	1	1	1.00	-18
212	Economic	Black Economic Transformation	Alternative 1	Decommissioning	-1	3	5	3	5	4	-16	-1	3	5	3	5	4	-16	Medium	1	1	1.00	-16
213	Economic	Alternative Land-use	Alternative 1	Decommissioning	-1	2	2	4	4	5	-15	-1	2	2	4	4	5	-15	High	1	1	1.00	-15
214	Economic	Need and Desirability	Alternative 1	Decommissioning	-1	4	2	5	4	4	-15	-1	4	2	5	4	4	-15	High	1	1	1.00	-15
215	Economic	Impact on individual farmland values	Alternative 1	Decommissioning	1	3	2	3	3	3	8.25	1	3	2	3	3	3	8.25	Medium	1	1	1.00	8
216	Economic	GGP Impact	Alternative 1	Rehab and closure	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
217	Economic	Employment Impacts	Alternative 1	Rehab and closure	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
218	Economic	Forex savings	Alternative 1	Rehab and closure	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
219	Economic	Fiscal Income	Alternative 1	Rehab and closure	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
220	Economic	Economic development per capita	Alternative 1	Rehab and closure	-1	4	5	4	5	5	-23	-1	4	5	4	5	5	-23	High	1	1	1.00	-23
221	Economic	Country and Industry Competitiveness	Alternative 1	Rehab and closure	-1	5	5	3	2	4	-15	-1	5	5	3	2	4	-15	Medium	1	1	1.00	-15
222	Economic	Black Economic Transformation	Alternative 1	Rehab and closure	-1	3	5	3	5	4	-16	-1	3	5	3	5	4	-16	Medium	1	1	1.00	-16
223	Economic	Alternative Land-use	Alternative 1	Rehab and closure	-1	2	5	4	4	5	-19	-1	2	5	4	4	5	-19	High	1	1	1.00	-19
224	Economic	Need and Desirability	Alternative 1	Rehab and closure	-1	4	5	5	4	4	-18	-1	4	5	5	4	4	-18	High	1	1	1.00	-18
225	Economic	Impact on individual farmland values	Alternative 1	Rehab and closure	1	3	2	3	3	3	8.25	1	3	2	3	3	3	8.25	Medium	1	1	1.00	8